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LEONARDO

Journal of the International Society for the Arts, Sciences and Technology

VOLUME 51 | NUMBER 4 | 2018

LEONARDO SPECIAL ISSUE

SIGGRAPH 2018 Art Papers and
Original Narratives Art Gallery

Front Cover

"Becoming Sky Woman" (production still from *She Falls For Ages*), 2017. (© Skawennati)

Back Cover

View from *Inhabitat*, a mixed-reality artwork. (© and Photo: Haru Hyunkyung Ji and Graham Wakefield)

ACM SIGGRAPH Distinguished Artist Award for Lifetime Achievement in Digital Art

Monika Fleischmann

Monika Fleischmann (Photo: © Wolfgang Strauss)

The 2018 ACM SIGGRAPH Distinguished Artist Award for Lifetime Achievement in Digital Art is awarded to Monika Fleischmann, a research artist who has contributed to the field of interactive media art from the 1980s to the present day. She has pioneered the field of new media art and was instrumental in consolidating digital media into a research-led interactive art practice and a creative discipline—one that is able to engage in, analyze and visualize digital media and their transformations in the context of shifting fields of cultural and educational matters. In Fleischmann's work, these transformations have turned digital media into a reflexive and analytical arena for critical social and cultural thinking. Her artistic goal is to shed light on the contradictory characteristics of digital media.

Fleischmann's work—realized since 1987 and in partnership with architect and artist Wolfgang Strauss—ranges from fashion to digital architecture, interactive design, and poetic and social sculptures that intuitively interact with people and environment to explore intersections between art, science, technology and society.

In 1987 Fleischmann cofounded Art + Com, an interdisciplinary research institute for the convergence of analog and digital culture in Berlin; she was vice chairwoman of this first research institute for digital media in Germany. This center has been carrying on collaborative projects at the intersection between art, architecture, design, computer science and technology.

Fig. 1. *Liquid Views—Narcissus' Mirror*, interactive art installation (1992–1993), by Monika Fleischmann and Wolfgang Strauss with Christian-Arved Bohn. (© Monika Fleischmann and Wolfgang Strauss)

In 1992, within the Scientific Visualization research group at the German National Research Center for Information Technology (GMD) in Sankt Augustin, Germany, Fleischmann and Strauss (two of the earliest media artists in Germany to initiate working closely with computer scientists for the purpose of increasing research) began to develop groundbreaking interactive media systems in both pure and applied areas. Her work has been exhibited and awarded internationally and is part of the collection of the ZKM, Center for Art and Media in Karlsruhe, Germany. Together they have written over 100 publications. One project was the *Responsive Workbench* (RW), an applied work that followed the artistic installation *Berlin–Cyber City*. Today, along with the immersive virtual reality (VR) environment CAVE (Cave Automatic Virtual Environment) and other VR tools, the RW is extensively deployed in visualization environments. *Home of the Brain* (1989–1992), represents one of the pioneering VR interactive artworks and has earned them a Golden Nica of Prix Ars Electronica for interactive art.

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In 1997, Fleischmann founded the MARS Exploratory Media Lab, a research laboratory at the forefront of artistic and technical-scientific research on digital media and one of the world's leading hubs for trans-disciplinary collaborations between artists, architects, designers, cultural scientists and computer scientists. As a research artist in a computer science environment, she has benefited from and extended the research in this field. Fleischmann brought this research across global networks by constructing <netzspannung.org>, one of the first media art archive and eTeaching platforms at Fraunhofer Research Society, Munich. The Fraunhofer is Europe's largest application-oriented research organization.

Fleischmann's multidisciplinary background—fashion design, art and drama, computer graphics—has made her an expert in the world of art, computer science and media technology. Her artistic work deals with the change of identity and perception in a digital media culture.

Fig. 2. Compilation of interactive artworks (1987–2017) (© Monika Fleischmann and Wolfgang Strauss.

In addition to the VR technology used in *Home of the Brain*, Fleischmann has contributed to the development of sensitive surfaces for the promotion of joint content exploration. These began with the mixed-reality installation about the fall of the Berlin Wall, *Berlin–Cyber City* (1988–1989), and continued with the interactive real time morphing installation *Liquid Views* (1992), which originated in the first mirror touch screen and extends to a contactless interface—the PointScreen technology that was motivated by a search for alternatives to touching the screen. PointScreen (patented in 2005) is based on gesture and the promotion of electric field sensing with the energy of the body was inspired by the theremin. Electric field sensing is a method to perceive the body in its essential condition.

Fleischmann uses interface design as a tool, as space and as a situation at the basis of communicative action and motivation for her scientific and artistic exploration of mixed realities.

ACM SIGGRAPH is honored to recognize Monika Fleischmann as an important pioneer for her research projects, based on interface design and new forms of communication.

Sue Gollifer
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ACM SIGGRAPH Distinguished Artist Award for Lifetime Achievement in Digital Art

Art Papers Jury

Shannon McMullen and **Fabian Winkler** engage issues in contemporary culture at the intersection of nature, technology and social inquiry through a practice they define as critical gardening. As interdisciplinary artists and cultural analysts, they combine their backgrounds in new media art and sociology to produce speculative social spaces and time-based installations. Their work has been shown internationally at venues such as Science Gallery, Dublin, Ireland; Art Center Nabi, Seoul, Korea; and ZKM Center for Art and Media, Karlsruhe, Germany. Winkler and McMullen are Associate Professors at Purdue University in West Lafayette, IN.

Anıl Çamcı is an Assistant Professor of Performing Arts Technology at the University of Michigan. His work investigates new tools and theories for multimodal worldmaking across a variety of media ranging from electronic music to virtual reality. He has been featured in leading journals and conferences around the world. <www.anilcamci.com>

Haru Hyunkyung Ji is a media artist and co-creator of the research project "Artificial Nature," exploring artificial life worldmaking. She holds a Ph.D. in Media Arts and Technology from UCSB and is an assistant professor in DPXA and the Digital Futures programs at OCAD University in Toronto, Canada.

Yoon Chung Han is an interdisciplinary artist and researcher. Her multi-disciplinary research interests range from data-driven design, interactive media arts and multimodal interaction using new media technologies. She received a Ph.D. at the Media Arts and Technology at UCSB and is currently an assistant professor at the California State University, Fullerton.

Graham Wakefield is an Assistant Professor of Computational Arts and a Canada Research Chair at York University, Toronto. He directs the Alice lab for Computational Worldmaking, whose research-creation program integrates AR/MR/VR with nature-inspired generative simulation and live coding toward worlds of open-ended creativity.

Daria Tsoupikova is an Associate Professor in the School of Design and the Electronic Visualization Laboratory at the University of Illinois at Chicago. Her research and artwork explore the art of virtual reality and computer graphics applications to educational multimedia and virtual rehabilitation for stroke survivors.

Everardo Reyes is Associate Professor in the Information Sciences Department at the Université Paris 8. He is a member of the Paragraphe Lab, a collaborator of the Cultural Analytics Lab and a board member of the International Association for Visual Semiotics. His research investigates relationships between humanities, the arts and computer sciences, particularly in visual form.

Robert Twomey is an artist and engineer exploring the poetic intersection of human and machine perception. He has several degrees, including a BS from Yale with majors in Art and Biomedical Engineering, an MFA in Visual Arts from the University of California, San Diego, and a PhD in Digital Arts and Experimental Media from the University of Washington. He is currently an Assistant Professor of Digital Media at Youngstown State University.

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Art Papers

Introducing the SIGGRAPH 2018 Art Papers

Angus G. Forbes

For ten consecutive years, ACM SIGGRAPH and Leonardo/ISAST have collaborated to publish this special issue of *Leonardo*, which this year showcases the Art Papers presented at SIGGRAPH 2018 in Vancouver, Canada. Fortuitously, it is the 50th anniversary of the founding of Leonardo by kinetic artist and astronautical pioneer Frank Malina, and this publication also commemorates the longevity of Leonardo and its continued impact in helping to foster a dynamic, international community of creative practitioners working at the intersections of art and technology.

The Art Papers track invites articles submitted in one of four categories—project description, theory/criticism, methods or history. This year we explicitly requested work in the project description category, introducing a new short papers track to encourage new ideas and innovative projects at different stages of development. We had an astounding number of submissions this year—well over 100 articles were submitted—and their overall excellence made it a challenge to determine the most worthy papers.

The Art Papers jury has expertise across a range of new media arts topics, including augmented and virtual reality, cultural heritage, ecological art, live coding, media archeology, data visualization, interactive design and robotics, among others. The rigorous reviewing process includes detailed feedback from jury members and external reviewers, a daylong jury meeting in which the top ranked papers are discussed at length, and a shepherding procedure that provides the authors with the opportunity to address reviewer concerns. Despite the varied topics, each of the 13 papers selected for journal publication presents an innovative project with a well communicated motivation for the relevance of the work and its impact on communities of practice and global culture. However, we also recognize that the final selection of papers cannot help but reflect the interests of the jury, and we further identified an additional 9 highly ranked submissions that are also very deserving of attention. These additional projects are featured in the SIGGRAPH Art & Design Posters track, and will be available online via the ACM Digital Library.

The use of contemporary technology to facilitate new forms of storytelling was at the forefront of this year's papers. "Holojam in Wonderland," by David Gochfeld, Clara Fernández-Vara, Corinne Brenner and Ken Perlin, defines a new artistic medium, Immersive Mixed Reality Theater, and introduces a compelling project based on Lewis Carroll's *Alice in Wonderland*. In "Alienating the Familiar with CGI," Paul Charisse and Alex Counsell describe their creative and technical process in developing the award-winning *Uncle Griot*, an "art house" film that makes use of big-budget animation techniques.

A series of papers describe creative projects that investigate new media as a means to interrogate complex systems. The *Diastrophisms* sound installation, presented by Nicole L'Huillier and Valentina Montero, explores poetical and political issues related to the destruction of the Alto Río building during the 2010 Chilean earthquake, highlighting the transformation dynamics between nature and culture. Haru Hyunkyung Ji and Graham Wakefield introduce their mixed-reality artwork, *Inhabitat*, in which participants become part of an imaginary ecology, interacting within the complex interconnectivity of an artificial nature.

Cultural heritage is a pervasive theme in this year's Art Papers. Todd Berreth's "Cop to Conductor" explores the role of the public monument and introduces strategies for remediating monuments for contemporary cultural interventions. Nicolas Henchoz and Allison Crank introduce a series of Jazz Heritage Labs in "Digital Heritage," describing their innovative immersive installations for presenting the audio-visual archives of the Montreux Jazz Festival. Yiyun Kang's *CASTING* uses projection mapping to

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create a mixed-reality environment within the Cast Courts exhibition at the Victoria and Albert Museum in London. Brittany Myburgh's article "Here and Now" explores how the use of new media in works by indigenous Canadian artists Ruben Komangapik, Kent Monkman and Adrian Duke disrupts linear time and Western visions of history.

Many of the papers emphasize the role of design and craft in digital media practices. Yuichiro Katsumoto's "Robotype" explores novel forms of kinetic typography using robotic displays. "Data Materialization," by Courtney Starrett, Susan Reiser and Tom Pacio, articulates the design workflow utilized to generate a data-informed fabricated object. Daniel C. Howe, Qianxun Chen and Zong Chen's *Advertising Positions* presents a provocative series of data portraitures that are based on the corporate advertising profiles used to target individual users. Daniel Temkin's *Entropy* and *FatFinger* projects imbue the craft of computer programming with an awareness of the inevitable presence of errors that arise when coding, resisting the perfectionistic compulsivity of trying to design these faults away. Tobias Klein discusses his projects *Augmented Fauna* and *Glass Mutations*, articulating a synthesis between digital workflows and traditional craft processes through explorations of glass blowing and 3D printing. The Art Papers jury selected "Augmented Fauna and Glass Mutations" for this year's Best Paper award.

The SIGGRAPH Art Papers jury serves the community through providing authors with valuable feedback, and I thank each of the jury members—Anıl Çamcı, Yoon Chung Han, Haru Hyunkyung Ji, Shannon McMullen, Everardo Reyes, Daria Tsoupikova, Robert Twomey, Graham Wakefield and Fabian Winkler—as well as the numerous external reviewers for their commitment to the reviewing process. Over the past year, I have been repeatedly reminded of the generosity, collegiality and vision of my fellow SIGGRAPH chairs and organizers, including especially Andrés Burbano, Fahad Haddad and Roy C. Anthony. The Art Papers track simply would not have been possible without the SmithBucklin Conference Administration team's organizational acumen, and in particular I relied on the support of Elizia Artis and Leona Caffey throughout the year, often on a daily basis. The 2018 Art Papers builds off of the successes of previous years, and I thank last year's Art Papers chair Ruth West for her guidance and inspiration, along with Roger Malina and the entire Leonardo team. Finally, I want to extend my appreciation to all of the 2018 Art Papers contributors for sharing their work with the ACM SIGGRAPH and Leonardo communities.

Angus G. Forbes is an Assistant Professor in the Computational Media Department at University of California, Santa Cruz, where he directs UCSC Creative Coding. His research investigates novel techniques for visualizing and interacting with complex scientific information, and his interactive artwork has been featured at museums, galleries and festivals throughout the world. More information about Forbes's work can be found at https://creativecoding.soe.ucsc.edu.

Augmented Fauna and *Glass Mutations*: A Dialogue Between Material and Technique in Glassblowing and 3D Printing

Best Paper Award

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See <mitpressjournals.org/toc/leon/51/4> for supplemental files associated with this issue.

ABSTRACT

3D printing allows unprecedented freedom in the design and manufacturing of even the most geometric complex forms—seemingly through a simple click of a button. In comparison, the making of glass is an analogue craftsmanship, coordinating an intricate interplay of individual tools and personal skills, giving shape to a material during the short time of its temperature-based plasticity. The two artworks discussed in this article, *Augmented Fauna* and *Glass Mutations*, were created during the artist's residence at the Pilchuck Glass School and articulate a synthesis between digital workflows and traditional craft processes to establish a digital craftsmanship.

Prologue

In December 2016, I was invited by the Creative Director of the Pilchuk Glass School, Tina Aufiero, to participate as Artist in Residence in the summer of 2017. I was intrigued by the theme for the residence, "Taxonomy," and decided to create a family of objects situated between my digital practice and the traditional glassmaking process to articulate a potential synergetic quality between the two.

In order to explore this relationship I planned two lines of inquiry into glassblowing and glass casting. Additionally, I set up a dialogue between the materials and processes used in the resulting objects and examined the advantages and restrictions occurring in the translation between digital and traditional methods. Therefore, the artworks would retain qualities of the different toolpaths and workflows. The traces of each process would allow me to identify synergies and new narratives between them.

Conceptual Framework

Traditionally, craftsmanship is understood as the interplay between tool, material and the skills of the craftsman. By contrast, digital design environments are not operating in the realm of physical materiality and its tooling. Instead, they poorly imitate the hand and eye coordination of the craftsman through interfaces such as the computer mouse and screen. This dichotomy is based on the notion that craftsmanship is solely understood as skilled manual labor. In Richard Sennett's seminal work, *The Craftsman* [1], he extends this notion and articulates craft as a human impulse to do a job well for its own sake—including computer programming. My discourse on digital craftsmanship, based on Sennett's writing and through the concept of the digital hand [2], is one that embodies craft as a cultural and sociological construct.

In order to establish this construct as a relation between digital practice and traditional craftsmanship processes, the project revisits the conceptual pair of techne and poiesis posited by Martin Heidegger. I argue specifically that Computer Aided Design (CAD) can be read as techne which, for Heidegger, does not describe *Technik* (technology) but constitutes the "bringing-forth of the true into the beautiful" [3] and thus extends the basic definition of "how to" to the actual genetics of the making itself. Reciprocal to techne, poiesis is the activity in which a person brings something into being that did not exist before. It articulates the making of the works and the intent behind the processes and their reevaluation in the context of craft and or digital workflow [4]. I further articulate this reading by comparing it to phase matter states, in which Sublimation and Reification act as techne and the methods of Amalgamation/Augmentation as poiesis.

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Techne:

The term Sublimation describes the transition of a substance from solid to gas phase without passing through an intermediate liquid phase. This process of dematerialization is comparable to the digitization of a physical object—a solid melting into digital air. It is the interface between an actual object and the digital 3D model becoming prosthesis, a doppelganger or "cybrid" as described by Peter Anders [5]. Thus, the emergence of a malleable information space enables intervention into the otherwise static properties of physical objects [6]. Sublimation is able to establish the transfer of traditional craftsmanship into digital workflows.

The results established a dialogue between immaterial and material processes and emerging properties based on craft and digital workflows and became the basis to articulate my notion of Digital Craftsmanship.

Poiesis:

Augmentation describes the addition of a prosthetic element into an existing form. I worked with the biological remains of a pelvis bone from a Pilchuck deer. The conversation takes place between a found object, its glass prosthesis and a negotiating sublimating 3D scan—and ultimately, printed—digital doppelganger. For this I chose what seemed comparable to 3D printing—glass casting.

Amalgamation is the combination of two or more components into a construct, where the initial components cannot be separated or read individually after their merging. Components therefore exist only in synthesis and form a new object that adds up to more than the sum of its parts. In this second argument, the finite sublimated form of the cast as a simulacrum of the physical original is replaced. Instead, the second work series uses glass blowing in synchronization with digital workflows of scanning and printing.

Fig. 1. Panorama view of the setup of the Artist in Residence studio at the Pilchuck Glass School including 3D scanning and printing station. (© 2017 Tobias Klein)

After three weeks of experiments, revisions and successes, I filled a room with glass casts, scans, drawings, 3D prints and glass blow specimens (Fig. 1). The results established a dialogue between immaterial and material processes and emerging properties based on craft and digital workflows and became the basis to articulate my notion of Digital Craftsmanship. Extending Neri Oxman's definition of digital craftsmanship (the ability to simulate and compute material behavior and design) [7] and the digitally derived formal exuberance [8] of Dillenburger and Hansmeyer's Subdivided Column [9] and Digital Grotesque [10], my work is situated among those by artists like Isaie Bloch and Nendo (featured in the global survey *Digital Handmade* [11]), and uses Digital Craftsmanship as a combining method where traditional craft and digital workflows are fluctuating constructs of techne and poiesis.

Fig. 2. Cast glass doppelganger and original deer pelvis bone, *Augmented Fauna*. (© 2017 Tobias Klein)

Augmentation—Sublimation

Glass casting's ability to duplicate a found object with a high level of detail and surface precision became the departure point for *Augmented Fauna*. I worked with three different setups of casting glass. The goal of the first experiment was to replicate the original object in glass (Fig. 2). Using the traditional method of casting, my full-time technical assistant Phirak Suon made a silicone mold, which we used to make a wax replica of the pelvis bone. Afterwards, the wax cast was used to make a second mold using silicate and plaster. The second mold with the wax model was fired in an oven at 300°, burning out the wax and leaving a cavity for the glass to be cast into. This process is called investment casting as the mold breaks when removing the cast glass and thus cannot be reused.

The second cast was digital instead of physical. I transferred the physical found object from its solid state to a digital data construct using structural light 3D scanning. I used a HP 3D Structured Light Scanner Pro S3 [12] including a turntable setup that allowed for a continuous 360° scan. After automated stitching of the individual scan sections, this created a digital copy of the glass cast and the original pelvis bone. Using structured light scanning, I achieved a surface derivation between the original and scanned surfaces of around 0.05–0.1 mm. The digital copies became sites for the prosthetic argument. I developed the prosthetic construct first by deciding on reference mesh areas on the surface of the scans. Those anchor areas were the basis for a series of mesh and subdivision modeling operations using 3DS Max 2016 [13]. I used the bridging software tool to sculpt a rough connecting volume between the areas and a series of interconnected tendril-like substructures, attached to the emerging mesh. Lastly, I applied topological surface mesh modifications (push, pull, extrude, subdivision modeling, etc.) to the resulting mesh, imitating the natural growth of the bone substrate.

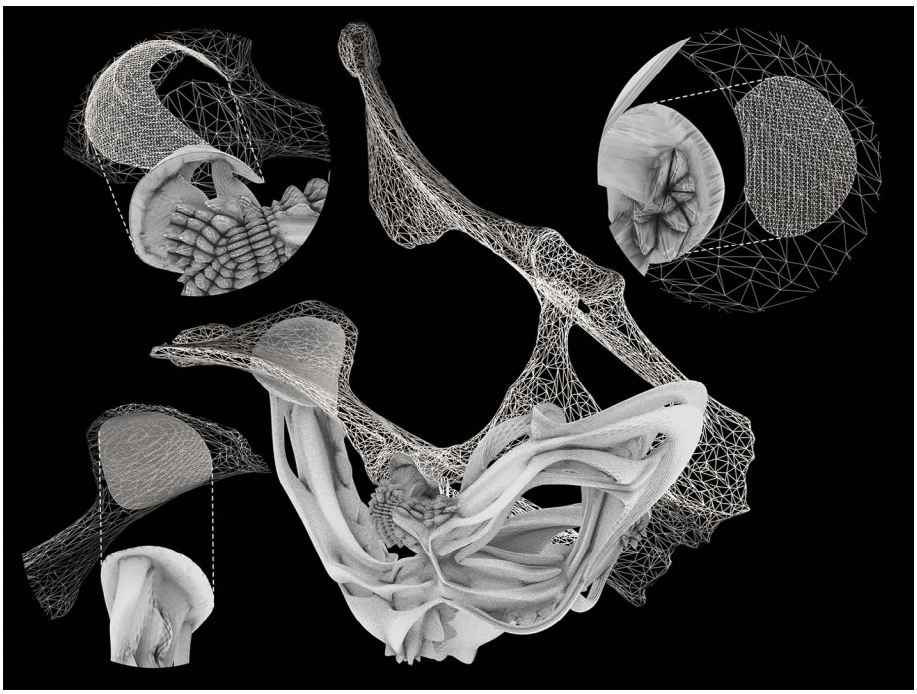

Fig. 3. 3D scan data of pelvis bone with reduced mesh count, 3D print prosthesis and high resolution mesh attachment points, *Augmented Fauna*. (© 2017 Tobias Klein)

The translation from actual to digital formed a tectonic intervention through fitting of the 3D-printed geometry grafted onto the scanned pelvis geometry, attaching it in three points (Fig. 3).

The last cast was similar to the investment cast, but involved 3D-printed substrate instead of wax. After 3D modeling of the additional prosthetic around the 3D-scanned digital copy, we printed the element using a fuse deposition-modeling printer. The printer was set up for the printed object to have a low internal density using a 3D honeycomb structure and a dense, precisely articulated, outer

shell/surface. This allowed for a faster and cleaner burning out of the 3D-printed substrate (a thermoplastic with a low melting point) and a higher quality surface finish in the resulting glass cast. We used a Flashforge FDM 3D printer [14] with a Polylactic Acid (PLA) biodegradable thermoplastic derived from renewable resources.

Fig. 4. Glass cast pelvis bone with 3D-printed prosthetic augmentation and pelvis bone with glass cast prosthetic augmentation, *Augmented Fauna*. (© 2017 Tobias Klein)

Augmented Fauna (Fig. 4) consists of two geometrically identical objects, each using all three methods of casting. Each generated an otherwise impossible situation for traditional craft by adding a secondary loop—or meta-conversation—between the original and the augmented object, exchangeable with its copy. The first is a construct containing a 3D-printed prosthesis grafted onto the glass doppelganger of the original pelvis bone. The second assemblage is identical in geometry, but retains the original pelvis bone augmented by a glass cast of the 3D-printed prosthesis. The work articulates a clear relationship between digital and traditional craftsmanship tools and processes used in its making, a comparison between 3D scan as immaterial materiality and the investment casting of resulting 3D-printed objects in glass. The dialogue between the two pelvises and their grafted prosthesis opened new narratives about the notion of the material involving physical and digitally shaped processes.

In the process of casting, and especially during the burning out of the 3D-printed PLA, fractures occurred and the process needed to be repeated. In addition, bubbles were trapped in the glass as the glass could not flow through all parts of the element and rendered the first cast almost useless. Thus, while using digital tools as a method of scanning and creating a reversed cast proved successful, the direct translation of digital materiality in the form of casting failed.

Numerous elements that are not part of 3D printing but feature in the process of glass casting require fine-tuning and balancing—notably the firing temperature, the making of the plaster/silicate mold, the amount of glass used for the cast, and the extra amount on top of the cast in order to add pressure so that the glass would fill the burned out cavity in the mold—and were neglected during the modeling of the prosthetic element. The almost immaterial qualities of a 3D-printed substrate allow for more detail but, compared to traditional glass casting, must follow different rules to achieve high fidelity parts.

The most successful part of the experiment was the digital modeling of the 3D-scanned surfaces and the recursive processes that allowed for the formation of connections between scan and object through sublimation of the physical bone and resulting glass objects. The emerging objects therefore pointed out the limitations of a direct methodological transfer from cast to 3D print via scanning sublimation processes: augmentation is a process that left the initial body visible and grafted with an alien element that imitated material- and making-processes.

Amalgamation—Reification

For the second body of works, *Glass Mutations,* I had the support of Sasha Tepper-Stewart and Lisa Piaskowy, two highly trained glassblowers (also known as gaffers). The work consists of a series of evolving,

Fig. 5. Spikes are added by pulling heated parts from the glass surface. These node points are clearly identifiable in the 3D scan. They are geometric interface points for the 3D printing, *Glass Mutations*. (© 2017 Tobias Klein)

simple, glass-blown volumes that gradually increase in geometric, interconnected and material complexity. The formation processes of a glass object using blowing techniques are very short in comparison to casting. Molten glass is taken out of the furnace on a blowpipe. Immediately, the material is cooling down and changes viscosity from a liquid to a rigid state. The molten material is centered on the blowpipe using continuous rotation. The glass craftsman blows air into the blowpipe to inflate the glass. More glass can be added and various rotational shapes can be made. Lastly, the object is finished through multiple reheating of the glass in a stationary oven, maintaining the material's plasticity and thus allowing shaping of the object with blocks, jacks, paddles, tweezers, newspaper pads and a variety of shears.

Glass Mutations is based on the concept of the primordial in cell mitosis. The process of mitosis occurs when cells split and build more complex organisms. The work extends this idea—the beginning of all complex life—and applies the residence theme of Taxonomy to an argument centered around the notions of evolution and mutation. By adding digital processes into the otherwise predictable sequential developments of the glass objects, the mutation starts at the surface. Deforming the glass surface by pulling it locally, we created geometrical anomalies that became attachment points and, ultimately, interfaces between the glass, 3D scan and printed object (Fig. 5). They enable Cartesian recognition in the 3D scan and, later in the assembly of print and glass, mechanically hold the 3D-printed elements in tension.

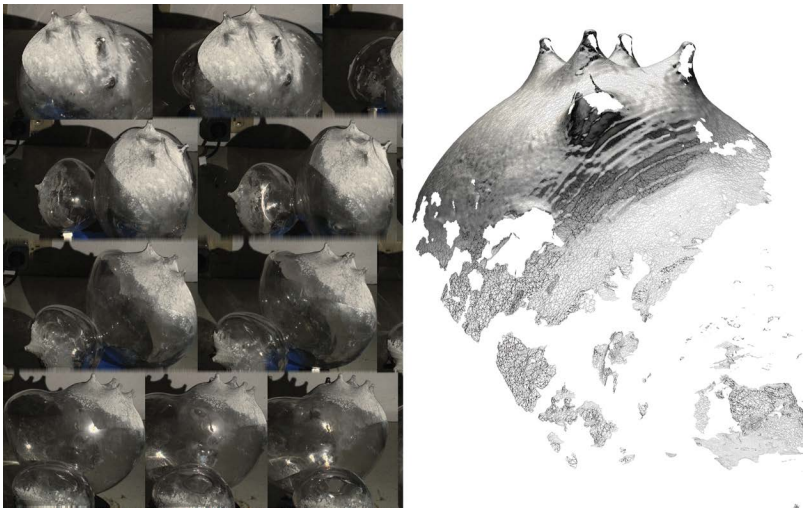

Fig. 6. Collage of automatically generated mapping data from the 3D scanning with resulting polygonal mesh and areas where reflection and refraction made scanning impossible, *Glass Mutations*. (© 2017 Tobias Klein)

Differently from the scanning of bone or cast glass in *Augmented Fauna*, the reflection and refraction of the glass did not allow a simple 3D scanning process [15]. This problem also occurs with traditional photography of glass objects where it is impossible to use the autofocus function of cameras or when the photographer deals with unwanted reflections from the studio. We designed a method to dull the reflective material property while retaining a high geometric precision by using a structured light scanner with a camera recording the pattern deviation on the surface of an object to generate 3D geometry. While in photography, hairspray is used to take away the reflection, we used a combination of hairspray and gypsum powder to allow for the projected patterns from the structured light to be recognized by the camera. This in turn allowed the software to apply photogrammetry algorithm and ultimately created a 3D model of the glass objects (Fig. 6).

Following the resolution of the scanning issue, we added further geometrical complexity by increasing the number of glass volumes. However, when adding a third volume in the glass blowing process, the linear development from single cell mitosis collapsed on multiple levels. In biological terms, mitosis would not be able to occur with three cells involved on a regular basis. Similar to cancer, where certain cells are able to split into more than two daughter cells [16], the work started to enter the territory of mutation rather than that of evolution based on repetition. In terms of craftsmanship, the added third volume destabilized the overall form and making process. The object was not a rotational form anymore and was therefore off-centered. It had multiple axes and all craftsmanship processes became so difficult that up to six helpers were needed to do the transfer from a single blowpipe to two blowpipes. Testing how far this type of unnatural approach—in both the biological and craftsmanship terms—could be taken, we created an interconnected four-volume object. Highlighting this spatial complexity, the volumes were completely evacuated and filled with neon gas. The gas was ignited through electrical charge and subsequently the gas illuminated the shortest path with the least resistance through the volume and between the two electrical poles. As glass is electrically isolating, the shortest path led through the four volumes. At points of smaller diameter, the light was more intense due to the higher density of ionization and thus illumination (Fig. 7). This showed the most extreme state of mutation in the work series, but it lacked the formal and methodological amalgamation between scan, 3D print and glass.

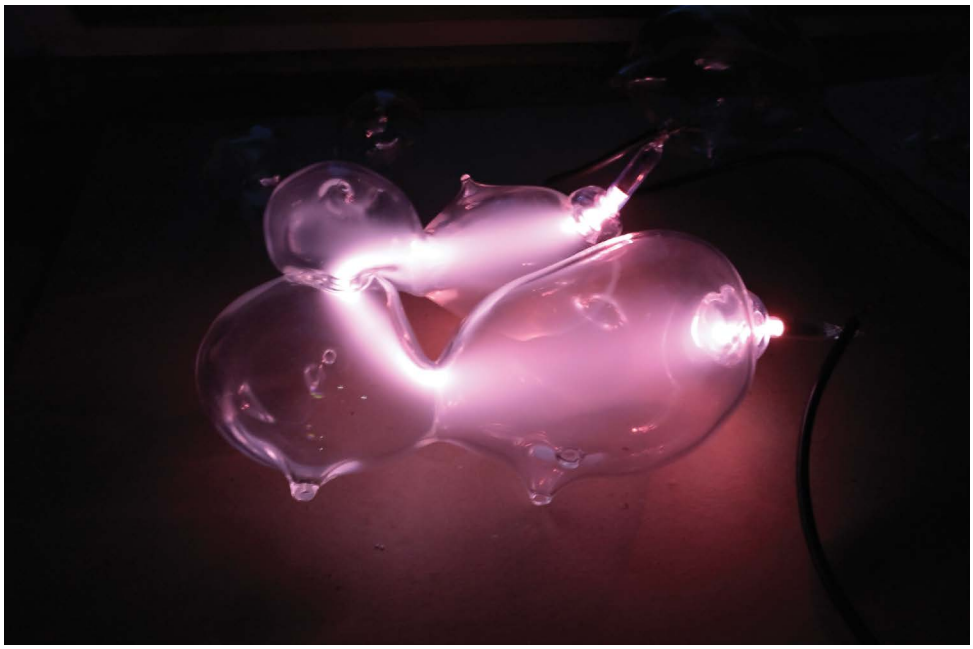

Fig. 7. Electrically charged neon gas illuminating an interconnected 4 volume glass cell, *Glass Mutations*. (© 2017 Tobias Klein)

As a consequence of working against the glass material behavior, we had several failures in the making. The forms were not controllable and broke off the blowpipe, fell in the furnace, fell during their transfer, or became too difficult to handle for a team of two glassblowers. In hindsight, these failures were unexpectedly fortunate learning experiences emerging from this project. They allowed us to rethink the relationship between 3D-printed and glass blown form.

Glass Mutations is not a work centered around the geometric complexity of glass and the imitation of the formal impossibilities of 3D printing. *Glass Mutations* is an amalgamate of glass volumes held in a larger organism-like construct through 3D-printed substrates. Differently from the augmentation experiment—*Augmented Fauna*—the new objects are not static and conclusive in themselves, but rather suspended in an arrangement that can only exist in a 3D-scanned state of sublimation. This work consists of the physical separation of the cellular glass volumes from one another and the 3D-printed form interacting with these single objects to form an ecosystem between the glass volumes. The elements are held together by digitally modeled, tendril-like structures, analogous to biological cell growth when forming multi-cellular higher-order organisms. When observed as a series (Fig. 8), *Glass Mutations* constitute a Biotope of craft, material and forms. Individually, they are comparable to the surface of cellular organisms like the radiolaria depicted by Ernst Haeckel [17].

Fig. 8. Two of the final works in the series, installed at the Industry Gallery in Los Angeles, U.S.A., *Glass Mutations*. (© 2017 Tobias Klein)

Conclusion

The process of fusion/synthesis outlined in *Glass Mutations* summarizes how "Sublimation"—the process of 3D scanning enabling the melding together of glass and the 3D prints—and "Reification"—which is the form of bringing the data back in 3D print—create complex life-form–like arrangements. In other words, whereas augmentation is a form of imitation, amalgamation is a process of inseparable fusion that, in the case of the series of pieces I created at Pilchuck Glass School, allowed me to articulate the notion of Digital Craftsmanship.

Acknowledgments

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Inhabitat: An Imaginary Ecosystem in a Children's Science Museum

Haru Hyunkyung Ji and Graham Wakefield

ABSTRACT

Inhabitat is a mixed-reality artwork in which participants become part of an imaginary ecology through three simultaneous perspectives of scale and agency; three distinct ways to see with other eyes. This imaginary world was exhibited at a children's science museum for five months, using an interactive projection-augmented sculpture, a large screen and speaker array, and a virtual reality head-mounted display. This paper documents the work's motivations and design contributions, along with accounts of visitors' playful engagements and reflections within the complex interconnectivity of an artificial nature.

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Inhabitat is a mixed-reality artwork of creative exploration within an alternate ecosystem of life-forms and a playful engagement with the complex interconnectivity of nature. It was exhibited at MOXI, The Wolf Museum of Exploration + Innovation, Santa Barbara, U.S.A., from August 2017 through January 2018. It follows in a series of *Artificial Nature* projects by the authors, in which the invitation is to become part of an alien ecosystem rich in feedback networks. *Inhabitat* was born out of a desire to bring biologically inspired complex systems into human-scale physical spaces while displacing the human from the center of the world [1].

Inhabitat is a single world that awaits active observation and playful engagement through three distinct perspectives of scale and agency—three ways to see with other eyes. At the macro-scale, the entire world is experienced as projection-mapped landscape of sand upon a hand-sculpted substrate that forms the centerpiece of the exhibit. Visitors may wander freely around the landscape observing the behaviors of the alien life-forms that inhabit it as they busily forage, metabolize, reproduce and emit sounds. A mediated meso-scale view of the world is projected onto the museum wall behind. By donning a virtual reality (VR) head-mounted display, visitors enter the world at the micro-scale.

The varieties of living and nonliving elements within this ecosystem are complex adaptive systems that form an interconnected food chain and web of relations. From the macro-perspective, moving creatures may seem to have the size of insects, while in the micro-perspective they stand as tall as we do. The VR perspective is naturally first-person, the large projection screen presents a third-person perspective as it follows one creature at a time, while the projection-mapped landscape affords a superpersonal perspective over the whole ecosystem (Fig. 1). It is important to us that the network of relations envelop the visitor through immersion and natural interaction to evoke involvement in an imaginary world, while the plurality of scales and perspectives is intended to encourage understanding of nature as a whole, through its diversity of organizations beyond and below human scales.

Over the exhibit duration of 142 days the museum estimates it received around 65,000 visitors. Just under half were under 13 years of age. The exhibit was continuously attended by one or more museum education staff who lent assistance and sometimes prompted questions to visitors. The education staff self-recorded commentaries, experiences and accounts of visitor interactions through an internal messaging system and kindly shared the collective results with us. We found that these recorded anecdotes breathe with the life of the work, and we are motivated to share these resonances and where they lead through this article.

Fig. 1. The *Inhabitat* installation at MOXI, The Wolf Museum of Exploration of Innovation, a children's science museum in Santa Barbara, CA, U.S.A, 10 August 2017–8 January 2018. Sand-sculpture augmented reality, head-mounted virtual reality, large-scale projection. (© 2018 Haru Hyunkyung Ji & Graham Wakefield)

Related Work

Several installations of the past decade have used simulated natures to playfully blur lines between virtual and real worlds, frequently using top-down imagery and physical topographies. Through camera and projector, Chris Sugrue's *Delicate Boundaries* (2007) allows animated bugs to crawl out of a computer screen and onto the human bodies that make contact with it [2]. In Everyware's *Oasis* (2008) populations of imaginary species on a tabletop screen flock within boundaries configured by visitors in black sand [3]. The widely exhibited *Augmented Reality Sandbox* is a university–science center collaboration that was developed primarily for educational purposes, but it does not sustain ecologies of flora and fauna [4]. In contrast, SEGA designed an interactive sandbox for arcades, sacrificing simulation for gratifying interaction [5]. Squidsoup created a series of child-focused projects in which virtual creatures roam over topographies of sand, wood, the gallery floor and children's bodies [6]. Creatures are almost the only functional element visualized, they are known species such as spiders, sharks and dinosaurs, and interactions with them are direct and with a predefined "god-like" narrative; whereas in *Inhabitat* creatures are less Earth-like and form parts of a larger ecosystem in which humans also have direct and indirect roles. *Efecto Mariposa* [7] comprises geosphere and biosphere (though no individual fauna are visible) and, like *Inhabitat,* is motivated to draw attention to an infinite dance of destruction and creation, and to invite perception of complexity over micro and macro scales. None of the above worlds were conjoined with parallel immersive displays.

System Description

Inhabitat's ecosystem comprises several layers of data, beginning with a lichen-like layer of vegetal biomass at the base of the food chain. Pulsating while it grows, the vegetation turns white when most prolific. Various creatures busily search for nutrients to metabolize, locating niches of survival within precarious evolutionary pressures defined in part by the topography of the land. Flocks of creatures graze on the vegetation, exposing the bare land beneath. Injured and dying creatures leave vermilion blood on the land, which social organisms collect and bring back to their hives, leaving pheromone trails to guide others

(while scavengers feed on the corpses). Predators descend from high altitudes to hunt any other organism they can find (Fig. 2).

The centerpiece was hand-sculpted from expanded polystyrene (EPS) blocks by hot wire cutting, sanding and aqua-resin coating. The child-safe sand upon it allows visitors to reshape the topography, and thus the adaptive conditions of the life inhabiting it: vegetation grows more abundantly at higher altitudes, while most creatures avoid steeper slopes [8] (Fig. 3).

The topography is measured through an above-mounted time-of-flight depth camera, which also detects the shapes and movements of human bodies in the space. Human and landscape features are distinguished in the depth image by spatiotemporal filtering: regions of higher spatial gradients and faster optical flow are assumed to be human rather than landscape. These features are then converted into height fields for rendering. The projection mapping onto the landscape depends on the accurate prior calibration of the depth camera and projectors, which also permits projection mapping onto humans in the interaction space. We duplicate the real shadows with virtual counterparts projected in black, thus minimizing light spillage onto visitors. Human geometries are also visible as wireframes on the large screen and in VR (Fig. 4).

More importantly, however, by computing where a visitor's shadow falls onto the landscape, we can give it a concrete impact within the simulation: the vegetation under their shadow is eradicated. They are literally a force of darkness, but like the passing of wildfire, life grows back more fertile as they move away. Optical flow is also used for interaction, so their moving geometry may lift and push creatures around the world. This becomes most sensitive as they reach down to touch the land: they may see organisms creep onto their hands, then they can carefully carry them elsewhere (Fig. 5).

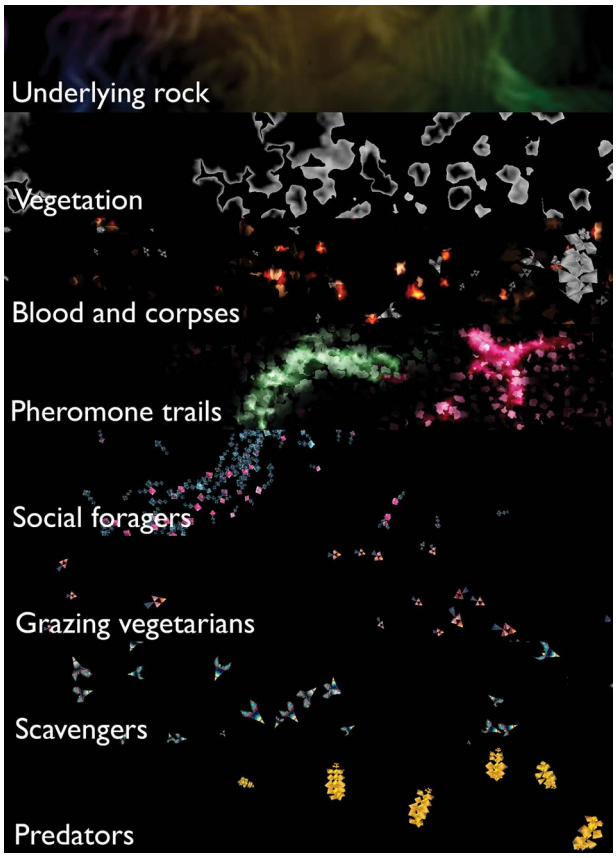

Fig. 2. How various components of the ecosystem are visually represented. (© 2018 Haru Hyunkyung Ji & Graham Wakefield)

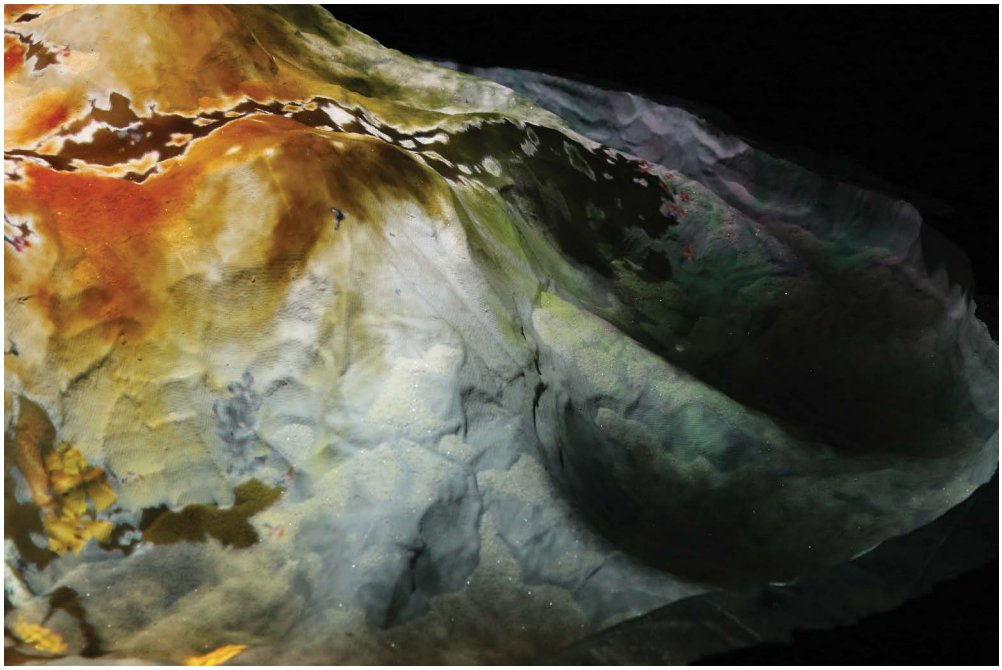

Fig. 3. The vegetation is darker in the lower valleys but grows more brightly and abundantly along ridgelines and peaks. (© 2018 Haru Hyunkyung Ji & Graham Wakefield)

VR

Visitors can view the ecosystem via a VR headset stationed nearby the sculpture. The VR perspective is located within the peaks and valleys of the mountainous landscape at 1:25 scale, such that visitors would be around 5 cm (2 in) tall relative to the sculpture. At this scale, immersants feel smaller and slower-moving than many of the creatures around them, while the

shadow geometries of other visitors appear to be 30-meter (100 ft) giants in the distant sky of the world, sometimes reaching over and down to the lands surrounding them. To prevent motion sickness, we did not incorporate any navigation. Landscape elevation changes are smoothed to suppress sensor noise and prevent disturbingly rapid updates within the VR view.

The VR viewpoint was very popular. An educator asked a visitor if she would like to try it after her children were exploring the sculpture for a while, and "fifteen minutes later . . . she laughed and giggled laying on the floor, crawling around exploring *Inhabitat* through the VR headset." We learned from our earlier exhibitions that VR headsets can be problematic in open galleries, inducing challenging queues for isolated experiences that limit other visitors' involvement. In contrast, with *Inhabitat* VR is one of a system of multiple perspectives, and not the most central. Moreover, the VR perspective is not disconnected: the simultaneous nature of the exhibit's perspectives led some visitors to more emergent playful behaviors. Educators noted guests around the sculpture asking, "where is the person who is wearing VR?" and conversing with the immersant to look for recognizable features or creatures to try to locate each other. One educator described how a particular group of visitors would hold still under the immersant's location on the sculpture long enough for the system to consider them another peak of the landscape, then quickly move away, causing the visitor with the VR headset to experience a kind of gentle sinkhole fall [9].

Fig. 4. Visitors seeing their geometry over the landscape with the shadow cast beneath. (© 2018 Haru Hyunkyung Ji & Graham Wakefield)

Children's Responses to an Alien Ecology

We have always drawn our inspiration from childhood experiences of playful wonder and the tension of the unfamiliar in nature. From our first exhibits we have felt that children have often been the deepest observers. Through conversations and recorded feedback with educators at the museum, we found more concrete grounds for why we have felt this way. Children by nature are more ready explorers of a world that is more alien than ours—especially of a world without language. Where the words are yet lacking to ascribe to the world, participation, observation and inquisitive storytelling become stronger forces. An educator noted that many older parents "were quick to say that it was 'too advanced' for their children, but their children didn't seem to notice." Within a younger 3–7 age group, "they like to make up entire stories about what's going on with each character. They start to get invested in their own imaginary world and spend much longer on the exhibit." We received multiple accounts of children staying with the exhibit for several hours, and often returning.

Another educator found that "the younger kids were much more open to being imaginative about the creatures and their activities, willing to make observations without fear of being 'wrong.'" Some of the older children actively questioned narratives given to them: "A boy's dad told him that the pink creatures were eating the yellow ones, which I knew wasn't accurate, but I was curious if he would figure it out on

his own. . . . Although he initially believed what his dad said, he still observed the mountain to figure out how the creatures were actually interacting and eventually came to the conclusion that it was different than he was first told."

Several times we overheard adults voicing uncertainty about explaining to younger children how some of the creatures feed on the corpses or blood deposits of others, and how some actively hunt. Nevertheless, those children had no difficulty in talking naturally about birth and death without shame or association with violence. One educator mentioned that it was refreshing to see children freely discussing concepts that are sometimes difficult to approach in contemporary life.

Despite the alien character of the world, visitors reflected the experience back to the world we know. "Discussions around 'the digital world' and what it means to be alive were also a common theme." Educators reported that "a lot of discussion was brought up around climate change" with "a lot of conversations about conservation." In December, the exhibit coincided with the largest wildfire in modern California history; clearly visible from the museum. Educators reported that "after the Thomas Fire, there was some reflection on 'regrowth' after destruction," such as a group playing with their digital shadows and watching the cellular automata regrow, commenting on "how that might be what it is like to watch a forest fire wipe out a mountainside."

Conclusion

We have described an exhibition of *Inhabitat*, an alternate-world ecosystem of interconnected components, focusing on how elements of its design allow visitors to experience otherness through three simultaneous perspectives. Accounts of responses, especially among younger visitors, show how participants create their own narratives and perspectives, linking and blurring between virtual and physical natures.

However, responses have also revealed some of the competing requirements we navigated in its design. In particular, while as artist-researchers we are committed toward generative complexity in the poised balance and independent evolution of an ecosystem, as designers of a long-term museum exhibit, we had to frame the installation with provisions of stability and longevity in its basic parameters such that the experience can be reasonably consistent at any moment visitors may enter. For example, populations of each species were given upper bounds to ensure that the overall system performance could never degrade, and though populations could dwindle to zero, this was never a permanent extinction—new individuals would gradually appear to return balance to the exhibit. Visitors discovered these constraints: "I had a group of kids come in the other day trying to make the predators go extinct. . . . It would be awesome

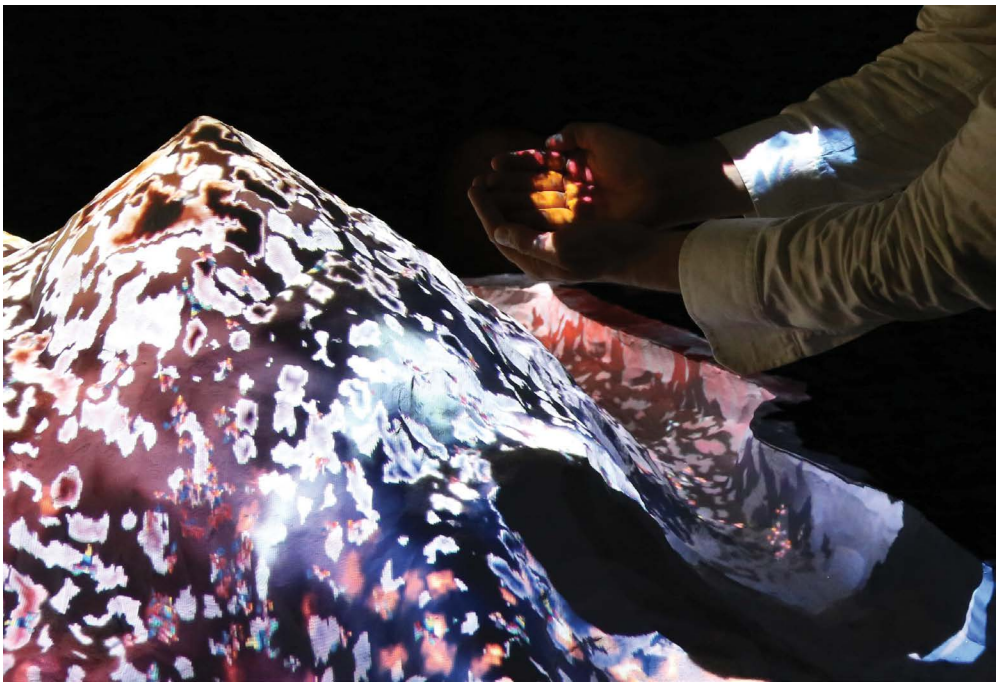

Fig. 5. Several organisms being carried by the hands they crawled onto, while vegetation is being destroyed by the shadow beneath. (© 2018 Haru Hyunkyung Ji & Graham Wakefield)

if the interactions guests had really could influence the overall balance of the ecosystem—it seemed like no matter what, it would come back into balance and remove the connection to the real environment." This is a crucial question for our continuing research.

Acknowledgments

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7. Patricio González Vivo, *Efecto Mariposa* (2012): <https://vimeo.com/32321634> (accessed January 2018).
8. Although the sand was chosen as the safest product available, some museum staff raised concerns about dust visible in the projections, and most of the sand was later removed, limiting this interaction.
9. Emergent play across huge scale differences recalls Rafael Lozano-Hemmer's *Sandbox* (2010): <www.lozano-hemmer.com/sandbox.php> (accessed January 2018).

Cop to Conductor: Negotiating and Remapping Meaning in Existing Public Art

Todd Berreth

ABSTRACT

There is a crisis in our communities about the tributes to a shared civic life represented in existing public artwork and monuments. Culture wars are being waged herein and appear increasingly unreconcilable. This paper discusses this moment and describes the range of strategies artists and designers have used to remediate these works. It presents a project description of an interactive artwork that suggests innovative approaches in this realm. The author introduces a conceptual model which served as inspiration for the piece that may be useful when discussing and designing such interventions.

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Background

There is a crisis of public perception in our communities, about the material tributes to a shared civic and cultural life, its heroes and their narratives. Historian Paul Farber, director of the Monument Lab, notes that "monuments are always products of their time (and) always reflections of power" [1]. Considering the shifts in political and cultural power across all strata of the United States in the twentieth and early 21st centuries, it's no surprise that the monuments of past generations no longer have a presumed sanctity and inviolability, faced with diverse populations of growing agency, who now question the legacies and forces that kept them down, and any perceived "false idols."

We are reminded of this fact with the flashpoint attention being given to civic artifacts in the Southern United States in 2017, referring of course to the monuments of the region's Confederate and Civil War past, statuary and the like. In the moments before and after contentious episodes in Charlottesville, Virginia [2], and Durham, North Carolina [3] (Fig. 1), among others, activists demanded a range of responses regarding these works, on a spectrum from destroying them to leaving them untouched, to a multitude of interventions in between. This phenomenon is certainly not limited to the South (or the United States).

Fig. 1. Charlottesville and Durham Confederate statues. (Photos left © 2017 Reuters/Justin Ide; right © 2017 Kate Medley.)

Currently, New York City has numerous existing public memorials and artworks under reevaluation. Some of these are nearly universally condemned; a bronze depicting J. Marion Sims, the "father of modern gynecology" (who barbarically practiced on unanesthetized black female slaves) was relocated without protest [4]. Others are more contentious and have diverse groups of antagonists. What to do with the form of Christopher Columbus, who presides over Columbus Circle, a cultural icon who once led a wave of systematic racial genocide? Former president Theodore Roosevelt is memorialized astride a horse at the entrance of the American Museum of Natural History. At his heels and walking, are an African American and Native American—to some, representing white-supremacist imagery and unjust social hierarchies [5].

Such examples of community re-appraisal and conflict, where changing dynamics force a "coming to terms" with symbols of a factious history, is nothing new. What is unique is the technological and media landscapes we live in, where citizens' thought-space increasingly exists in digitally mediated spheres, and people live in their own virtual realities, disconnected and alienated from a diversity of neighbors. It hints at an overall decrease of social capital in American culture, a phenomenon described by Robert Putnam in his book *Bowling Alone*, where "the fabric of our connections with each other, has plummeted" [6]. There is no doubt that as we collective re-approach existing public artworks, literally or figuratively, we often arrive there from separate places, foreigners to each other, seeing differing things and speaking different languages.

Motivation

In this environment, it is difficult to negotiate a path forward. What are we to do as artists? Is there any chance to participate in this effort and perhaps design interventions that might build bridging languages, help generate a productive and respectful public exchange, provide insights, and ultimately be healing?

I approach this question as a computational artist, where the medium we work with is rarely as weighty or enduring as bronze or stone. The digital medium has its strengths, one of its most useful being its ability to remap meaning, through the superimposition or juxtaposition of media artifacts. Can we build new visions that trace a future geologic change in culture, aspire to transform the aggregate community's view of the contested artifact, and suggest a constructive mutual future?

Spectrum of Interventions

We should ask ourselves: Does an existing public artwork continue to serve a useful purpose, can it be redeemed and made relevant (if it needs to) or should it be dismantled? It is helpful to look at a few precedents, to discuss the continuum of responses.

At one extreme is an intervention that is not artful, except arguably in the performative sense—that of civil disobedience, resulting in the destruction of the contested artifact. The earlier mentioned action in Durham is an example. Here activists chose not to pursue legal remediation of their grievances, but instead transgressed to make an aggressive unilateral political statement (pulling the statue down). The result is noted by the void left by the disputed work. In some cases, it can be argued that the void is ultimately a positive and healing thing.

The next category involves relocating of the work, spatial recontextualization. An important project in this vein is designer Ákos Eleőd's *Memento Park* in Budapest, Hungary. Monuments from Hungary's Communist era (1949–1989), Lenin, Marx and others, are moved from their original locations and resited together as an interpretive experience (Fig. 2). The repositioning depowers the original artifacts by segregating them into a more powerful interpretive space, attempting to overwhelm whatever influence the original piece sustains [7].

Other approaches address these works in situ. Some of these involve clandestine or unauthorized interventions—defacing the object, staging protests, mapping other associations onto the artifact and site. The J. Marion Sims statue attracted activists and performance artists, reenacting gruesome tableaus that highlighted disturbing histories. The Theodore Roosevelt statue was vandalized and coated with fake blood. The artistic collective The Illuminator has worked with guerrilla projections, staging protest interventions to sometimes illicitly intervene on a diversity of issues and landmarks, including NSA whistleblowing exploits (Fig. 3) and the Occupy Wall Street Movement [8].

Fig. 2. *Memento Park*. (Photo © 2003 Szoborpark. CC-BY 2.0 license.)

There are numerous efforts that instead cooperatively worked with community leaders and monument stewards. One seminal example is Krzysztof Wodiczko's *Bunker Hill Project*, staged in 1998. Here Wodiczko collected stories and imagery, illuminating a decades-long epidemic of unsolved murders and police/community dysfunction that occurred in Charlestown, Massachusetts. He then projected these narratives onto the Bunker Hill Monument, a famous 221-ft obelisk in the city (Fig. 4). As the artist explained, "We should be able to call these monuments into question, to ask them what they think about what is happening today and ask ourselves if we still believe in the ideals of these monuments. We should even be able to shock and astonish these monuments" [9].

In these examples, we might examine the net benefit of the intervention. Does it create a space for dialogue, inject meaningful contexts, allow the participation of missing voices, defuse tensions and ultimately bridge the distance between disaffected parties? The validity of any of these aspirations is up for debate, depending on the circumstances and artifact. That said, any approach that unilaterally asserts power, without space for mutual respect, a shared history or the potential for dialogue, risks exacerbating whatever conflict is at play.

Fig. 3. The Illuminator, *Edward Snowden Intervention*. (© 2015 Kyle Depew)

Project

I recently completed a work with two collaborators, Patrick Fitzgerald and Emil Polyak, that involved an intervention with an existing public sculpture. While the site in question is not actively contested, there are enough parallels to much of the previous discussion that the work might be a useful example.

Fig. 4. Krzysztof Wodiczko, *Bunker Hill Project*. (© 1998 Krzysztof Wodiczko)

The location of the project was Richmond, Virginia. The context was a curated one-night light-art festival hosted in the city's downtown in November 2017. Our chosen site was the side of the Richmond Police Headquarters Building. Featured on a gray exterior wall is an existing monumental sculpture of a police officer's head, created by artist Michael Stutz in 2005, titled *A Thin Blue Line* (Fig. 5). We proposed transforming the figure into a train conductor, through projection mapping, and surrounding the head with an interactive pachinko game and other generated digital media. The piece would be titled

Fig. 5. Michael Stutz, *A Thin Blue Line*, 2005. (Photo © 2017 Google)

"Mr. Conductor," a playful reference both to the beloved Thomas the Tank Engine children's television character and to electricity, connecting the piece to Richmond's history as a regional leader in the rail and electrical production industry. With some assurances and negotiation, the police department and festival approved the piece.

Consider, for a moment, Richmond's other histories. The city was the short-lived capital of the Confederacy during the Civil War. The contested statue of General Robert E. Lee in Charlottesville was largely paid for by the Sons of Confederate Veterans, an organization established here in 1896 and still existent. Like other southern cities, Charlottesville has a long history of Jim Crow–era injustices and continues to be relatively racially segregated.

One can't help but wonder what a diversity of communities sees in the *A Thin Blue Line* sculpture. It is at turns evocative and beautiful, yet also looms over the street with vacant eyes, a vaguely menacing and fascist-looking figure. The idea of "a thin blue line" imagines the police as a fiercely loyal brotherhood, the symbolic boundary between order and anarchy, and the protector of the people against victimization. Considering that the police traditionally enforce prevailing power structures, it's likely that historically marginalized communities approach this figure warily, remembering painful legacies. The opportunity for intervention here was irresistible, if only to alter, mediate and soften this image.

Pachinko is a gambling game, and the tension between chance and fate, and (unreasonable) hope confronting a rigged system, is implicit. Visitors propelled a ball into the works, which was eventually funneled one of two places, either into the head of the conductor or through gates, which triggered graphics and video loops seen at street level. The imagery represented the range of railroading history in the South—the manufacturing process, commercials of 1950s white passengers served by black porters, trains' mechanisms, black Gandy Dancer work crews laying track (sometimes forced labor), railroad tycoons, segregated rail cars and so forth, presenting the true gamut of the era (Fig. 6). Once the conductor's head filled up with balls, it then dumped them onto the street, exclaiming "All Aboard!" with a paired train whistle. A soundtrack cycled through a range of train songs and related African-American spirituals.

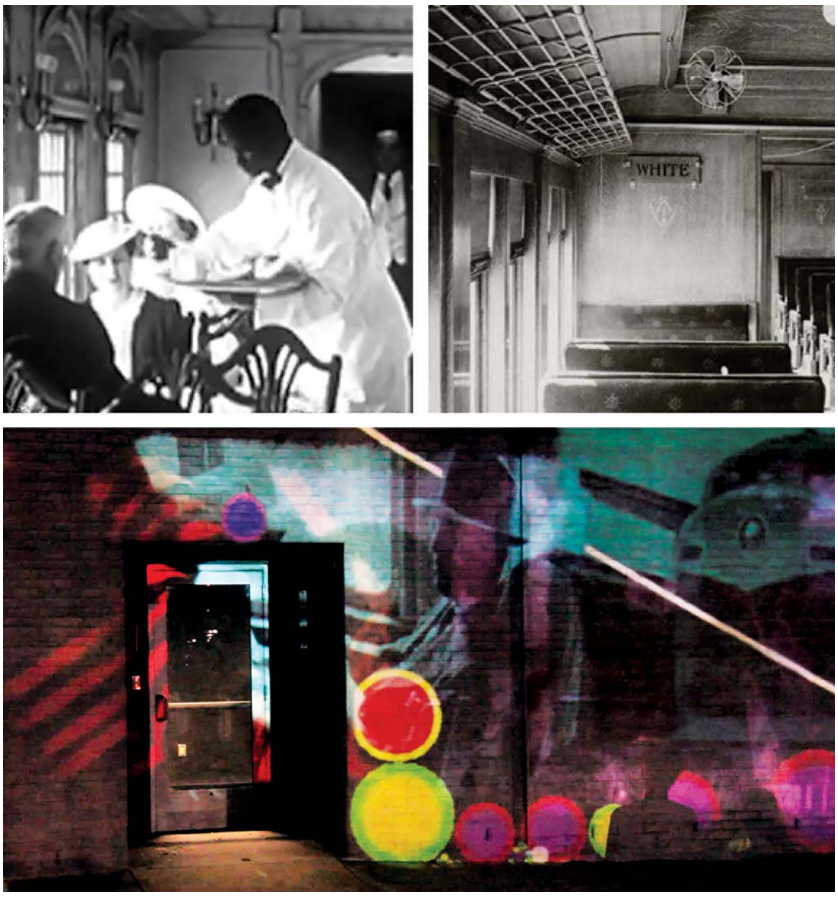

Fig. 6. Railroad media and generative collage. (Top © Smithsonian, public domain. Bottom © 2017 BFP.)

The work is a computational generative system, where interactivity, curated algorithms and media meet with intrinsic randomness and happenstance. The meaning of the piece arises emergently, through the visitor's interaction with the entire system—the existing/altered sculpture, the interactive pachinko game, the video imagery and soundtrack, and the unpredictable frame of reference each viewer brings to the experience (Fig. 7).

Fig. 7. Todd Berreth, Pat Fitzgerald and Emil Polyak, *Mr. Conductor*, 2017. (© 2017 BFP)

Nearly everyone loves trains and carnival games (at least as a child), so a breadth of community could approach the work with a sense of interest, nostalgia and even wonder. It was playful and whimsical, and encouraged visitors to drop their guard.

The piece didn't present an explicit indictment, was open to alternate readings, and created a common space for engagement, emergent storytelling and dialogue, where a multitude of parties could approach the same artifacts and ponder a shared history. What we expected was that the context (the police building and sculpture) were part of the dynamic of the piece. The image of the police officer or railroad conductor would at turns assert itself, influencing the viewer's reading of the work.

Cop to Conductor

I sketched a conceptual model for myself which began to articulate a range of design responses to contested public artworks—this served as an artistic inspiration in the piece's evolution. We might imagine the polar conditions of a continuum of intervention strategies, considering how any art piece addresses questions of power. I'll term these *cop* and *conductor* modes.

I use the terms "cop" and "conductor" in the most inclusive (including multiple meanings) and non-pejorative sense. *Cop* would include the noun definition *police officer* and *law enforcer*, as well as the verb definition, *to catch or arrest* and *to strike (an attitude or pose)* ("I copped an attitude, acted tough"). Likewise, *conductor* would include a *train agent*, an *electrical conduit*, a *facilitator on a mutual journey*, and a *musical conductor*.

This dichotomy is interesting, as it forces a mapping of behavior that doesn't mirror existing preconceptions of action (reactionary/progressive). Any response to a contested artifact or situation, regardless of political persuasion, will approach the questions of power on this continuum.

Cop modes tends toward overt expressions of unilateral power, black and white thinking, opposition (us versus them, "a thin blue line") and aggressive reactions to perceived offenses. Conductor modes try to divert oppositional power into mutual constructive avenues, search for common ground ("all aboard") and build bridges. Interesting analogues of this polarity abound—impede/facilitate, enforce/persuade, intimidate/reassure, dissipate power (a resistor)/carry and route power (a conductor), and others.

Both modes are used to a greater or lesser extent in all the interventions discussed, and the effectiveness of each strategy is worth studying. I would argue that when addressing sites that are heavily contested, emotionally charged and have painful legacies, it's not always constructive or effective to be a cop. We should be looking for more opportunities to be conductors—to design interventions that allow oppositional communities to look at the same thing and, if only for a moment, drop their guard and start a dialogue.

There were a breadth of reactions to our artwork, but the most consistent, heard from both police representatives and a diversity of local residents, focused on the alteration of the police image—first, that is was wonderful to transform a stolid (and menacing) figure into a delightful one, and more unexpectedly, that both the police department and the community began to see the police as participating in, and not just policing, the festival. Such altered perceptions and coming together (if for a night), and the potential they represent, instill anticipation for other positive exchanges—this seems a promising and hopeful path forward.

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Diastrophisms: Visual and Sound Assembly in Remembrance of an Earthquake

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ABSTRACT

Diastrophisms is a sound installation with a modular system that sends images through rhythmic patterns. It is built on a set of debris from the Alto Río building that was destroyed by the 27F earthquake in 2010 in Chile. *Diastrophisms* explores poetical, critical and political crossings between technology and matter in order to raise questions about the relationship between human beings and nature, to consider the construction of memory in a community by questioning the notion of monument, and to imagine new forms of communication in times of crisis.

KEYWORDS

Sound, matter, material, immaterial, earthquake, memory, communication, transduction

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Diastrophism: a set of processes and geological phenomena of deformation, alteration and dislocation of the earth's crust due to the effect of internal tectonic forces.

Yasushi Sakai (Japan), Nicole L'Huillier (Chile) and Thomas Sánchez Lengeling (Mexico) are the creators of *Diastrophisms*, an installation curated by Valentina Montero (Chile), presented in Chile at the 13th Media Arts Biennial (BAM) in Santiago in 2017; the theme for the biennial was the word *tremor*. The nationalities of these artists are relevant. Japan, Chile and Mexico are distant countries marked by a similar seismic history. In the last decade, their cities have withstood massive earthquakes with the highest intensities recorded in human history.

The 13th BAM invited different creators to reflect on the "tremor" concept, which helps us to describe not only tectonic movements but also psychic or emotional states that are characteristic of moments of crisis on a personal and collective level. Although Japan, Mexico and Chile have experienced several

Fig. 1. Alto Rio building after earthquake 27F, Concepción, Chile, 2010. (© and Photo: Juan Carlos Briede)

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intense earthquakes, contemporary art has not sufficiently addressed this phenomenon as a subject matter. Beyond the illustration of these events, the curatorship was interested in "tremor" as a broader concept. The telluric quality of the territory—especially in Latin America—has also determined its identity both as individuals and as a nation. The seismic condition has become an extension, a feature that reflects the instability of institutions, the fragility of political projects and at the same time the way in which, at a psycho-social level, an attitude of resistance has been built in relation to drastic changes—for better and worse. The tremor or earthquake shifts from a geological event or an intimate accident into a metaphor for a state of being, where an imminent collapse conditions a shifting, nervous and expectant present.

Fig. 2. Detail of devices actuating the debris, Centro Nacional de Arte Contemporáneo Cerrillos, Chile, 2017. (© and Photo: Yasushi Sakai)

On this basis, Montero's curatorship embraced Sakai, L'Huillier and Sánchez Lengeling's proposal, which aimed at the articulation of technological, material and emotional aspects in an experimental artwork. *Diastrophisms* is a sound installation with a modular system that sends images through rhythmic patterns. It is built on a set of debris from the Alto Río building that was destroyed by the 27F earthquake in 2010 in Chile (Fig. 1). This piece is nourished by a transfer of what is material into immaterial, and vice versa. The operation of this work consists of an image turned into sounds, and then those sounds creating a new image. The original image contains the memory of the earthquake represented in a fragment of the former Alto Río building. In turn, debris from that building physically operates as material support, which, when being struck, opens up a new cycle of value for that material (Fig. 2).

Matter, Technology and Networked Affection

One of the challenges posed by artistic practices combining science and technology in their experimental proposals lies, according to the Actor Network Theory (ANT), in recognizing or revealing what can be described as the implicit socio-technical assemblage in our relationship with the world [1]. Based on this perspective, ANT seeks to make visible the material and semiotic relationships between a cross-linked organization of technology, humans and non-humans (other living beings, matter, etc.). When we recognize our interactions with nature manifested in operations of dominance, resistance or passivity, we forget that humans are in turn a part of nature and as such we are imbued in a dialectical and fluctuating relationship that does not distinguish dichotomies, thus making the physical, material, poetic, affective and imaginary dimension indiscernible.

Post-humanist and neo-materialistic approaches introduced by Barad [2] and Dolphijn and Tuin [3] present conceptual frameworks that enable us to assess the interaction between human and non-human elements affecting the flow of life. In *Diastrophisms*, debris, circuits, monitors, energy, memory and history

are intertwined to recall a specific episode of the past and at the same time to imagine a communication system that could be useful in times of catastrophe.

Following DeLanda [4], we see the debris of the Alto Rio building, a common silent witness of social catastrophes, as evidence of a cyclical evolution: its history begins as an amalgam of minerals from the earth: flows of iron, limestone, water, gravel, sand that are then transformed by labor, cranes, electricity, speeches, economic indicators, desires, contracts and signed papers into the walls of a building that contains human biomass in a city; then the building is destroyed and fragmented into pieces and its components are returned to the ground, becoming silent again in a cemetery; afterwards, it is unearthed, re-organized, and it becomes an artifact, a monument, a container of the memory of an event.

The relationship of matter and sound becomes intertwined into a single unit. This exchange is fundamental to understand the function of *Diastrophisms* as an installation of several dimensions, spaces and temporalities.

On Memory

Diastrophisms, can also be described as a device for memory. In recent decades, contemporary artists have been concerned with archive and memory as subject matter. In most ancient cultures the transmission of events found its way into oral tradition. As Le Goff [5] points out, in modernity the document acquires greater prominence as the main source of knowledge, opposed to a memory of the community (ethnic or religious) manifested above all in rites or ceremonies. It is then that a clear distinction emerges between memory and history [6]. Memory would be embodied in the collective, therefore it is changeable; it oscillates between memory and amnesia. With the massive use of technological means of capturing information—from analogue to digital—the relationship between representation and memory becomes more convulsive. We imagine that the past is present and available. We assume that image and sound are traces, but behind the sonorous or visual signs that our technological devices can store, there is a hidden field outside, a whisper or a spectrum that keeps on circulating among people and that seems to need rites and the community in order to become activated. Between the massive inventory of images and sounds of the past circulating in a digitalized society, and the institutions that claim to be the new custodians of the memory of peoples, the field of art can offer alternatives for reflection that bring us closer to more subjective aspects, enabling us to think from other points of view. This is one of the main objectives of *Diastrophisms*.

Fig. 3. Digging Alto Rio's debris from debris cemetery, Penco, Chile, 2017. (© Fundación Proyecta Memoria. Photo: Gino Venegas.)

Heritage management is characterized by the protection of buildings, territories to which a historical value is attributed in its conservation. The artists established collaboration with Proyecta Memoria Foundation (Chile), which is committed to the recovery and recycling of debris resulting from natural catastrophes. The rubble becomes evidence and at the same time a symbol of a part of our history.

Proyecta Memoria managed the possibility of accessing the debris, which lay in a landfill (or debris cemetery) belonging to the Dibam (Chilean Directorate of Libraries, Archives and Museums) in Penco, in the south of Chile. A team was organized with local volunteers to go

to the site and unearth the fragments of the former building, which was now underground (Fig. 3). They located the pieces, dug them up, cleaned them and sent them in a truck to the Cerrillos National Center for Contemporary Art in Santiago, Chile. The disinterment was very moving as most of the team members were inhabitants of Concepción and had lived through the earthquake. After years, pieces from the Alto Rio Building were emerging from the earth full of memory and testimonies.

Sound as Memory

At dawn on 27 February 2010 in Concepción, after the Alto Río building collapsed, splitting in two, many people became trapped. As mentioned to the press by one of the inhabitants of an apartment who managed to get out alive: "Most people banged on the walls with their hands and made noises in order to communicate themselves." Percussion surfaced once again as the first system of innate communication. Before word, before image, it is vibration, sound—a vital energy translated into blows—that builds a rhythm, a code emerging as a communication system.

Fig. 4. Arrangement 1, outdoor installation at the entrance of the exhibition, Centro Nacional de Arte Contemporáneo Cerrillos, Chile, 2017. (© and Photo: Yasushi Sakai)

Diastrophisms recovers this primal energy. On the debris we placed devices that struck the material producing a rhythmic pattern. The arrangement of the modules in different densities of debris provided acoustic variations and different resonances (Fig. 4). The devices communicate with each other; they listen and repeat the percussive message. Each rhythmic pattern transmits a sound pixel, and after several sequences an image begins to appear as a result, creating an action of cyclic transduction. Here we see the full cycle: raw matter begins in the earth, becomes a building, then returns to the earth, where it is found as debris, which vibrates again, revealing the memory impregnated therein.

Communication Methods for Times of Crisis

Diastrophisms operates as a memory register, but also as a communication system. It presents a rhythmic syntax, using sound as a tool for communication and organization. We created a custom protocol that enables the devices to communicate with each other by generating acoustic information based on an input (image) and by listening to sonic information from its surroundings. The input is a digital image encoded in binary data and transformed into rhythmic patterns. Devices communicate and transmit these rhythmic patterns pixel by pixel by means of percussive strikes on the surface of the debris. In turn, human interference can modify the sound pattern and affect the output image.

Eschewing conventional systems based on hierarchical structures of power and governance, this system could be thought of as an autonomous and independent alternative for communities. Its structure has the ability to hide messages/images from existing surveillance systems, thereby guaranteeing cross-sectional communication and the avoidance of censorship. On the other hand, these devices communicate exclusively through sound, generating a stable and self-sustaining "offline" system, offering an alternative and independent communication protocol. This enables the system to remain standing and functioning if conventional communication networks were to collapse, deteriorate, expire, be forgotten or cease to exist.

Fig. 5. Arrangement 2, indoor installation, Centro Nacional de Arte Contemporáneo Cerrillos, Chile, 2017. (© and Photo: Yasushi Sakai)

Each device is composed of a custom-made circuit board with an ATmega328 microcontroller that picks up the input signals through an Electret microphone (100Hz–10kHz) with a 60x mic preamplifier to be processed as an output rhythmic message via a mini push-pull 9V solenoid that actuates the debris. The microphones have an extension cable so they can be placed next to the neighbor debris and pick up its sounds. The software layer of this protocol is designed to send gray scale pixels (or a byte) for each transmission. One can observe the variations on the data transmitted by looking at the displays attached to both ends of the installation (Fig. 5). The end result is archived on a remote server. Each data transmission also contains a header that declares the start of a message, which contributes to the rhythmic sounds.

Diastrophisms was installed at a location that functioned both as a space of work/construction and exhibition. Although the installation could be obscure or cryptic to viewers at a first glance, this mysterious appearance opened up an interactive scenario that encouraged visitors to be curious and to engage with the piece. The curatorial text helped people remember and understand the complexity that embraced the earthquake of 27F. The audience rapidly engaged with the piece by talking, screaming, tapping and making noise near the devices. They were stimulated by the piece and wanted to interact, to be part of it, to be part of the interference and disruption of the image.

Conclusions

Diastrophisms can be considered an exercise in which subjectivity, technology and materiality are articulated in order to demonstrate the transformation dynamics implied in the physical and social world. It enables us to observe from new epistemological perspectives (new materialism, ANT, post-humanism) the traces of a given material and cultural history, activating our collective memory. Additionally, it opens the way for imagining new communication protocols for future times.

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Holojam in Wonderland: Immersive Mixed Reality Theater

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ABSTRACT

Holojam in Wonderland is a prototype of a new type of performance activity, "Immersive Mixed Reality Theater" (IMRT). With unique and novel properties possessed by neither cinema nor traditional theater, IMRT promises exciting new expressive possibilities for multi-user, participatory, immersive digital narratives. The authors describe the piece, the technology used to create it and some of the key aesthetic choices and takeaways.

Virtual, augmented and mixed reality provide a new toolbox for creating a broad range of experiences, including new forms of expressive works. Many artists are exploring the potential of virtual reality (VR) as a narrative medium and for its ability to foster deeper engagement with characters and stories. Narrative VR has much in common with theater, using the three-dimensional space around the viewer and multiple sensory modes to tell the story. What has been missing until recently is the ability to share the experience with others in real time. By investigating the affordances of virtual reality for multi-user, live, immersive performance, we have developed the concept of a new type of performance activity, which we call "Immersive Mixed Reality Theater" (IMRT). To explore the aesthetics of IMRT we created a seven-minute piece, *Holojam in Wonderland*, inspired by *Alice in Wonderland*, in which two performers and four audience members share a magical journey to Wonderland and back.

Background

The term "mixed reality" (MR) was coined to refer to a "subclass of VR related technologies that involve the merging of real and virtual worlds" [1]. Microsoft proposes that MR spans the entire spectrum from physical reality to "digital reality," placing VR at the "immersive" end of that spectrum [2]. IMRT combines 3D, 6DOF VR imagery with real people and objects physically present in the space around the viewer. Thus, a participant may see a virtual table which is also physically present and touchable. Similarly, they will see another person as an animated avatar in the virtual world and both hear their real voice and sense their actual touch. The result is an immersive sensory experience combining virtual imagery with physical presence.

This approach allows us to intermingle live performers with the audience. There have been other narrative productions which do this with only one performer and audience member, such as *Draw Me Close* (National Theater of Great Britain and the National Film Board of Canada, 2017) and *Jack: Part One* (Mathias Chelebourg and Baobab Studios, 2018), and there are game-like experiences where multiple players can navigate a VR space together and participate in an interactive adventure (cf. productions by The Void). In contrast to these, our goal was to create a narrative piece with multiple performers and audiences, expanding the kinds of stories that can be told and the number of people that can experience them simultaneously. The present limitations on scale are the size of the area in which participants can be tracked and the bandwidth required for transmitting tracking data: both restrictions that will relax as the technology evolves.

IMRT is a form of immersive theater in which the audience experience is central to the work [3]. The current popularity of participatory immersive performance pieces like PunchDrunk's *Sleep No More* (2011) coincides with easier access to virtual reality technologies, the generalization of digital games as an entertainment activity and the growth of escape room activities, all resulting in audiences being more accustomed to the idea of becoming participants in the stories that are told to them.

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The use of virtual reality technology enables us to do things that cannot be done in physical theatrical spaces. Our project explores the new affordances provided by this technology to enhance the capabilities of theatrical storytellers and pushes on content and technology simultaneously. Although this is a difficult challenge, we believe it is the most effective way to advance a new artistic medium.

Content and User Experience

Holojam in Wonderland is a linear narrative with clearly defined story beats, and audience interaction does not influence how the story progresses. But the audience members are not mere spectators: they are given roles in the story world as Alice's friends. Alice addresses the audience directly, sharing her emotional state with them and inciting them to participate at various points. Alice is both a virtual avatar and a living actor right there beside them (Fig. 1). The performance is a live interaction between real people, and the actress can improvise based on how the audience responds.

At the start of the show, the audience enters a black box performance space containing a few set pieces suggestive of a Victorian drawing room. As they put on their headsets, they find themselves in a fully realized version of the room, with virtual representations of the real-world set pieces in the same locations.

Audience members are represented by avatars of butterflies in the virtual space; their position in the virtual room corresponds to their position in the theater. When the actor playing Alice dons a headset and controllers and begins speaking, the audience sees her avatar appear in the virtual space and she begins walking among them.

Alice adopts the audience as playmates and carries them to a forest glade where the rules of physics don't quite apply. They encounter the White Rabbit (another actor), and are magically shrunk to a tiny

Fig. 1. Actors Lulu Ward and Brian Alford perform as an audience member looks on. Behind is the minimalist physical set; these pieces were represented in the same positions in the VR world, while the rest of the room was filled in around them. (Production © NYU Future Reality Lab, 2017. Photo: © Juan Pablo Sarmiento, 2017. Props curated by Carol Silverman.)

size where mushrooms tower over them and a songbird threatens to eat them (Fig. 2). Alice enlists the audience to attract the now-huge Rabbit's attention as his voice booms overhead. The Rabbit restores everyone to their normal size and returns them to the drawing room where they began. Docents then help the audience out of their headsets and escort them out of the performance space.

The Technology

Multi-user, co-located VR experiences require accurate spatial tracking of all participants: everyone must be represented in the correct location in the VR world so people don't collide. We accomplished this using the Holojam platform [4], a software stack designed to integrate data from a motion tracking system into a multi-user VR application built in Unity. Holojam supports various VR headsets and motion capture systems, including OptiTrack (multiple IR cameras) and the HTC Vive trackers and base stations. The guiding principle has been to combine the features of current hardware platforms to prototype the kinds of experiences and interactions we will want to build using future technology.

Another principle of the Holojam project has been to develop a system that is cost-effective, using consumer grade hardware, so that this type of experience can be accessible to a wider range of artists and technologists. For this piece, we used the Samsung Gear VR headset, combined with HTC Vive trackers and controllers. One tracker was attached to each Gear VR HMD, to provide accurate positioning in space. The performers each held two controllers and wore a tracker at their waist and on each foot, allowing them to control fully expressive full-body avatars.

Holojam shares the tracking data for all the players plus shared virtual objects through a local wifi network. The software also performs sensor fusion between the Gear VR's IMU and the position and orientation data for the Vive Tracker attached to the HMD, to provide very accurate and responsive room-scale tracking for the players (Fig. 3).

The VR experience was built in the Unity game engine. Our technical director also built a means for live show control, running a version of the project on a desktop computer and using keyboard input to send show cues to the Unity game clients on the HMDs.

Fig. 2. A magical transformation as Alice and the audience shrink. (Scenic and character design: © Kris Layng, 2017)

Design Process

VR still has a strong novelty appeal, which helps attract an audience, but that is not a sufficient reason to use it to tell a story. We sought to demonstrate not just how to use VR for a theatrical experience, but why to do so. What sorts of stories would benefit from being told in virtual reality?

The visual fluency that CGI has brought to film has not been available to the theatrical creator, except through projections. VR can leverage the complete 3D CG toolset, making it particularly useful for telling stories that involve elements of magic or fantasy. Because the experiences are immersive, we can fully transport the audience to fantastical worlds.

Janet Murray describes transformation as one of the key pleasures of digital environments [5]. The flexibility imparted by CG allows us to take audiences from one place to another in any number of magical ways. Another effect that we have observed to be particularly powerful in VR is the ability to manipulate scale. Because there is no external frame of reference, we can make the user feel like a giant, or make them feel tiny relative to giant characters.

Given these affordances, *Alice in Wonderland* presents a natural story to start with: we could transport the audience to Wonderland and allow them to experience Alice's changes in size alongside her. Being well known, it helps bring the audience into the story quickly and efficiently; the name alone gives the audience sufficient context to follow along.

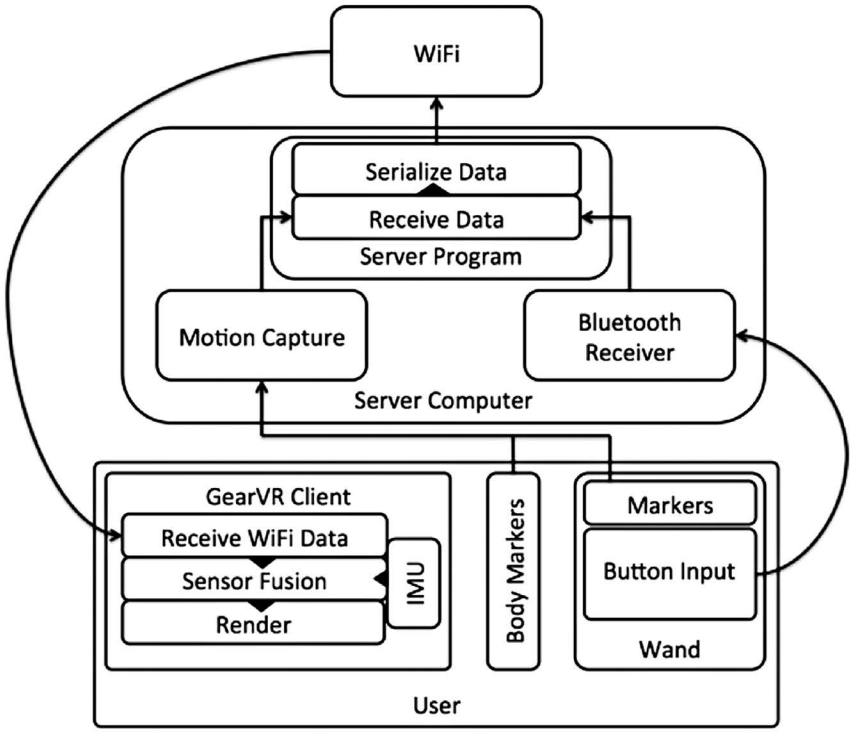

Fig. 3. Diagram of the Holojam system. (© Connor DeFanti, 2017)

Character Design

Performance in this medium is a form of puppetry. In our first iteration, the characters were only represented by a head and two hands. Because these moved in perfect synchrony with the actors' heads and hands, they felt alive and expressive (Fig. 4). In our final piece we used full body avatars, which gave more of a sense of the characters and better visual integration into the world, but did not necessarily convey a greater sense of aliveness (Fig. 5). This corresponds to observations of various styles of puppetry, as well as to recent research in avatar representations and presence in VR [6].

For the audience, butterfly avatars accomplished several goals. Aesthetically, the audience avatars should fit the world of the play and be similar to each other but clearly different from the characters to avoid distraction. Logistically, they also had to make sense without full body tracking and take up enough space around each audience member to avoid collisions in the theater.

Early audiences responded positively to their avatars not having any hands: it made it clear to them that they were not expected to do anything besides watch. Since Alice spoke to them directly, the primary mode of interaction would remain speaking with the characters. The audience avatar design helped focus attention on these key elements of the experience.

Sound Design

To support the story with sound and music we used a 5-speaker surround setup, with a speaker at each corner of the space and one hung from the ceiling. This allowed our sound designer to situate effects in space, including a bird chirping or a large rabbit looming overhead, corresponding with the visuals the audience saw. Subtle sonic effects were used to underscore moments of transformation during the piece and to emphasize the scale differences. The actors' voices were carried through the air, with no mediation. This reinforced that the actors were physically present with the audience.

Observations on Audience Engagement

The design team and authors observed approximately 150 participants through the course of a three-day run, and spoke to many of them after each session. As such, these observations were informal and unstructured.

During performances, the directions of audience members' gaze was informative. The audience was largely in sync during big movements like Alice or Rabbit entering the scene, or a bird flying overhead, especially when accompanied by a sound cue. At other moments, individuals were not united: during big, unpredictable changes or emotionally threatening scenes, they would follow their own interests in the environment, scanning the scene and looking quickly around them. This suggests that they were following the development of the story and responding to the dramatic events.

When Alice entered the scene, audience members usually oriented to her, responding to her questions, comments and requests. Alice had "power" over the audience members and they quickly learned to follow her lead. We did not observe any audience members taking on a disruptive action or contradicting Alice.

The audience clearly understood the rules of the world. For example, audience members watched Rabbit drink from a flask and shrink in order to fit through a tiny door. When Alice wanted to follow him and sought advice from the audience, most suggested that she drink from the flask as well, demonstrating that they understood the magical properties of the drink. Similarly, when it came time to grow back to normal size, audiences suggested Alice should eat the other edible item in the environment (a cupcake), transferring their knowledge about the world to achieve a new end.

Fig. 4. First iteration of character avatars had only head and hands, but with accurate tracking still felt alive and present. (Scenic and character design: © Kris Layng, 2017)

Like any experimental platform, *Holojam in Wonderland* experienced some technical difficulties. These moments illustrated an unexpected advantage of using live performers: they could smooth over the glitches, keeping the audience engaged. Users were usually the last to know something wasn't right.

Audience feedback was overwhelmingly positive, commonly describing the experience as "magical" and expressing the sensation of having been on a journey. This response suggests that IMRT is a viable medium for creating satisfying, collectively enjoyed, narrative entertainment.

Fig. 5. The White Rabbit in the final piece, more fully a part of the world. (Scenic and character design: © Kris Layng, 2017)

Conclusion

Holojam in Wonderland demonstrates a new type of experience: immersive mixed reality theater. Unlike theater or cinema, IMRT allows audiences to share an experience in a virtual environment with nearly unlimited possibilities for visual and sound effects. As source material, *Alice in Wonderland* offers narrative-driven opportunities to use the affordances of IMRT to full effect: changing the scale of the environment, staging a scene for multiple perspectives, and sharing this in real time. The opportunity for creators to build new experiences with these tools is exciting, and future work could explore additional interactivity as well as the creation of longer, more sophisticated pieces on a larger scale.

Acknowledgments

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Alienating the Familiar with CGI: A Recipe for Making a Full CGI Art House Animated Feature

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ABSTRACT

This paper is an exploration of the processes used and ideas behind an animated full CGI feature film project that attempts to reach blockbuster production values, while retaining Art House sensibilities. It examines methods used to achieve these production values in an academic production environment and ways costs can be minimized while high quality levels are retained. It also examines the film's status as an Art House project, by comparing its narrative design and use of symbolism to existing works of Art House cinema.

Making feature films is an expensive business, and making animated full computer-generated imagery (CGI) feature films is particularly so. Films that fall under the banner of "Art House" traditionally do not have the budget of their blockbuster counterparts. Our project is an ambitious attempt to make and finance a full CGI feature film that combines blockbuster production values with Art House sensibilities. It is an animated, motion-captured magical realist adventure that we hope takes CGI to a place it has never been before: CGI Art House cinema.

Our feature is called *Stina and the Wolf* and its accompanying short film is *Uncle Griot* (Figs 1–4). They are the result of a combined student and lecturer project at the University of Portsmouth in the U.K. The production has been carried out by our in-house studio, Foam Digital, which is a lecturer-run and student-staffed organization. It uses a traditional TD pipeline that allows students to work on a CGI-animated film project, learning valuable industry skills with the latest software and production methods. It uses staff mentorship to help establish a threshold industry quality, with the work integrated as an optional project across a number of degree courses. It also aspires to produce innovative and high quality content as part of lecturer research output. For the *Stina and the Wolf* project, we have now completed the screenplay, production design, storyboards and all of the performance-capture. We have raised over $250K in software sponsorship, and $100K in direct funding and have completed a five-minute short using data and assets created for the full feature production. Our next big challenge is to finish the whole feature, a daunting prospect, but one about which we are very excited.

Fig. 1. Stina's epiphany. Still from the *Stina and the Wolf* trailer. (© University of Portsmouth)

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CGI as Art House

So why make a full CGI Art House feature film? Nobody, as yet, has made one, so its potential has yet to be explored. CGI has been used as an addition to conventional photography; examples include a brief cyber-sex scene in the French film *Holy Motors* [1] and in Art House/mainstream crossover films *The Life of Pi* [2] and *Pan's Labyrinth* [3], where CGI plays a role in recreating the imaginary world of the protagonists. However, full CGI is mainly used for cartoon-like mainstream features aimed at family audiences or for anime adaptations. The medium has yet to be used as the principal tool for more challenging and abstract works of feature-length cinema.

Blockbuster-level investment in Art House projects is rare. This is mainly due to the prohibitive cost of production versus box office returns, and is particularly relevant when considering full CGI animation production costs. (*Avatar* cost between $237,000,000 [4] and $425,000,000 [5] vs *Holy Motors* $4,000,000 [6].) As our project was originally intended to rely purely on staff and student enthusiasm and expertise, equipment and software already available and a development cycle as long as our enthusiasm held out, we decided to make the Art House film we really wanted to, beyond the restrictions of mainstream box office expectations. This would involve researching methods of raising appropriate additional financing and sponsorship as needed, as well as concocting creative solutions to save money along the way.

Art house films that have influenced our project include *Mulholland Drive* [7], *Picnic at Hanging Rock* [8], *Don't Look Now* [9] and *The Company of Wolves* [10]. All of these share the eerie quality of magical realism that we want to capture. They all approach ideas of "Otherness": "the state of being different from and alien to the social identity of a person and to the identity of the Self" [11], and the characters often act as symbolic vehicles for another area we wanted to explore: the sublime, with all its notions of nature beyond human control, death and the infinite. As in Peter Weir's *Picnic at Hanging Rock*, our production exists very much in the English philosophical tradition of the sublime [12], with its veneration, awe and

Fig. 2. Above the clouds. Still from the *Stina and the Wolf* project. (© University of Portsmouth)

Fig. 3. Stina plays with Griot. Still from the film *Uncle Griot*. (© University of Portsmouth)

Fig. 4. Griot speaks. Still from the film *Uncle Griot*. (© University of Portsmouth)

Fig. 5. Stina's "Egg Head" rig. Image from the *Uncle Griot* previz. (© University of Portsmouth)

terror at the natural landscape and separation of humans' and nature's aesthetics. David Lynch's film *Mulholland Drive* has also been a particular influence, with dream logic playing a central part in our narrative design. Lynch's film uses a similar device to that at the beginning of the *The Company of Wolves*: the protagonist is put in crisis, then a world is built for her to inhabit and solve a mystery, a world created partially out of symbols made during their moment of crisis. Our film uses this narrative device and puts the crisis at the start of the film (unlike *Mulholland Drive* where it is placed in the middle between the two worlds of the symbolic and the literal, with the powerful central dinner scene acting like a shopping list of ideas to abstract into dream-like neurosis.) As in the *Wizard of Oz* [13] our protagonist goes straight from crisis into a strange world of adventure. On entering this new world, she is, as in *Mulholland Drive*, both experiencing and subconsciously creating the stories she inhabits, as in a dream. At its core our film is rumination on these stories. They are the ones we tell ourselves to make sense of the world, particularly our need to make meaning and narrative sense out of death. *Stina and the Wolf* is an Art House film and also a horror story, a love story and a coming of age journey:

> A teenage girl on a school holiday abroad is involved in a catastrophic coach crash. She is catapulted into a new world and a new life. It is a world she has unwittingly constructed out of symbols that represent her experiences on the coach, the real life predicament of lying badly injured in the crash site, her teenage hopes and fears about the future, and the excitement and danger of a new relationship. She finds herself in a world of impossibly high mountains, cloud-covered forests, strange militarised gypsy fairgrounds, surreally disabled relatives and frustrating new love. She embarks on a perilous journey to save the boy she loves and find some children kidnapped from the village by a mysterious and terrifying figure: the Pipe Catcher. As her quest unfolds, she slowly lifts the veil on her world and realises she is in the wrong place. She confronts her fears, finishes her story and returns home to face the truth. (*Stina and the Wolf* synopsis)

Production

As our production is at a stage where we are looking for financial investment to speed up the next stage of development, we have made a short film to act as an example for potential producers and distributors. This short filmed entitled *Uncle Griot* has been developed from a single scene in the film and taken from our motion-capture performances before being pushed through our entire production pipeline.

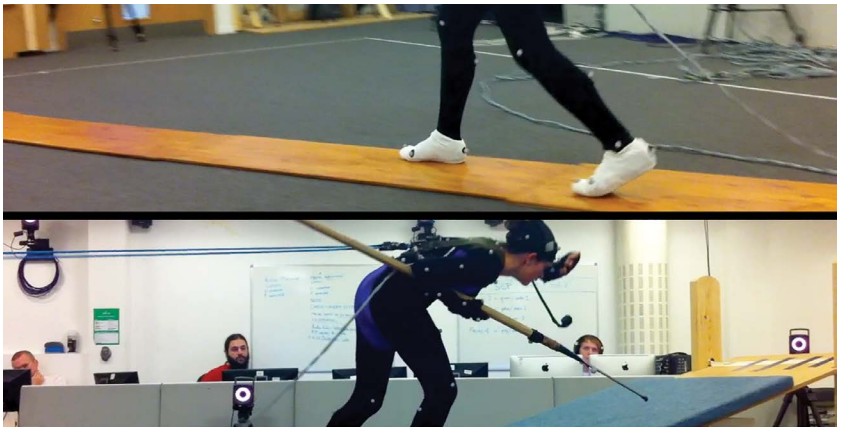

Fig. 6. Ice and snow on the mocap stage. (© University of Portsmouth)

Our protagonist "Stina" was motion captured and her facial performance was recorded through video using head-mounted camera rigs (made by the director in his shed) (Figs 5,6). The translation of the facial performance to the animation rig required a two-stage process of using one of our sponsor's software, FACEWARE, for the tracking, then a final clean-up of hand-keyed animation. This was then put onto our FACs-based blendshape facial rig. The shaders also needed to approach a high level of realism, so Arnold shaders were developed in Softimage,

which took the skin and eye shaders to the fidelity we thought would be sufficient for the effect. We stopped short of adding too much pore detail, as we wanted Stina to have an otherworldly idealized "Hollywood" quality. This was in contrast to the character of Griot, her uncle, whom we wanted to feel much more rough and ready (Fig. 7). This also reflected a thematic element in the film, with Stina acting as a symbol of idealized youth and beauty contrasting to Griot, who represents reality and aging, farts and all! (he does indeed fart off camera early on in the short film) (Fig. 8). The final level of realism we achieved we believe falls somewhere between *Beowulf* and *Avatar*.

Fig. 7. Early Griot concept sketches by Chavdar Yordanov. (© University of Portsmouth)

As the effect we aspire to is intended to work on the subconscious level of the viewer, the process of making it has needed to be a very reactive one, and this extends to how it combines with the edit, the sound design and the music. This need to create a reactive cycle with the work as it's being produced reflects the methodology of one of our biggest influences, David Lynch:

> A script is just words to remind you of the ideas. And you follow that, but always staying on guard, in case other ideas come in, because a thing isn't finished till it's finished. And one day, it's finished [14].

The planning involved in CGI work means that in order to reach this often more subconscious, reactive and transcendental way of working, we have had to find ways of reacting to the work as we make it beyond just storyboarding, concept art and previz. Often the work has been passed backwards and forwards between the different stages, with the ability to respond and react to apparent mistakes in the work being an invaluable tool in its development. The reactive element of producing good art can often get lost in the relentless march of the CGI planning stages, particularly in larger and more complex productions. We have a previz stage where we project the actor's face back onto a smooth representation of his head shape. This is done in combination with the body motion capture and allows us to get a good sense of the performance beats.

Fig. 8. Finding the right Griot. Shader and groom look-dev. (© University of Portsmouth)

This then allows us to be as reactive and experimental as possible with the camera placement. This process is counter-intuitive to many traditional filmmakers, as we have not blocked out and staged every scene beforehand for the camera. We used storyboards on set, but some were left very loose to be completed after the shoot. As we motion-captured in an environment with restricted space, our only concern for blocking was allowing enough room and props to amplify the honesty of the performances. We did all we could to recreate the physicality of the set for the actors. This involved a plethora of Heath-Robinson/A-Team style solutions: everything from polished boards and greased socks for ice; arm weights on the ankles for ocean drag; crash mats for snow and army webbing attached to a rope harness to simulate the buffeting wind of a blizzard.

The ability to go in and block the camera after the shoot has given us an incredible amount of freedom (too much in some cases, as we are left with infinite possibilities!). It has also allowed us to hone in on potential areas for development before committing to the full facial animation pipeline.

Although our protagonist Stina is a standard human character, her uncle Griot was inspired in part by the terrifying dog/tramp combination in the 1978 American science fiction horror film *Invasion of the Body Snatchers* [15]. This practical-effect combination of a realistic rubber mask of an old man worn by a real dog, who then licked said mask though the mouth slot, is uncanny. I wanted Griot to have the potential to be as downright terrifying as this, certainly at first, then eerie, then as the story develops the audience could finally warm to him, as they see his humanity and get used to his strangeness.

He is effectively the heart and truth at the center of our film, with his combination of all the weirdness and uncomfortableness that comes with aging, and bodies in general, as well as an illustration of the day-to-day realities of familial love. I wanted a character who could transition from a shocking monster to an adorable border collie to a slightly weird, physically exposed and disgusting uncle, and finally to a sage-like voice of wisdom. We settled on a goat body, the head of an old man and the locomotion of a border collie when moving slowly and of a bounding goat when moving quickly. We went through many look-dev stages to get what we felt was the right balance of human/animal, keeping a keen eye on the overall anatomical logic.

For timing and performance reference we used an actor (the director) crawling around on all fours (Fig. 9) captured on our mocap stage (with extra cameras thanks to sponsorship from VICON). This was essential in eliciting a genuine performance and interaction from our young actor who played Stina. It also allowed for a level of improvisation on set which we hope added to the authenticity of the performance. (It certainly made the crew laugh.)

Fig. 9. Motion-capture shoot for the film *Uncle Griot*. (© University of Portsmouth)

The character was then keyframe-animated based on the actor's reference as a performance guide, but with enough license to bring in the animalistic elements as required (using extensive goat and dog references). We used separate actors for facial animation reference for his animal and human states, to exaggerate the difference between them. Both of these states are presented to some extent in the short film (Fig. 10).

Fig. 10. Griot plays fetch. Still from the film *Uncle Griot*. (© University of Portsmouth)

Using a Game Engine Instead of a Traditional CGI Pipeline

As traditional shot-based pipelines are part of the reason CGI features are so expensive, we have been looking at cheaper alternatives. One alternative is a game engine. We are presently investigating the Unreal Engine for our previz stage. As well as potentially cutting production costs, this will help us get a closer representation of the final artifact earlier in the process. It will allow us both to see how light and atmospheric conditions affect our performances, and to make more informed and reactive choices regarding cinematography. Our ideal is to replicate the condition of being on a location shoot and add the ability to react to the vistas and action in real time. We are also looking at the options this will give us with regard to lens mimicry, allowing us to experiment with focus pull and other techniques. In addition to Previz, we are also investigating Unreal for use as our main rendering tool. With recent developments in its rendering and VFX capabilities, we feel it might be the ideal tool to knock our development costs down substantially, but still allow us to keep the fidelity we want. There is a precedent for cost-saving productions using Unreal, as seen in the recent animated feature rendered entirely in Unreal: *Allahyar and the Legend of Markhor* [16]. An initial budget for our feature, using Unreal and based on a breakdown of animation, modeling, rigging, VFX, tools, production, foley, mixing and grading that we made from our assemble of the film (a 110 minute long cut constructed from on-set reference footage, storyboards and concept art), came to $2.5 million. This would pay for a small professional animation studio, staffed with junior- to mid-level artists and a few seniors working for two years. It would also allow us to formalize the student contribution, by running year-long paid placements as part of the degree program. This budget sits well in the indie horror market, which is a realistic genre to pitch to, given our content (*The Company of Wolves* was also marketed as a horror film, even though predominantly an Art House experiment). Film producers I have spoken to have stressed the importance of finding a realistic budget that matches the intended marketplace. The horror market in particular can accommodate films "budgeted between $500K and $3 million," which can generate "at least $10 million in Producer's Net Profit" with "Income Streams: 28% from theatrical, 60% from home video and 11% from TV and other ancillary income" [17]. This also provides an indication of our distribution approach. Lessons from research into these lower budget films also tell us we should "look for good actors, not big stars, and do the same with all of the technical crew on a film" [18]. This is a fairly accurate description of our project: great performances and visuals, but absolutely no one famous involved.

Conclusion

Making an Art House film with blockbuster production values requires a balance between expectation and cost. A lot of effort is required on every level to find innovative cost-saving measures which can balance these factors favorably. Identifying a clear marketplace for the work, aligned to a target production cost, sets the template for realizing these ambitions. Much of the expense in CGI production resides in technology, but its costs are constantly becoming more manageable as solutions that are quicker, higher quality and cheaper emerge. The next few decades should, with any luck, see a lot more Art House filmmakers able to take risks and bring more innovative projects to the big screen. We hope that *Stina and the Wolf*, a full CGI film that sits comfortably in the Art House genre, will be one of them.

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Glossary

FACs—a system to measure discrete movements on the face developed by Carl-Herman Hjortsjö

Digital Heritage: Bringing New Life to the Montreux Jazz Festival's Audio-Visual Archives with Immersive Installations

Nicolas Henchoz and Allison Crank

ABSTRACT

To revive the Montreux Jazz Festival's archival live-concert footage, three immersive installations were designed using three different principles of augmentation, physicality and interaction. The primary aim was to engage the user in a new relationship with digitized heritage. Audience observations indicated a strong emotional connection to the content, the artist and the crowd, as well as the development of new social interactions. Experimentation showed close interaction between the three principles, while the three installations suggested methodologies for reviving audio-visual archives.

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The Montreux Jazz Festival was founded in 1967 by Claude Nobs, who recorded most of the concerts with the latest available technologies. With over 5,000 concerts, it became one of the world's largest audio-visual archives of live blues, jazz and rock concerts. In 2013, UNESCO deemed the festival's archive a pivotal part of human heritage, "something that is, or should be, passed from generation to generation because it is valued" [1], and entered it into the UNESCO's Memory of the World Register.

Heritage digitization occurs in most cultural institutions around the world. The Montreux Jazz Digital Project involved researchers, computer scientists, engineers, designers and architects. They faced the challenge of digitizing 14,000 tapes with 18 different recording formats introducing a huge diversity among the content, from low resolution, black and white, 4:3, 16:9 to 4K multitrack uncompressed tapeless formats. Another issue was the lack of metadata on the oldest content. Lastly, copyright practices have changed dramatically over the past five decades. Open access to this content is not possible; therefore, public accessibility can only take place in approved installations.

Our project builds upon the Montreux Jazz Digital Project by exploring how to revive this digitized heritage. If digitized archives can provide better access to heritage content, then the corresponding increase in maintenance costs must be balanced with generating valuable user experiences. If we fail to create engaging interactions with the digitized content that add value to this heritage, we risk losing part of our history.

Audio-Visual Heritage

Digital archives are not only an issue of storage architecture or maintenance, but also one of accessibility [2]. Issues of how to access the content or how to represent large pools of heterogeneous materials raise new questions. For example, Petras et al. [3] designed a large-scale search engine for digitized cultural material involving 53 million objects in 50 languages, where the team combined technologies, associated metadata and user inputs to improve the engine's overall navigation. User interactions and the medium (i.e. the physical device to view the content) emerges as a core issue. This question of how to access audio-visual heritage in an engaging manner has been explored by Bugalia et al. [4], who found that through hand gestures and projection mapping, users could physically interact with multimedia data in order to generate new interactive and semantic relationships to the digitized heritage. Here, immersion and physicality combine with interaction principles to enrich the overall impact of the installation, while the installation still primarily focuses on information dissemination. Sanders and Salgado [5] built a tool that allowed users to create their own digital narratives with audio-visual archives; the existing archive was improved by adding user-generated metadata, hence enriching the interaction. Murphy et al. [6] researched methods of

how to create new user experiences of past environments, in particular that of acoustic heritage and how to recontextualize audio data in order for the user to feel new relationships with intangible cultural heritage.

Reviving a cultural event, such as a concert, sets other dimensions that are impossible to recreate; the impact of a crowd of 3,000 people, the presence of the real artist and the unexpected events in a live performance. Additionally, the Montreux recordings provide tailored views of the original event which differ from the public viewpoint. Therefore, these observations and references set the need to revive audio-visual cultural archives through new experiences—experiences that are specific to digital content. Through redefining the use and combination of the three principles: augmentation, physicality and interaction, as identified by previous works in various fields between 2012 and 2017, we set out to build three installations to investigate these principles.

Montreux Jazz Heritage Lab I

The first installation (Fig. 1) explores creating specific experiences for digitized heritage. Immersion principles are based on screen size and perception of depth. The screen installation takes its inspiration from the trompe l'oeil perspectives of baroque churches [7]. The surrounding enclosure serves to reflect the screen luminosity and creates an overall ambiance for the viewing experience.

The interface design promoted dialogue exchange between users. By using a large multi-touch screen, two people can simultaneously explore the database and exchange their search results. Physical interaction with the content (from an "active" selection position to a "passive" viewing position) involves natural body movement, improving one's sense of presence.

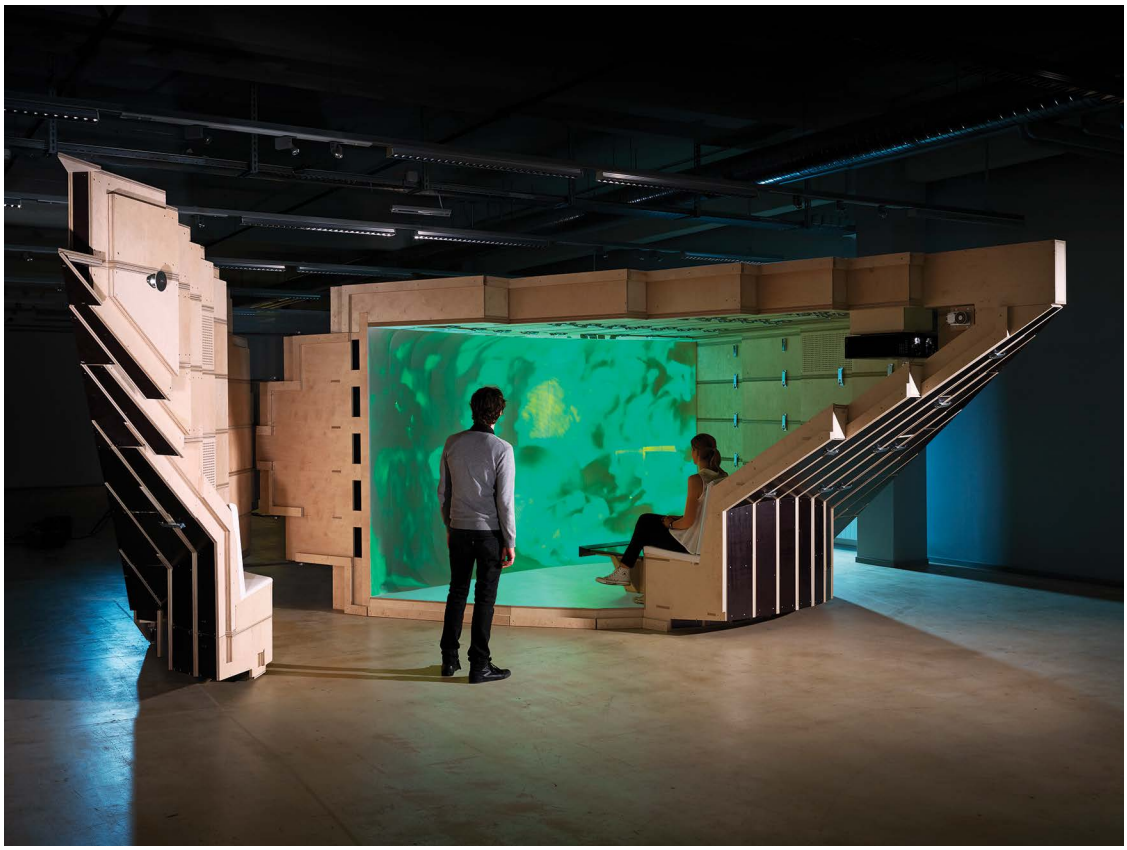

Fig. 1. Users viewing archive content in the Montreux Jazz Heritage Lab 1, 2012. (© EPFL+ECAL Lab. Photo: Daniela Droz and Tonatiuh Ambrosetti.)

Montreux Jazz Heritage Lab II

In late 2016, a second installation (Fig. 2) which accommodates up to 20 people opened as a permanent fixture at a Montreux Jazz Café. It investigates several aspects of augmentation.

The main architectural research focused on the augmentation and materiality of the screen. Inspired by Carsten Nicolai's Unicolor installations [8], the screen is designed like a small portion of a torus. The surface is faceted to create screen physicality. Lateral two-way mirrored walls on either side of the main screen induce the perception of an endless image (or when showcasing the concerts, of a continuous stage). Behind the mirrors, two LED screens display metadata: information about the song and iconic visuals from the festival. User testing demonstrated the preference for a low resolution metadata screen in order to keep a clear differentiation between the central "concert" screen and the lateral "information" walls.

Fig. 2. Montreux Jazz Heritage Lab II installation, 2016. (© EPFL+ECAL Lab. Photo: Joël Tettamanti.)

Sound is augmented by a 3D sound reconstruction of the original concert halls and different up-mix from original stereo recordings. The audio hardware is a 32.2 audio system. Storytelling contributes to the augmentation with short emotional anecdotes about the festival's history projected between songs.

The Montreux Jazz Heritage Lab Nomad

The nomad prototype (Fig. 3) aims to bring the heritage experience to the greater public around the world. To play with this nomadic notion we also took concepts of flexibility, portability, user inputs and storytelling into account as foreign users may know less about the festival and its cultural impact on music history.

Visual investigation led the architectural team to build the screen installation on a hacked Smart car. The final screen geometry is a deformed sphere. This introduced a new challenge: overcoming the poor image resolution incurred by spreading the image over a 180° field. The solution involves two projectors. One directly projects a full picture at the screen center. The second, placed at the front of the car, illuminates by bouncing off a curved mirror and, through masking techniques, provides an ambient image, extracted from the main footage in real time. Sound is integrated with a new up-mix algorithm on a 10.1 system.

External virtual reality devices point to the car and provide a new form of augmentation through immersive and interactive storytelling about the festival. The installation's theatrical aspect is that users

can become a protagonist. A video camera captures user memories by recording their thoughts after they experience a performance and integrates their inputs into the database.

User Experiences

We performed qualitative observations with musicians, music producers, festival audiences as well as the greater public, which led to several observations about the three principles.

For augmentation, we observed that using 3D sound reconstruction and up-mix, reflections in the architectural space (so that the image expands beyond the screen), metadata displays and storytelling heightened the users' sense of presence and enhanced the immediacy of the concert experience, e.g. ambiance, artist–crowd interactions, historical setting, venue, stage and concert progression. Sound, in particular, seems to be a critical parameter for global credibility.

Fig. 3. Prototype for the Montreux Jazz Heritage Lab Nomad. (© EPFL+ECAL Lab. Photo: Daniela Droz and Tonatiuh Ambrosetti.)

To increase physicality, we designed curved and structured screens and took advantage of interactions that play with the users' body postures, which increased exploration behavior and stimulated social interactions.

To increase interaction, we introduced new interface typologies for browsing the archive that were structured on the festival's program. We also empowered users through virtual reality to explore the festival's history and to leave a trace of their experience through the recorded user testimonials.

We noted a significant positive emotional impact in most participants. Our installations engaged users across generations and promoted social dialogue and empathy. Sound in audio-visual archive material plays a strong role; if there was poor sound (for example, audio glitches), users also perceived "poor image resolution" (even if the picture image had not altered). However, our installations may not enhance all audio-visual archive content. For example, our designs had little effect on content that is inherently devoid of context and emotion (i.e. charts, graphs and text). Likewise, our installations did not work when showing GoPro sports footage where shaky cameras and distorted lenses induced motion sickness when viewed in hyper-scale. Participant responses may have been biased, for example, by ascertainment bias, rhetoric bias and/or observer bias.

Redefining a physicality enhances the immediacy of the experience. Screen physicality (the screen as a three-dimensional object with tangible qualities) can enhance immersion, but it also makes it sensitive, especially in the case of low-resolution visuals where screen material qualities may overpower the picture image. Physicality must, therefore, always support immersion in the service of the original content. Interaction has been defined, here, as specific to the archive experience with a focus on linking users to the content; it revolves around how the user accesses and views the content rather than serving as a kind of universal search tool.

Conclusion

If digitized archives can provide better access to heritage content, the corresponding increase in maintenance costs needs to be balanced with generating new valuable user experiences. If we fail to create engaging interactions, we risk losing part of our history; the content "potency" could decrease over time as newer generations lack personal relevance to the original material. The field of archaeology has tackled this issue on numerous accounts by trying to revive static environments. These projects often employ advanced concepts of immersion and interaction such as exploring reconstructed simulations of historic buildings and environments in virtual reality. Our experience for the Montreux Jazz archive shows the challenge of reviving digitized concert footage that is directly linked to the specific nature of its archival content.

The quest for recreating the "world exactly as it used to be" is nonsensical, at least in the context of cultural events. The goal for reviving concert material is not to provide a better understanding of its environment, but to revive an event, an event that is fueled by the intensity of the live audience, the uncertainty of the real performance and the presence of the real artists. Our proposition aims to define new experiences for reviving audio-visual cultural archives—experiences that are specific to digital content. Combining new media, technologies and content (including metadata and user recordings) creates a new kind of "Gesamtkunstwerk"—Wagner's vision for a total work of art.

Our work emphasizes the three principles: augmentation, physicality and interaction in the revival of digital archives, but also underlines the sensitive link that connects them. Like the 1958 Philips Pavilion by Le Corbusier, Xenakis and Varèse [9], the search for a multiplicity of physical relations unite the space, content and interactions, leading to a contemporary Gesamtkunstwerk, where the audience is no longer passive, but becomes the protagonist in the space. However, this ambition is threatened by the danger of the user running away with the story. Therefore, we assess the importance to work with these principles within specific criteria.

The principles can be applied to many other audio-visual archives. However, archival content must be first categorized to define whether it will benefit from being viewed in an immersive and physical experience. For example, footage with flat perspectives and cognitive content (i.e. text and charts) could be poorly perceived in an immersive environment. Specific criteria for this categorization of archival material must be developed to predict suitable content.

Future work will assess how to combine the principles to complementary archives and enrich their content through real-time information.

Acknowledgments

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Data Materialization: A Hybrid Process of Crafting a Teapot

Courtney Starrett, Susan Reiser and Tom Pacio

ABSTRACT

Data materialization is a workflow developed to create 3D objects from data-informed designs. Building upon traditional metalwork and craft, and new technology's data visualization with generative art, this workflow expresses conceptually relevant data through 3D forms which are fabricated in traditional media. The process allows for the subtle application of data in visual art, allowing the aesthetic allure of the art object or installation to inspire intellectual intrigue. This paper describes the technical and creative process of *Modern Dowry*, a silver-plated 3D-print teapot on view at the Museum of the City of New York, June 2017–June 2018.

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Data Materialization

A giant teapot loomed across the sky in a parody of Kubrick's *2001: A Space Odyssey* playing on the big screen during SIGGRAPH's Electronic Theater Opening Sequence in 2001 [1]. This digital short paid homage to the teapot, an iconic object. In 1974, University of Utah graduate student Martin Newell was looking for a complex surface on which to test reflections, and his wife, Sandra, suggested that he use their Melitta teapot as a model. That virtual teapot model lives on in the world of computer graphics [2]. Its now familiar shape influenced and continues to influence a myriad of digital models. The process presented in this paper takes a reverse approach: A digital application and 3D print are used to fabricate a physical object: a silver-plated teapot, *Modern Dowry* (Fig. 1).

The teapot's story began when the Museum commissioned me to develop a piece for "New York Silver: Then and Now," an exhibition independently curated by Jeannine Falino. Through the piece, I wanted to bridge two seemingly disparate creative disciplines, silversmithing and computer graphics. I reached out to my collaborator, Susan Reiser, an educator in computer science, new media and mechatronics. This work melds craft and digital fabrication by augmenting digital tools, techniques, finishes and materials with their traditional alternatives. I used conceptually relevant statistical data to inform the geometry of the work in a process my collaborators and I call *data materialization*, a process inspired by data visualization—the intersection of data communication and design. However, there is an important distinction between the two: Data visualization prioritizes the clear and accurate communication of data while data materialization prioritizes the design. In other words, the object's looks are more important than the direct communication of the data. The input data set may be revised if the resulting form is unappealing or uninteresting. For example, if plotting a curve and all inputs were equal, the end result would be a flat line. Because a single flat line is not visually interesting, it would be replaced with a dataset that remained conceptually relevant but resulted in a more dynamic curve. This process is not data visualization because the statistics are analyzed and curated to identify datasets that produce interesting results within design constraints. In the following sections, the data materialization workflow is described from concept and design to fabrication, which is infused with historical

Fig. 1. The *Modern Dowry* teapot. Nylon polyamide, copper and sterling silver. 22.1 × 23.9 × 24 cm, 2017. (Photo: © Courtney Starrett)

Fig. 2a. *Clever on Sunday* (2016), silicone rubber, pins and Saarinen Tulip table courtesy of Knoll and iPad, 18 × 10 × 6 ft. Installed at the Samuel Dorsky Museum of Art in 2016. Fig. 2b. User interacting with QR code doily and information graphics at the Samuel Dorsky Museum of Art in 2016. (© Courtney Starrett. Photo: Esther Joy.)

context and interdisciplinarity. The initial projects, *Clever on Sunday* (2016) and *Layer Chiffon* (2017) lay the foundation for *Modern Dowry* and the data materialization workflow.

Clever on Sunday (2016) is an installation (Fig. 2a) consisting of about 200 hand-cast silicone rubber doilies with designs computed from statistical data on gender balance and imbalance in education and the professional world. Working backwards from a vision and concept, we began with a computer-generated design, the output of a custom program. The program takes spreadsheet data (percentages) and converts them to a radial pattern of overlapping circles of different radii. Each "spoke" represents one column in a dataset; for example, female students in a particular STEM major. Each circle along the spoke represents a different spreadsheet row; in the preceding example, a particular year. In other words, the size of a circle's radius corresponds to the relative size of the number of majors in that particular year. Each doily pattern was laser cut, and the model was used to construct a silicone mold. The doilies were then hand-cast from the molds using custom-tinted silicone rubber. Exhibit viewers could scan an individual doily which acted as a "QR" code and hyperlinked to a webpage infographic explaining its underlying statistics (Fig. 2b). As part of the exhibit, a few of the doilies were displayed on a table. A surprisingly high number of guests touched or picked up the silicone pieces off the table, which inspired the use of silicone forms as sensors in *Layer Chiffon*.

Fig. 3. *Layer Chiffon* (2017) silicone rubber, projector, various electronic components (Arduino, etc.) and table, 3 × 10 × 8 ft. Installed at Vassar College in 2017. (Photo: © Courtney Starrett)

Layer Chiffon (2017) is a hands-on interactive installation (Fig. 3) inviting viewers to explore a sampled history of food, materials and gender roles in mid–twentieth-century America. The exhibit consists of a traditional table with three colorful silicone Bundt®-like forms, and a projector that displays video and animated commentary based on viewer interactions with the silicone forms. Videos include

archival commercial advertising footage and custom animated data visualizations. The data materialization workflow was again used to create the silicone forms. A custom script used spreadsheet inputs to create the relative sizes of the curves at the bottom of the bespoke forms. These curves were merged and lofted in a modeling application to produce 3D forms. The models were CNC-milled in polystyrene foam which were then used to create plaster molds. Custom silicone forms were hand-cast, in layers, from the molds. Once displayed, the jiggly, Jello®-like objects invite the viewers' touch; force-sensitive resistors detect pressure. In turn, each selected form or combination of forms causes a different video to project, allowing the viewer to interpret a custom narrative.

The Teapot

Modern Dowry began with background research on silver in colonial New York. Through conversations with Falino, an expert in the history of American metal and ceramics, I learned that prior to an official currency in the colonies, silver had monetary value and was often made into functional objects and kept in the home for security, as well as a demonstration of wealth to visitors. Thus, the cupboard became the bank account in Colonial America, and the silversmith the banker. Traditionally, functional and decorative silver pieces were wedding presents from a bride's family—a dowry—and symbolic representations of wealth and status. These gifts and other inherited assets automatically became the property of a bride's husband [3]. Conversely, typical newlyweds of today bring some combination of student, mortgage, car and credit card debt to a marriage. Today's bride may be an equal equity partner in marriage and, as in my case, may acquire more debt than wealth—resulting in the designation of the title "*Modern Dowry*." To apply this concept, I used autobiographical financial data in the data materialization workflow to reinterpret a teapot body. Echoing the deliberate selection of the form and its underlying conceptual data, a variety of fabrication techniques and materials were also identified and evaluated. The use of a nylon core layered with copper and, finally, plated with sterling silver references the illusion of wealth in the 21st century (Fig. 4). One may carry a six-figure debt, yet appear to be financially stable, thanks to credit.

Fig. 4. Details of the teapot (from left to right) in SLS nylon polyamide, copper electroform and silver plate. (Photo: © Courtney Starrett)

Initially inspired by John Crawford's 1825 teapot in The Museum of the City of New York's collection, the choice to work with the teapot compliments our backgrounds in art, design and computer graphics. The teapot has iconic significance in multiple realms: the Utah teapot in computer graphics and the sterling silver teapot as a status symbol and a literal representation of wealth in Colonial America. *Modern Dowry* references the iconic status of the teapot in multiple domains and represents a fresh approach to object-making by combining the relevant tools and techniques with contemporary context.

The teapot footprint depicts my monthly finances: debt payments and potential savings (Fig. 5). A custom script converts spreadsheet data into a circular pattern of adjacent circles. The curves are trimmed and joined to be a continuous path of alternating convex and concave curves. Each concave arc represents the relative size of a debt payment, and each convex arc is relatively sized and repeatedly inserted as a separator

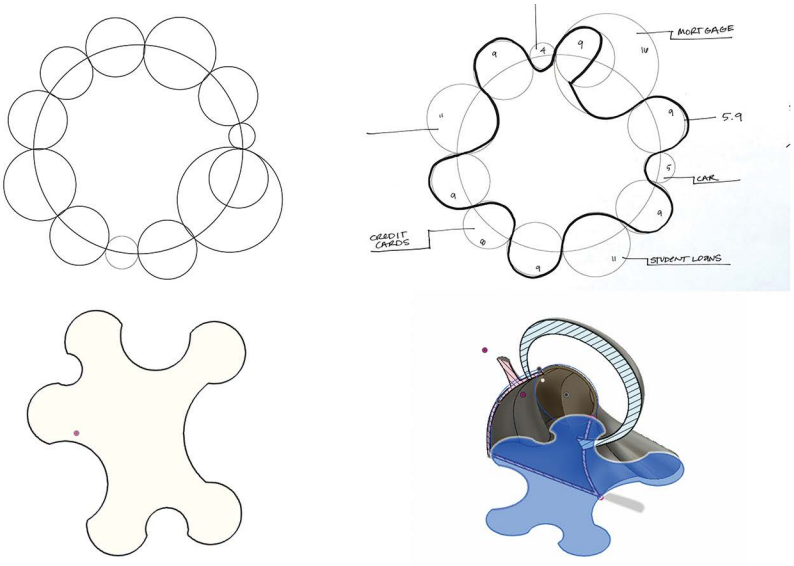

Fig. 5. The evolution of the *Modern Dowry* teapot footprint from the script produced adjacent circles to profile curve of the three-dimensional model. (© Courtney Starrett)

(savings) between the debts. The teapot body was 3D modeled from the profile; and a spout, lid and handle were added to complement it. Ultimately, the teapot was exported and fabricated by selective laser sintering (SLS) in white nylon (a polyamide), hand-sanded, copper electroformed and plated with sterling silver.

Context

While working with Tom Pacio at our summer residency at Vassar College, we contemplated where this work fits into the broader context of art, science and technology. We questioned how the work relates to traditional craft mediums, new media art, data art, data visualization, installation art, generative art and data sculpture. Although similarities were found in many of these categories, several examples resonated more than others.

While at first glance this work appears to exemplify data visualization, it is not "readable and recognizable" as a visualization, a minimal requirement for such designation [4]. Without an external explanation, one cannot infer what data *Modern Dowry* communicates. Similarly, it could be called information art, a subset of ambient visualization, but the work fails to meet information art's three data communication requirements posited by Skog et al.—that the viewer comprehends (1) "*that* something is visualized," (2) "*what* is visualized?" and (3) "*how* the data is visualized?" [5]. The teapot could be considered a data physicalization, defined by Jansen et. al. to be "a physical artifact whose geometry or material properties encode data," but their definition omits a reference to design or art [6]. Based on a literature review, we believe *Modern Dowry*, along with our other work, is best categorized as data sculpture, a type of physicalization, exemplified by artists such as Nathalie Miebach [7] and Doug Bucci [8] and defined by Zhao and Moere to be "a data-based physical artifact, possessing both artistic and functional qualities, that aims to augment a nearby audience's understanding of data insights and any socially relevant issues that underlie it" [9]. Even so, we will continue to use the term data materialization because, as described previously, they prototype different datasets in the design process.

Lev Manovich claims "data visualization moves from the concrete to the abstract and then again to the concrete," and cites Benjamin Fry's visualization *Anemone* (2004) as representative of another new quality of modern visualizations called "reversibility." When the viewer clicks on any part of the active representation a label describing the data is presented, allowing the viewer to access the data that generated the visualization, making the process "reversible" [10]. One challenge in the data materialization workflow is how to balance referencing the data, inherently crucial to the concept, with the aesthetics without being overly literal from the visual art perspective. "Reversing" the data is important to this work, although labels are too direct. *Clever on Sunday*'s QR code doilies, which link information graphics presenting the data in a tertiary way, are examples of the efforts to connect the data to the form.

Conclusion

The Utah teapot began as a ceramic teapot which was converted to a digital representation with both self-reflective and environmentally reflective surfaces, meant to coexist with the virtual environment, and presented as a 2D image. Conversely, the *Modern Dowry* teapot began with spreadsheet data, from which I generated curves and 3D virtual surfaces, which are fabricated to produce a functional silver-plated teapot. *Modern Dowry* employs a new interdisciplinary approach to making 3D data materializations through a unique workflow. Harvard's Peter Galison compared interdisciplinary work to a "trading zone" in which a new language of collaboration can be formed and in which we can coordinate action and belief across academic silos [11]. Although each collaborator brings different skills and techniques to the table, their shared goals and design process inform how they work together in interdisciplinary, interinstitutional projects. The data materialization workflow described in this paper utilizes both traditional and emergent processes and tools to create a functional and visually compelling teapot that inherently represents the concept-relevant data.

Acknowledgments

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Robotype: Studies of Kinetic Typography by Robot Display for Expressing Letters, Time and Movement

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ABSTRACT

Humans use letters, which are two-dimensional static symbols, for communication. Writing these letters requires body movement as well as spending a certain amount of time; therefore, it can be demonstrated that a letter is a trajectory of movement and time. Based on this notion, the author conducted studies regarding multidimensional kinetic typography, primarily using robots to display a letter and visualize its time and movement simultaneously. This paper describes the project background and design of the three types of robotic displays that were developed and discusses possible expressions using robotic displays.

Humans invented words to communicate with each other and letters to record these words. Owing to letters, humans have been able to communicate beyond the present into the future. The durability of paper is substantially longer than a human life span, and thus letters written on paper can be retained almost indefinitely. Although the written letters themselves do not move, humans require moving their body and spending time to create them.

The movement and time spent by the writer are usually apparent in the brush or pen stroke of the letter. The shading, blurring and density of ink demonstrate the behavior and movement of the writer over time; one can deduce the writer's emotion or thought. Thus, our letters are not only two-dimensional symbols that convey messages, but also involve the time and movements that humans devote toward communication.

The time and movement observed in handwriting have not been regarded as important for letterpress printing and computer monitors that have appeared more recently. However, could it be possible to obtain a display technology for letters that coexists with time and movement beyond the two-dimensional plane? With the development of such a technology, we could determine implications beyond those of the words themselves. Based on this notion, we explored a new form of typography. We began by developing a multi-dimensional display for kinetic typography, primarily using robot technology and the illusion of depth. We named the project and the devices Robotype.

We have developed three types of Robotype thus far: Sujigen for displaying Arabic numerals, Mojigen [1] for the Roman alphabet, and 7×7 [2] primarily for double-byte characters such as Japanese. Each display is designed with conventional computer displays as a motif. In this paper, we describe the design of Robotype, its kinetic typography and the possibility of its expression.

Background

Multi-Dimensional Display

A common method to display a computer-generated multidimensional image in the real world is to place actual pixels in the space. In the example of using light as a pixel, a three-dimensional shape can be represented by arranging pixels sterically using an LED matrix cube [3] and plasma [4] or by using the afterimage of a rotating light source such as an LED strip [5]. Although the viewpoint is limited, a three-dimensional depth can be represented by superimposing transmissive planar displays [6,7]. Displays that use physical objects as a voxel, which is a pixel with volume, also exist. *Kinetic Rain* by Art + Com [8] is an exceptional work that displays three-dimensional patterns using an array of hanging weights controlled

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via motors. In addition, inFORM [9] can be mentioned as a tabletop display that expresses three-dimensional shapes using a grid of linear actuators.

In recent years, Fuwa-Vision [10] and fVisiOn [11] have been established as technologies that realize holography, similar to Princess Leia projected by R2-D2 in the movie *Star Wars*.

Kinetic Typography Using Computer

Letters traditionally have been shaped using media and tools such as stones and chisels or paper and brushes. Moreover, kinetic typography was developed via the invention of film. Computer technology is also guiding new expressions of typography in the same context.

One of the advantages of computational typography is letter generation and movement through human–computer interaction or coding itself. Forerunners generated the shape of letters and the kinetic movement of typography by algorithm, as observed in 1990s' works by John Maeda [12] and typography using modern creative coding platforms [13]. This advantage is also utilized in *Text Rain* by Camille Utterback [14], which enabled interaction between poetry and the user's entire body. Another advantage is enabling physical materials to become computational displays via DA converters and actuators. Although these are nearly two-dimensional displays, related works exist where letters and numbers are displayed by mechatronics [15,16]. Further, several planar displays exist where letters and numbers are displayed by controlling natural substances such as water [17], bubbles [18], moss [19] and fur [20].

Principal Concept of the Robotype Display

Exploring through the history of multidimensional displays, it appears that most prior arts aim to realize volumes to computed three-dimensional images. Moreover, there is a possibility to explore the design of multidimensional kinetic typography via computing. Our objective is to design a display for letters that is also able to express letters' time and movement; we were inspired by the seismograph because of this realization.

Figure 1 illustrates our principal concept regarding the Robotype display. A string is deformed by actuators, and the string is observed as the letter (A) from the front view. Simultaneously, the trajectory of time and movement can be observed from other points of view. This expression using an optical illusion of depth is also observed in the works of advanced graphic designers and sculptors [21–23]. If this string is deformed using robot arms, it is possible not only to express the dynamic strokes as a live animation but also to express the trajectory of the strokes. The trajectory appears as a brush stroke or a spill of ink on paper in handwritten letters.

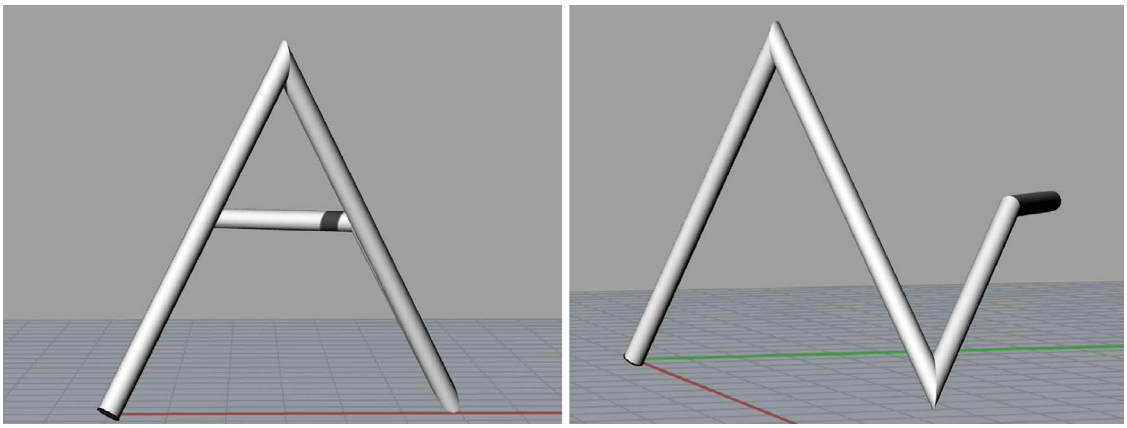

Fig. 1. Robotype concept (left: front view; right: side view). (© Yuichiro Katsumoto)

Thus, we decided to pursue this concept and developed Robotype for numbers, alphabets and double byte characters, primarily Japanese. As described in the following subsection, each Robotype was designed with respect to the motif of a seven-segment display, vector scan display and bitmap display.

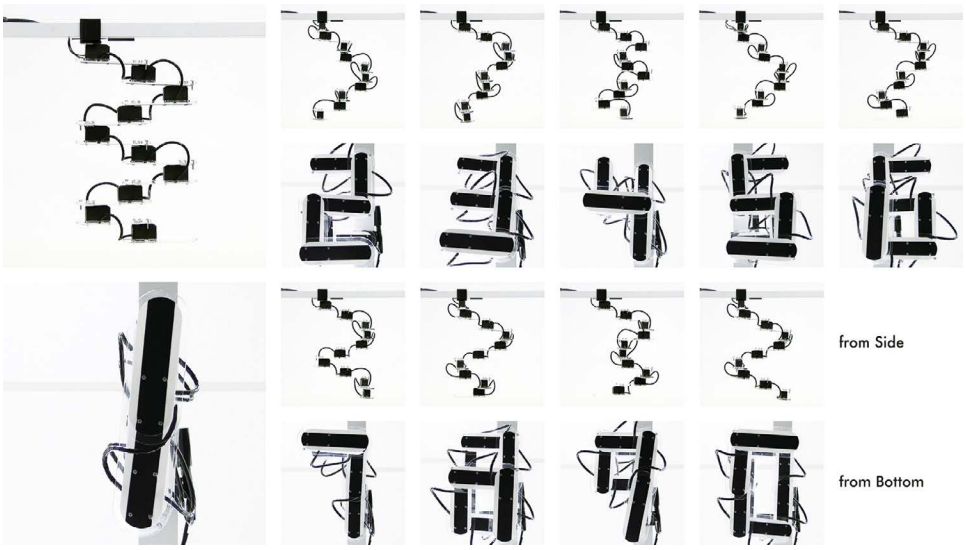

Fig. 2. Sujigen and its display numbers. (© Yuichiro Katsumoto)

Sujigen

Initially, we designed Robotype for Arabic numerals, called Sujigen (Fig. 2). A seven-segment display is the most common computing display for numbers; with its minimal function and beauty, this design is still used in calculators with a bitmap screen. Using this display as a motif, we developed one long robot arm with 10 segments and designed it as a mobile that hangs from the ceiling. In addition, we choreographed this Robotype with circular motion by referring to a dial face and clocks.

This robot arm consists of 10 segments. Each segment consists of two layers of acrylic board (transparent and white) shaped as a running track (length: 140 mm; width: 55 mm). A black tissue tape is sealed under the acrylic layers for drawing an actual line segment. A servomotor is installed at one end of each acrylic frame and this servomotor, Herkulex DRS-0201 [24], can rotate through 320°. Numbers in a seven-segment display are composed of straight lines and right angles; therefore, the servo is set to rotate to four types of angles: 0°, 90°, 180° and 270°.

Each segment is linked together so that the position of the servomotor is staggered, and the segments rotate horizontally. The total height of Sujigen mobile is 400 mm, and its weight is approximately 1,200 g. At one end of the mobile, an ABS adapter is located for connecting the device to the ceiling or beams.

Sujigen displays numbers by rotating each segment simultaneously. Therefore, numbers will appear from a spiral as if they were written in a single stroke (Fig. 3). This number can be observed by looking up from below. Simultaneously, the trajectory of the transition between the numbers can be visualized from the side as shown in Fig. 2. The rotation angle of each servomotor is preset for each displayed number, and the transition time is set to 2 sec. This transition time was determined to drive Sujigen elegantly and as fast as possible.

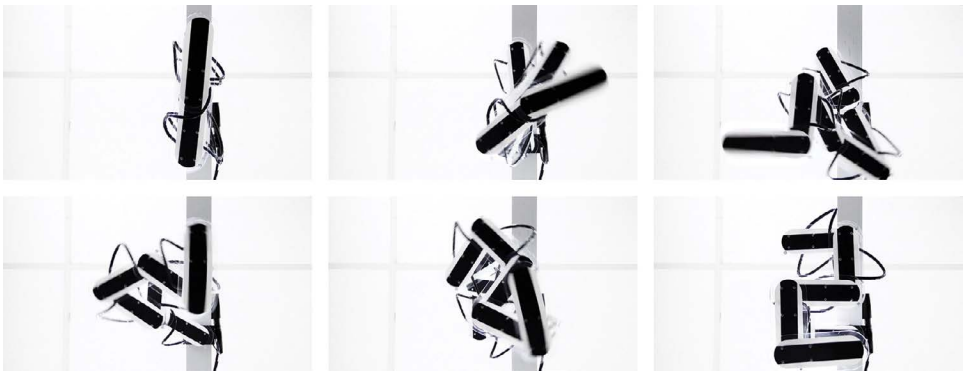

Fig. 3. Kinetic typography of Sujigen (from 1 to 2). (© Yuichiro Katsumoto)

Theoretically, it is possible to display numbers with eight segments and motors using this design; however, to avoid unattractiveness caused by parallax of its depth, and to maintain the weight balance of the kinetic mobile, we decided to add two more segments for Sujigen.

Mojigen

The second Robotype was designed for the Roman alphabet and named Mojigen (Fig. 4). A display called the vector scan can show figures on a screen using the trajectory of a rapidly moving beam. This display does not rasterize images, and therefore it beautifully expresses a line as a pure line. Similar to the vector scan display, we aimed to display letters via beautiful lines with certain anchor points. As a result, this display distinctly reflects the concept of Robotype.

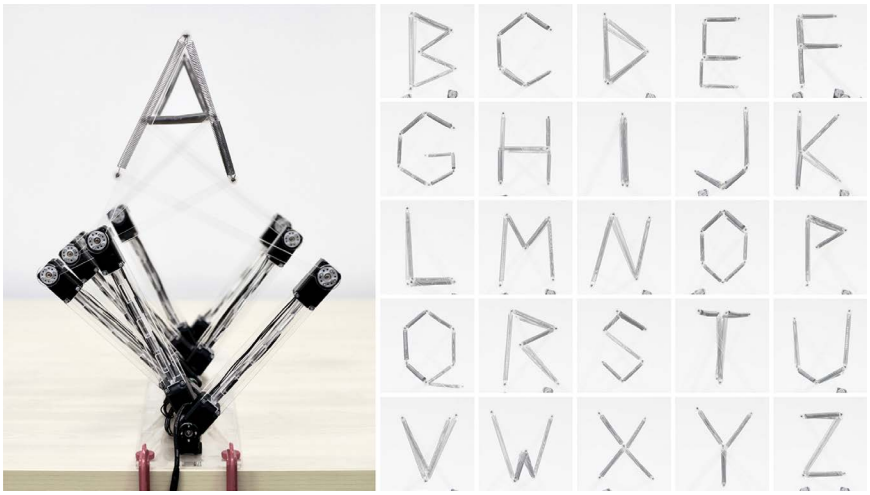

Fig. 4. Mojigen and its display alphabet. (© Yuichiro Katsumoto)

Mojigen consists of robot arms constructed by assembling transparent acrylic boards (5 mm thickness) and coil springs. Each robot arm consists of two joints equipped with the same motor as Sujigen. The design of each robot arm is shown in the left side of Fig. 5. The total length of the robot arm is 440 mm and it can move the tip arbitrarily within a range of 160 × 160 mm in air (blue and purple grid in the left of Fig. 5). This range of motion was determined by the torque of the motors and the tension force of the coil springs. The length of the arms and the motion range can be adjusted according to the motor specification.

For Mojigen, eight robotic arms are placed 60 mm apart on a long rectangular acrylic board (Fig. 5, right). This interval was set based on the thickness of the servomotor. The narrower the interval, the better the readability of the letters, as parallax is reduced.

A swivel, designed for fishing, is installed at the tip of the robotic arm; this is used to prevent twisting of the coil spring. A total of seven handicraft coil springs are installed, connecting each joint of the robotic arms. Initially, we planned to use rubber string instead of the coil springs; however, the elongation was not sufficient compared to the springs, and the rate of deterioration was severe.

Mojigen displays the alphabet in the air by moving each robotic arm to a preset position and extending the springs (Fig. 6). Similar to Sujigen, the letters are displayed to the front, with the trajectory of the movement and the elapsed time observed from other directions as shown in the right side of Fig. 5.

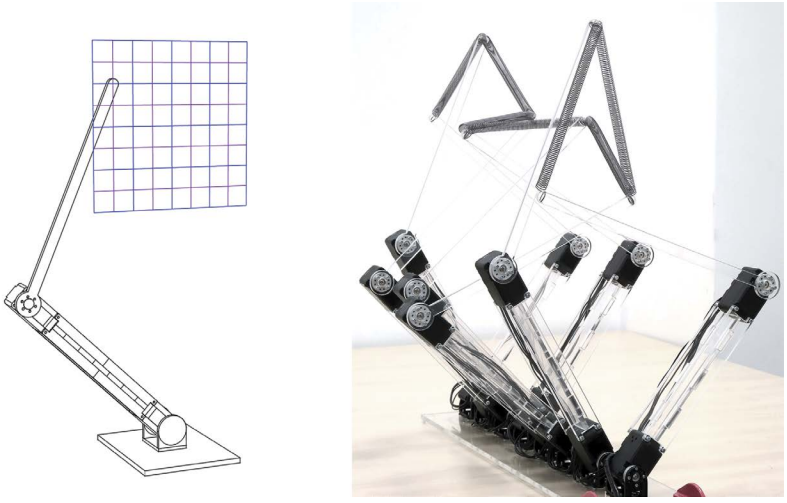

Fig. 5. Design of robot arm (left) and an actual working Mojigen (right). (© Yuichiro Katsumoto)

Unlike Sujigen, Mojigen drives each of the robotic arms from the front in turn. This is because the mechanism of Mojigen allows emphasis on the writing of the letters; those who observe this movement often comment that it is similar to synchronized swimming. The current Mojigen is designed to display capital letters. To achieve this, we decided that at least six robotic arms and five springs were required, but to display more natural and readable letters, we added two anchor points and lines.

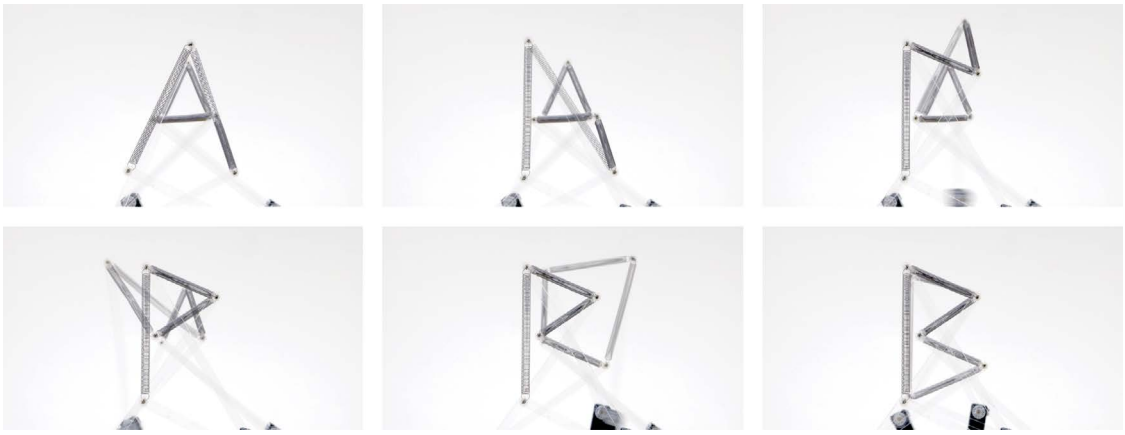

Fig. 6. Kinetic typography of Mojigen (from A to B). (© Yuichiro Katsumoto)

In the current motor setting for gallery exhibition, the work requires approximately 3 sec to display one letter. Although it is technically possible to make it faster, overheating will occur owing to the current motor limitation.

7×7

A pangram called Iroha exists in Japan. A pangram is a type of word play that uses all the letters of one language. Iroha not only uses all Japanese Hiragana characters but also expresses traditional Japanese aesthetics (impermanence/ever-changing). From this aesthetics point of view, words are like bubbles on water, and so, they are not eternal or immovable. Based on this interpretation, we decided to develop a device named 7×7 (Fig. 7) to visualize Iroha as if Iroha already is passing in a space instead of representing characters by moving them.

Current computers are able to display Japanese characters, owing to a bitmap display. Therefore, we decided to construct 7×7 based on the concept of bitmap. As a result, various characters other than Japanese can be displayed using 7×7. Further, 7×7 is able to display a split letter like "i," or a complicated curved letter like " ξ ." The 7×7 consists of 49 voxels, an acrylic frame and a moving base (Fig. 8, left). This number of voxels was selected because 7×7 displays 49 characters (48 characters of Japanese Hiragana and one blank). For displaying Japanese characters, we referred to Misaki Gothic [25], which is a license-free computer font used primarily for dot matrix display. It is possible to display characters in a relatively smooth and fine manner by increasing the number of voxels and reducing the voxels' size.

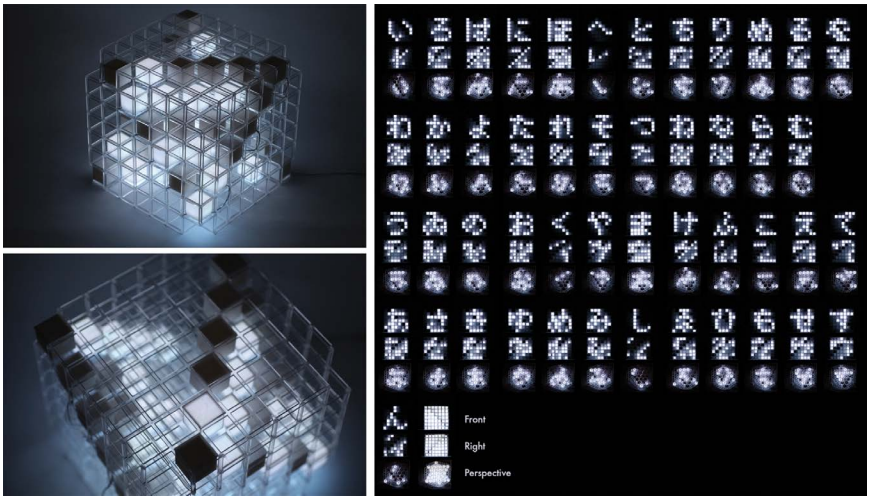

Fig. 7. 7×7 and its display Iroha. (© Yuichiro Katsumoto)

Each voxel is composed of white ABS cubes containing full color LEDs and wired to a microcontroller in the base. These voxels are arranged in a cubic structure constructed with transparent acrylic. Pixels in a conventional LCD are arranged in a plane matrix. However, in 7×7, they are arranged so that no voxel overlaps in any direction. This arrangement is realized by sequentially shifting the normal pixel arrangement in the depth direction and further reshifting a group of pixels forward

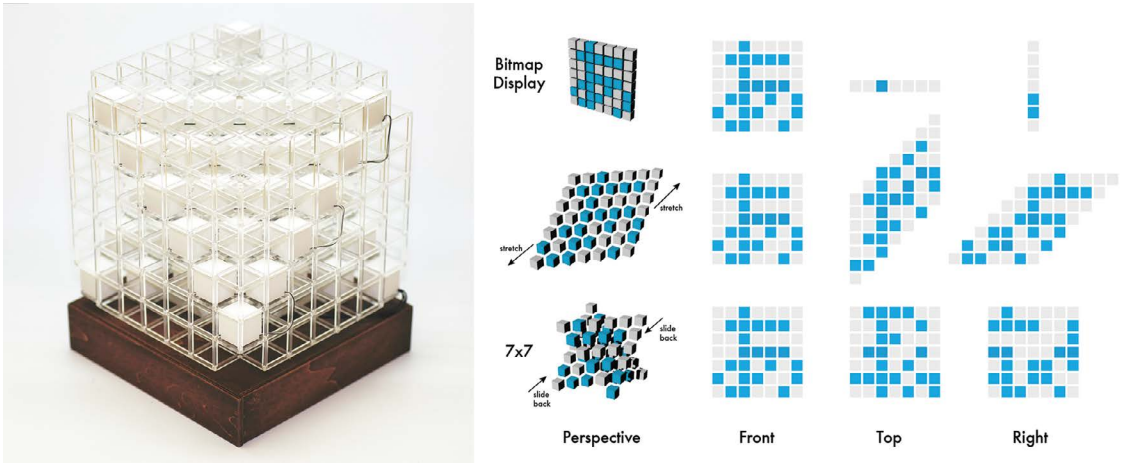

Fig. 8. 7×7 with moving base (left) and voxel shifting of 7×7 (right). (© Yuichiro Katsumoto)

(Fig. 8, right). The total size of the acrylic structure is 200 × 200 × 200 mm. Further, this structure is mounted on a moving base to rotate the structure in an arbitrary direction.

To express the impermanence of Iroha, we choreographed kinetic typography to display Iroha as being transient. The 7×7 displays Japanese characters by illuminating LEDs when Iroha is imagined as moving in space and passing through the structure of 7×7 (Fig. 9).

Thus, the LEDs gradually light from the back toward the front, and then gradually turn off in the same manner (Fig. 10). Owing to the fact that the voxels do not overlap each other, the character is displayed to the front and the fragmentation of movement and time are observed from other directions (Fig. 7, right).

The lighting point of voxels and the rotation angle of the motor are preprogrammed. Even if the cubic structure is turned via the mounting base or by a human, the characters are always displayed to the front. Therefore, to indicate that the characters are flowing in space, 7×7 rotates the structure. The moving base changes the front face of the cubic structure after every paragraph displayed in the previous exhibition [26].

Discussion

Robotype is a computer display that allows letters to coexist with time and movement in physical space. Any of the Robotypes could be used like an automaton clock. Furthermore, we believe that poetry and haiku are suitable for Robotype because they are in-between spoken and written language. We were convinced of this by displaying a meaningful pangram using 7×7.

The current Robotype follows a minimal path based on mechanical efficiency. However, choreographing its movement and timeline using a computer, Robotype can display words with the associated emotion intact. For example, the speed of movement makes it

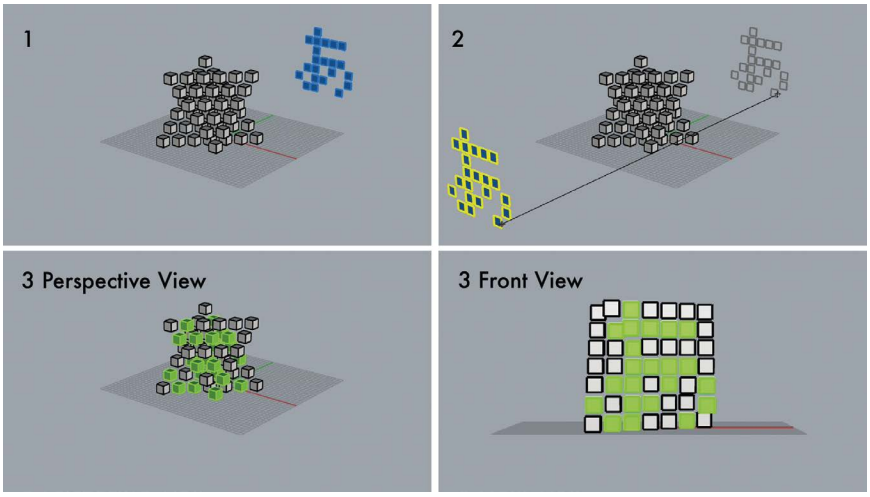

Fig. 9. Concept of kinetic typography of 7×7. (© Yuichiro Katsumoto)

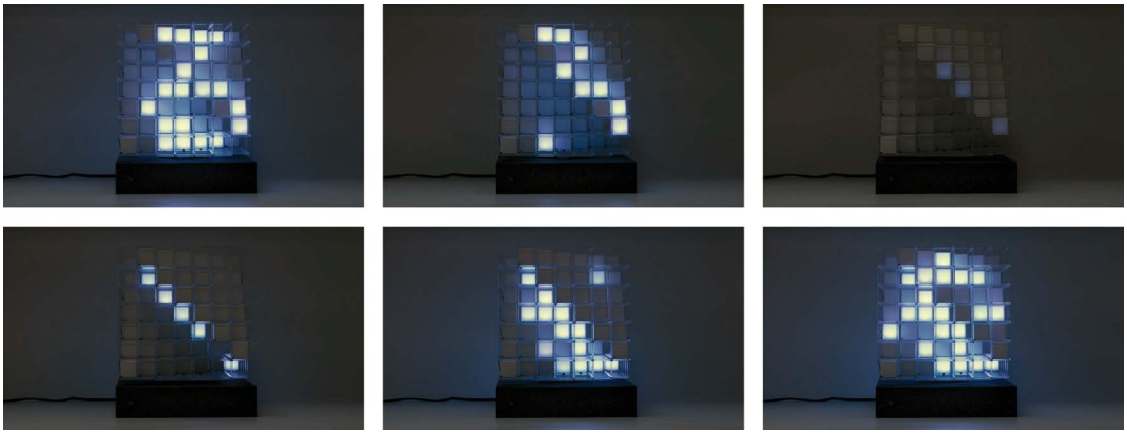

Fig. 10. Kinetic typography of 7×7 (from る to を). (© Yuichiro Katsumoto)

possible to express the gentleness or roughness of words, and the font size can express volume. To display words and lines, multiple Robotypes will stand in a line. Thus, words can be displayed similar to a group of dancers choreographed to articulate a ballet performance. This would exude presence beyond the kinetic typography in the two-dimensional monitor if it is realized. It would be interesting for poets and novelists to be able to interactively manipulate Robotype since it can materialize the artist's emotions in real time. As letters and languages inspire poets, there might be poetry inspired by Robotype too. For this purpose, we intend to develop software to animate Robotype.

Robotype is controlled using multiple actuators so that it cannot stop completely. When it seems to be stopped, it vibrates finely. It is a type of error that is caused by the twist of springs, acrylic distortion and heat accumulated in the motor, but the error provides daily changes to Robotype behavior. Several audiences commented that they perceived beauty in this uncertainty and we therefore regard this in the same manner as ink bleeding; it is a particular nuance of the Robotype.

Conclusion

This paper describes the research on Robotype, which involves a series of kinetic typography using robotics. Robotype is also a device that is able to display letters considering their time and movement. We have created three types of Robotype: for Arabic numerals, the Roman alphabet and Japanese characters. In the future, we plan to increase the number of displays and to explore how to express poetry and haiku while considering time and movement.

Acknowledgment

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Here and Now: Indigenous Canadian Perspectives and New Media in Works by Ruben Komangapik, Kent Monkman and Adrian Duke

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ABSTRACT

Examining the use of new media in works by Ruben Komangapik, Kent Monkman and the Wikiup Indigenous Knowledge Network reveals the diverse ways in which technologies are used to disrupt linear time and Western visions of history. New media works challenge those misleading stories that have been told about Canada's indigenous peoples and assert indigenous presence in both the digital and physical landscape. These artists employ QR codes, video and augmented reality to push artistic boundaries and create representations of the past and present.

Situated in the Inuit Gallery of the National Gallery of Canada, Ruben Komangapik's Sedna holds her legend (Fig. 1). Framed by the curve of her hybrid human torso and sweeping seal tail, the Inuit goddess of the sea extends a small QR code towards the viewer. Carved from stone containing fossilized shells, the material of the work emphasizes Sedna's existence since time immemorial. While the sculpture's form appears to draw on traditional practices of stone carving, *Tigumiaqtuq* displays the goddess enacting a gesture that powerfully locates her representation and her legend in the digital age.

Fig. 1. Ruben Komangapik, *Tigumiaqtuq*, 2014, stone, silver, mussel shell, ivory, National Gallery of Canada, Ottowa. (© Ruben Komangapik)

New media is employed in indigenous art to disrupt linear experiences of time and visions of history, enabling indigenous artists to share their own representations of the past and present. In writing a genealogy of indigenous new media practice it is possible to look to the history of indigenous art and to the history of new media art, yet it remains vital to acknowledge that both histories have largely been constructed from a Western perspective and through Western systems of knowledge. Historically, symbols of indigenous artistic authenticity were created through processes that essentialized and homogenized indigenous art and identity. Indigenous new media art challenges the categories of "traditional" and "modern" that are frequently applied in histories of indigenous art. Technologies ranging from video to Augmented Reality are employed by artists, not only to preserve or re-present the past, but also to imagine the future from indigenous perspectives. The use of technology locates these practices in the "here and now" and asserts that indigenous new media artists are contemporary artists. New media works by Ruben Komangapik, Kent Monkman and Adrian Duke engage with indigenous identities and histories, demonstrating the various ways in which new media can be employed to tell stories and address complex indigenous issues.

In his practice, Komangapik creates QR codes from traditional materials such as ivory and sealskin, fusing traditional processes with new media to create storytelling devices. While emphasis is often placed on how new media translates traditional stories for a digital age, Komangapik's work does not simply digitally preserve Inuit stories; it enables them to be told and accessed anew through technology. The mechanism of the QR code in *Tigumiaqtuq* allows the viewer to retrieve a video of Komangapik telling Sedna's story. The work enables a kind of participatory performance between sculpture, data and viewer; the viewer holds out their phone toward Sedna so that her myth may loop between the

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digital sphere and the active, participating viewer. The artist himself speaks through the transmission of data in the present, employing new media as an extension of the oral tradition of storytelling. As Candice Hopkins highlights in her discussion of indigenous aesthetics, these stories inhabit both the past and present: while replicated and reproduced, each enactment is nonetheless original [1]. Re-presenting the past in the present through a looping mechanism is one strategy used by new media artists to challenge conventions of linear narrative time, and to represent the ways in which indigenous stories and histories are simultaneously of the past, present and future. Indigenous new media theorist Steven Loft highlights that this "circularity of thinking and concepts of time/space and continuity" are intrinsic to an indigenous perspective of the world [2].

The disruption of linear time through a dynamic blurring of boundaries between past and present allows indigenous new media artists to challenge established Western linear narratives and colonial histories. Indigenous art, cinema and media production have responded to negative stereotypes of indigenous peoples—misrepresentations that were based on visual conventions established during the colonial period. Indigenous new media artists work not only to reclaim and challenge colonial visual conventions, but to gain visual sovereignty over the images of indigenous people that are now disseminated globally. Digital and new media enable the sampling and quotation of stereotypes, which are then subverted through editing processes, montage and reframing. Processes such as montage are historically linked to political commentary, and while no longer considered new, they are employed by indigenous artists in conjunction with new media to subvert colonial visions of history in dynamic and novel ways. Control over the representation of indigenous peoples may also be gained by indigenous artists employing the Internet to produce and globally disseminate their own representations of indigenous identity [3]. Kristin Dowell has theorized visual sovereignty as building on the concept of indigenous political sovereignty [4]. Dowell argues that the idea of visual sovereignty could be used as a wider framework within which media and art practices could be linked to broader indigenous political movements [5]. New media is therefore perceived by Dowell and indigenous new media theorists as a medium that allows indigenous artists to respond to the politics of representation, as well as to contemporary political movements.

Kent Monkman's practice exemplifies the use of moving image and new media to challenge representation and provide commentary on political situations. During Canada 150 events, one could view Monkman's *Sisters and Brothers* as part of the National Film Board's *Souvenir Series* [6] (Fig. 2). Archival footage that was itself employed as a medium to produce knowledge about indigenous peoples is recut and reclaimed by Monkman to construct a haunting critique of the residential school system. Monkman's temporal

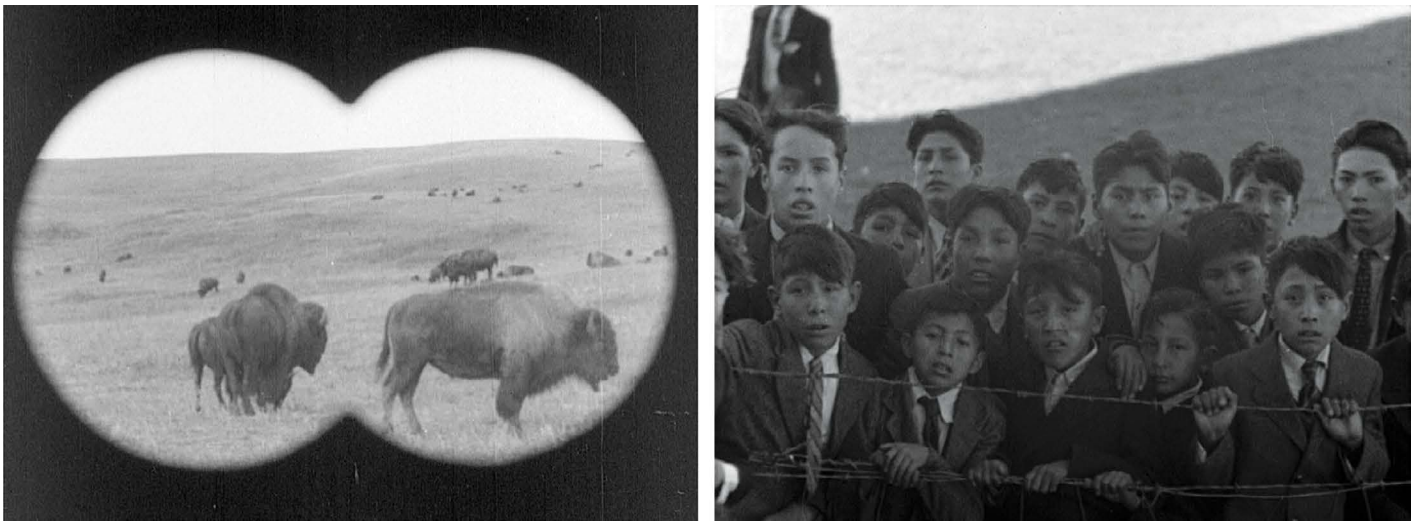


Fig. 2. *Sisters and Brothers*, directed by Kent Monkman, produced by Anita Lee, 2015, film stills. (© National Film Board of Canada Archive)

montage disrupts the colonial narrative by drawing parallels between the annihilation of the bison and the treatment of indigenous children. The work opens with a shot of an uninhabited and vast Canadian landscape. A group of settlers on horseback survey this land, followed by a shot of wild bison viewed through binoculars. In this short opening sequence, the work comments upon the view of Canada as an empty land available to be framed, claimed and settled. The subsequent footage cuts between images of bison being herded and indigenous children arriving at residential schools.

Fig. 3. Kent Monkman, *The Human Zoo*, 2015, HD monitor, media player. (© Kent Monkman)

Monkman's video critiques perhaps the most significant political policy that continues to negatively impact Canadian indigenous communities: the establishment of residential schools. Following a policy of aggressive assimilation, indigenous children were removed from their homes and placed in institutions where the use of indigenous languages was prohibited and punished. Many children felt the loss of their cultural identity and suffered moral, physical and sexual abuse at the hands of those responsible for their care [7]. The impact of the residential schooling system on indigenous communities cannot be understated, and the effects of this trauma continue to be felt. Monkman often employs montage and juxtaposition to challenge the notion that sociopolitical indigenous issues are resolved in a "post"-colonial Canada. His recent series of video paintings speaks back to static historical paintings and European representations of indigenous peoples. Displayed on media players, works such as *The Human Zoo* introduce live performers into European landscapes to reenact the European past from an indigenous perspective (Fig. 3). The series explores the fraught relationship between indigenous peoples, primitivism and modern art, the impact of Christianity on indigenous notions of sexuality, and the commercial display of indigenous peoples in Europe.

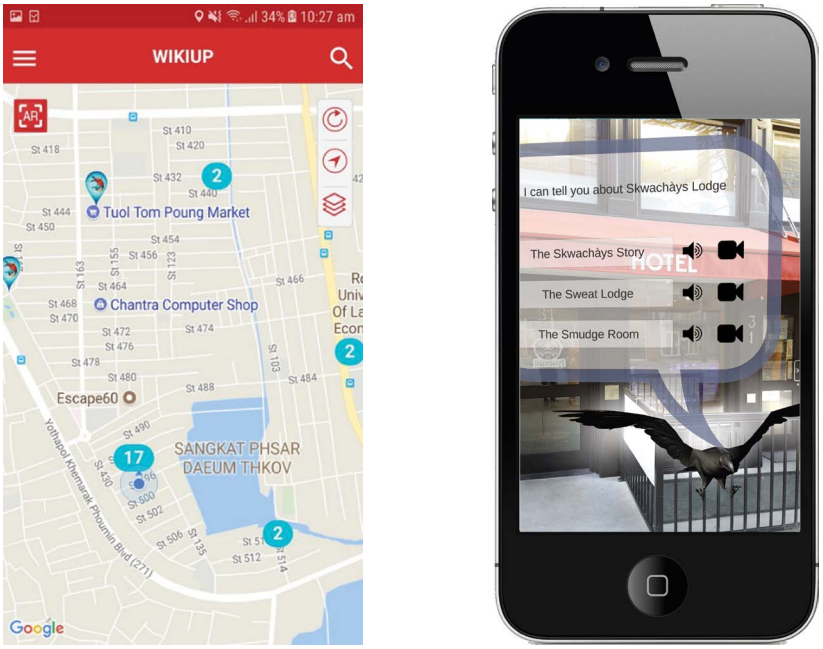
A broader concern for many indigenous new media theorists is where indigenous stories can now be located. Monkman emphasizes the importance of being able to disseminate his practice to a wider audience via the Internet [8]. Komangapik's QR code similarly allows Sedna's narrative to be disseminated through the digital sphere, allowing Sedna to inhabit cyberspace. Cyberspace is often conceived as a digital landscape, a landscape in which traditional conceptions of space and physical distance are collapsed, allowing artists to imagine new ways of being in the world [9]. While concerns are expressed over the imagined freedom that this space provides, the ability to locate indigenous stories and representations in cyberspace affords indigenous artists visual sovereignty.

Digital mapping and the use of geolocation are some of the ways in which indigenous artists can conceivably assert an occupation of cyberspace, and particular technologies enable this virtual presence in cyberspace to be overlaid onto real landscapes. The project *Wikiup* proposes to do this through Augmented Reality, an artistic medium that enables a merging of the digital sphere with lived reality [10]. Augmented

Reality (AR) works challenge conceptions of artist and viewer through the facilitation of new forms of participation. The existence of an AR work "is determined by the human presence," as viewers must locate and activate these works [11]. The medium is often employed by those artists who seek to close the gap between artwork, life and user by bringing works into the physical space of the viewer [12]. Through AR, the sites and destinations of artworks have increased dramatically in scale. While traditional video installations were dependent upon the gallery, new technology and portable screens allow works to be mapped and accessed across entire landscapes. *Wikiup* is an AR project that seeks to superimpose individual digital augments onto the Canadian landscape. The work is produced by Adrian Duke and attempts to facilitate an interaction between elders as storytellers and those who can act as digital scribes, or "story catchers." Traditional stories are transferred to cyberspace and avatars can be activated to access traditional knowledge about a specific location (Figs 4,5).

The translation of traditional knowledge through new media poses several problems, and the scope of the *Wikiup* project presents several challenges. Duke engages with the issues of verifying stories, gaining permissions to tell stories and using the medium appropriately to tell stories from different First Nations [13]. What is demonstrated by this project is that the medium of AR appears particularly suited to activating invisible histories. Through the incorporation of video and audio the application extends the oral tradition of storytelling. The work requires the viewer to occupy the same space as the augment and experience the story in real time, with the aim being to merge the story told with the physical landscape and the lived experience of the viewer. These stories therefore inhabit real space, revealing the history and memory of a landscape [14]. They allow not only for an occupation of cyberspace but for a reclaiming of the physical environment. It is augmented reality's ability to make the invisible layers of a landscape visible that will encourage viewers to reexamine the physical environment even after the application is closed.

Wikiup was launched during Canada 150 events, at the Kanata festival led by the Vancouver Native Housing Society. The festival saw the creation of an art installation on unceded land in a parking lot in downtown Vancouver, consisting of a map of Turtle Island populated by iconic indigenous housing archetypes. *Wikiup* and the Kanata festival received media coverage, which enabled the dissemination of



Figs 4 and 5. *Wikiup*, produced by Adrian Duke, AR Application screenshots, 2017. (© Vancouver Native Housing Society)

Duke's ideas to viewers outside of downtown Vancouver. Media coverage of another indigenous housing installation reinforces the politics at stake in the Kanata festival and Canada 150. In the early hours of 29 June 2017, a tepee was erected on parliament hill in protest of the Canada 150 celebrations. Art and activism reinforce the continuing struggle of indigenous peoples to assert their presence on the land and to have their stories told. AR activism currently has the advantage of allowing indigenous protesters to augment landscapes without the threat of prosecution, but as the technology becomes widespread, legislation may follow.

The question of access is often raised in relation to AR art, as the activation of the work is dependent upon both geographic location and the use of screen-based devices. Access to technologies within Canada is frequently determined by geographical, socioeconomic and political factors. It remains necessary to consider that many indigenous people still remain excluded from accessing new media art's means of production and viewing. Access to video and mobile technologies has proved fundamental to those new media artists pushing the definition of indigenous art. Digital processes and new media such as AR present numerous opportunities for artists to investigate issues of culture, memory and place. Works by Komangapik and Monkman emphasize that indigenous art is contemporary art, and that the binary descriptors of *traditional* and *contemporary*, which were previously applied in indigenous art's history, fail to reflect the complexity of indigenous practices. *Wikiup* demonstrates that new media may be used to establish an indigenous presence in both the Canadian and global digital landscapes. New media works therefore have the potential to challenge colonial interpretations of people and place as well as the history and categorization of indigenous art.

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CASTING: Site-Specific Projection Mapping Installation

Yiyun Kang

ABSTRACT

This paper investigates *CASTING*, Yiyun Kang's site-specific projection mapping installation at the Victoria and Albert Museum in London, U.K., and the acquisition of the piece by the V&A in the following year. It identifies how *CASTING* developed distinctive properties in the field of projected moving-image installation artworks and how these novel characteristics were reflected in the acquisition by the V&A.

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CASTING (2016) was an object/site-specific installation exhibited at the Victoria and Albert Museum (V&A) on two separate dates—12 February and 18 March 2016. The medium of this work is projection mapping, a relatively new projection method that can be used to transform objects—often irregularly shaped—into display surfaces. This mode of projection wraps three-dimensional surfaces, from small objects to entire buildings, with digital moving images. This exhibition was the culmination of my six-month artist-in-residency program at the V&A sponsored by Samsung. *CASTING* was acquired by the museum in 2017 as the V&A's first purchase of a projection mapping installation piece.

Background

CASTING, an object/site-specific installation regards its location—the Cast Courts, Gallery 46A of the V&A—as both the subject and object of the projection. First opened in 1873, the Cast Courts were built to exhibit comprehensive collections of casts of postclassical European sculpture, housing the V&A's largest objects (Fig. 1). As a resident artist, I was attracted to the Cast Courts' unique ontology, which led to my making *CASTING* a site-specific project. The Cast Courts have often been a source of controversy during their roughly 140-year history. For example, by 1928, the Museum considered discarding the Cast Collection because it was considered "unworthy of the Museum and [. . .] injurious to students" [1]. However, during the Second World War, some of the original pieces of art were destroyed, and in a few cases the casts remained a unique record of lost work. Accordingly, the perception of the Cast Courts began to change, and the collection has now come to be fully appreciated.

Fig. 1. Photos of the Cast Court, Gallery 46A. (Photo: Yiyun Kang)

One of my reasons for working with the Cast Courts was that its collections are reproductions rather than originals. As noted, the dominant opinions of the Cast Courts in 1920s and 1930s were unfavorable because the works were not seen as real, authentic, original pieces. This issue of copy versus original is significant in digital media,

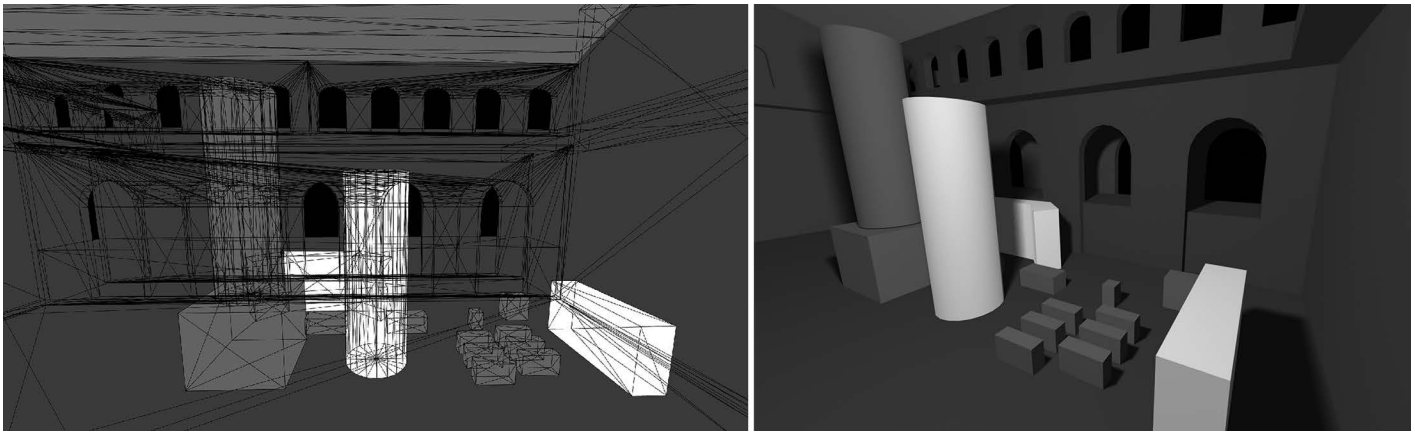

Fig. 2. Still images from 3D models. (© Yiyun Kang)

given that the notion of originality does not strictly exist in the digital realm. This ontology was also relevant for my project because the notion of originality does not firmly exist in projection mapping either, as it uses digital moving images. However, I argue that projection mapping entails a somewhat different ontology; despite its digital nature, it exists only when incorporated with its physical environment.

I titled this project *CASTING* because I intended to "cast the casts" through my digital projection, both in their given sense as artificial casts of original objects and in terms of "casting" as enlisting them as actors in a moving-image production.

Process

I began the project by measuring the real space and building a virtual model of the entire gallery (Fig. 2). Based on this real and virtual exploration, I decided to map three individual casts: Trajan's Column, the Western Portal of the Cathedral of St. Sauveur and the Shreyer-Laundauer monument from St. Sebaldus. In choosing these, my concern was to generate an overall environment because the primary focus was the meaning of "cast" as situated in the Cast Courts rather than the specific content of the selected casts.

In producing animations for the three casts, I used Maya software, a Non-Uniform Rational Basis Spline (NURBS) program used in computer graphics for generating and representing curves and surfaces in virtual environments (Fig. 3). Alicia Imperiale explains that NURBS software is based on a dynamic system in which shapes are morphed in shifting relation to a surface [2]. The use of NURBS software in *CASTING* thus enabled me to focus on creating the structural sequences to fit each of the projection surfaces of the three casts. As a result, I produced black-and-white animations that are composed of dynamic movements of geometrical shapes devoid of any reference to the real.

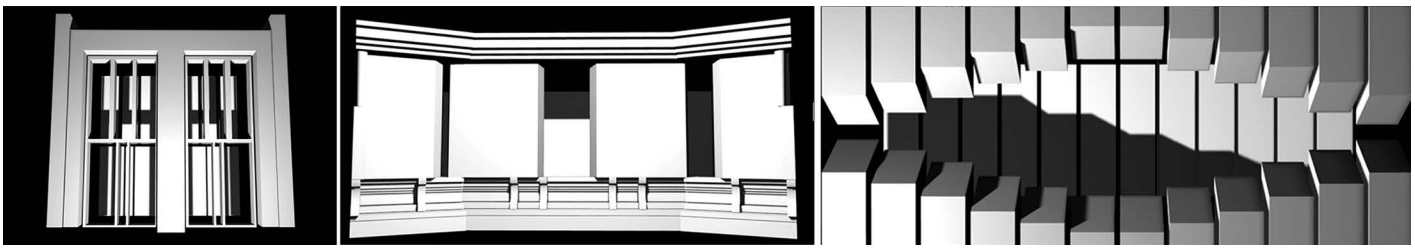

Fig. 3. Still images of final .mov files of the three casts. (© Yiyun Kang)

I then used real-time surface-mapping software, MadMapper, to merge the separate animations. In *CASTING*, MadMapper created virtual surfaces, assigned moving images to them, and projected them onto the real surfaces of the three casts. Consequently, the entire process demonstrates that *CASTING* was developed in tandem with the investigation into the contextual and formal features of the chosen projection surface and space. To achieve my intended result, I gave equal consideration to the historical context of the Cast Courts and the physical conditions of the site and three casts.

Analysis

As seen in Fig. 4, the three projections intervened in the Casts without physically altering them. This integration of the projected moving images and site was enabled by my refusal to use a canonical screen circumscribed by a rectangular frame. Instead, I augmented the surfaces of the three casts by using them as projection surfaces.

Andrew V. Uroskie argues that screen-based projected moving-image works have two different places: the "represented place" inside the screen and the "taken place" outside the screen (the actual location of the screen) [3]. Due to the rectangular screen that demarcates the two discrete sites, the represented site and the exhibited site cannot be integrated. Anne Friedberg writes that the screen's frame marks a separation—an "ontological cut"—between the view contained within the frame and the outer space [4]. In this system, a frame draws a boundary that divides the real world from the world of moving images. Distinctively, *CASTING* does not bring a viewer's gaze to a separated reality contained inside a screen. Rather, it incorporates the surfaces of the volumetric casts for projection and thus merges with the surrounding environments.

As the production process shows, *CASTING* is conceptually and formally integrated with the specificities of the projected surface and surrounding space. This character is reflected in the 3D-rendered moving images created for *CASTING*. It is useful to visit the term "indexicality" in understanding this. In the context of photography and cinema, indexicality has been regarded as the guarantee of film's privileged relationship to the real, or to referentiality [5]. In this perspective, "digital" is regarded as an increasing threat and has even been announced as the "death of cinema" [6] that erodes the very nature of filmic and electronic moving images anchored in indexicality and claims of truth because digital technology can create perfect photographic credibility without real footage [7].

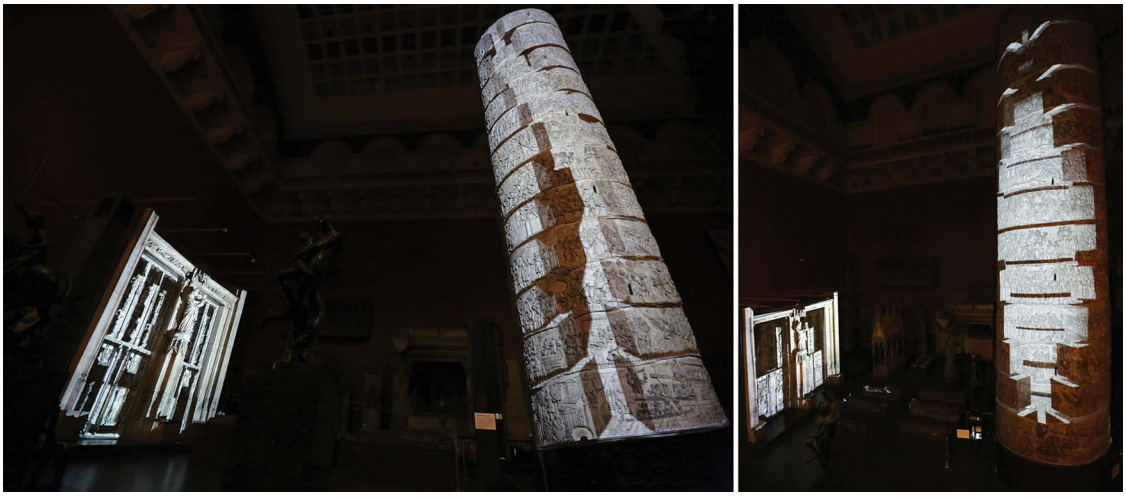

Fig. 4. Casting, 2016. Installation view. (© and Photo: Yiyun Kang)

In contrast, I found that *CASTING*'s 3D digital animations established a distinguished type of indexicality. As seen in Fig. 3, the abstract sequence itself does not contain a reference to the real world outside of the screen. However, the animations are particularly responsive to their screens—the three casts as projection surface. In this system, rather than finding the indexical reference in the outer world, the screen itself becomes an index for moving images. This indexical relationship between the casts and animation originated from my creative intention, which was to "cast the casts" through the projected moving images. To "cast," by definition, is to "shape metal or other materials by pouring it into a mold while molten." I cast the casts through projected light and shaped them by superimposing structural digital moving images onto them. As a result, the 3D animation in *CASTING* does not discard the notion of indexicality in moving-image works. Rather, it introduces a novel type of indexicality in digital moving-image works by opening up a conceptual and formal dialog between the moving image and its screen.

As a result, this structural sequence transformed the narrative of the casts. Trajan's Column, for example, depicts a continuous narrative of the Dacian Wars. The pictorial narrative spirals along the column in a single frame. The Shreyer-Laundauer monument follows the serial narrative structure of a triptych. In a triptych formation, thematic importance rather than chronological order determines the centrality within the scene. In contrast, *CASTING*'s structural moving images transformed the continuous narrative of these casts into a spatiotemporal narrative by adding a durational dimension to the space. Therefore, while the projectors were running, projection surfaces (casts), moving images (structural sequences) and space (the Cast Courts, Gallery 46A) formed an inextricable relationship. They simultaneously supported *CASTING* as a whole in dramatizing the original space and transforming it into a temporally augmented space by superimposing the virtual space onto the real space. If either of these constituents had not been linked, the intended installation could not have been achieved.

Seen in this light, *CASTING* can be aligned with James Turrell's notion of "viewing chambers." This term underscores how a viewing experience can be configured spatially, not as "looking at" but as "looking into" [8]. "The surfaces turned into chamber, became habitable space" in Turrell's light installation [9]. In this view, to use Giuliana Bruno's description, *CASTING* engenders a "projective environment" mediated by the surface through the projected moving image that turns "the art of projection [into] a durational, relational experience that is materially sited" [10] (Fig. 5).

Acquisition

CASTING was acquired by the museum in September 2017. Since this was the V&A's first purchase of a projection mapping installation piece, there were several issues to resolve. According to V&A curator Dr. Rosalie Kim, who led the acquisition process, the primary reason for this purchase was because "*CASTING* is a projection mapping (new territory for the Museum) specifically designed for the V&A's collections, engaging the audience by its strong immersive qualities despite using complex digital techniques and logistics" [11].

Due to the complex technical requirements of this project, we established a detailed manual for its installation and preservation and considered alternatives to prepare for future practical and mechanical problems. Execution issues were also prioritized in the discussion. For example, we decided that the particularities of the hardware and file formats used in the real exhibition can be modified following technological obsolescence as long as the outcome meets the artist's requirement. Additionally, I provided a technical demonstration of the mapping process to the curators involved in the acquisition process to give them a basic understanding of projection mapping installation work so that they can adjust their fundamental knowledge even after the employed techniques become unavailable.

Beyond these technical matters, the more significant concern was the conceptual aspect of the project. As such, the critical issue was to find the best way to preserve this nonmaterial, ephemeral projection mapping installation without losing its conceptual essence that is specific to the contexts of the museum's collections within the Cast Courts. Subsequently, the V&A decided to collect the entire process of this work, from the first stage to the final one. The purchased package included hand drawings, computer-drawn diagrams and sketches, virtual 3D models, physical models, final digital files for the exhibition (animation and sound files), and documentary materials such as photos and films (Fig. 6). The work of wrapping artist Christo is useful in understanding this outcome. The drawings and photographic collages that accompany Christo's real installations are not merely witnesses to or post-products of his works' existence; rather, they are formative constituents that collectively complete the works. He has described his projects as having two distinct periods—the "software" period and the "hardware" period—and explained that the software period is important because it is "exactly the moment when the project exists in the drawings as an expedition" [12]. Even though the tool is different, *CASTING* similarly includes a "software" stage that was demonstrated in multiple formats, as detailed above.

Fig. 5. Casting, 2016. Installation view. (© and Photo: Yiyun Kang)

Therefore, the V&A's acquisition identified that both the final exhibition materials (hardware stage) and the complete developmental cycle (software stage) were accepted as inseparable entities for the optimal preservation of the project. The course of the acquisition showed that the conceptual part of the work and the employed technologies cannot be detached because together they offer technical and conceptual support for *CASTING*. The use of software applications equipped me to investigate the creative connections between

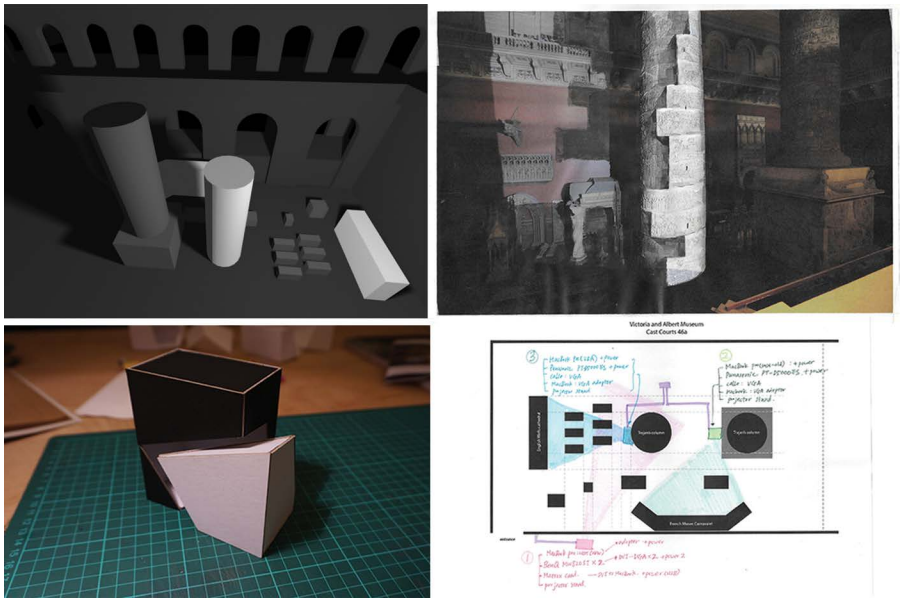

Fig. 6. Selected image from the final collection package: (clockwise from top left) 3D modeling image, sketch, installation diagram, physical model. (© Victoria and Albert Museum. Photo: Yiyun Kang.)

moving image, projection surface and surrounding space and thereby informed an inextricable relationship with the space. As Kim explains,

> Acquiring the entire process allows a deeper insight in the thinking, designing and making process behind the artwork, showing the fine balance between drawings, writings, physical models, digital sketches and coding. As a museum of art and design, this part is of great interest for both curators and audience alike [13].

This acquisition demonstrates a model for future cases of archiving, preserving and documenting projection mappings and similar types of work. As detailed, technical and conceptual concerns were raised during the process of acquisition. Similar and even more challenging issues have arisen across the digital field, so this acquisition was an opportunity to face these issues properly, in a collective way, through discussions within the museum. This project would have not been possible without the help of people at the V&A and Samsung's sponsorship that had supported my residency, exhibition and acquisition.

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Entropy and FatFinger: Challenging the Compulsiveness of Code with Programmatic Anti-Styles

Daniel Temkin

ABSTRACT

Coding, the translating of human intent into logical steps, reinforces a compulsive way of thinking, as described in Joseph Weitzenbaum's "Science and the Compulsive Programmer" (1976). Two projects by the author, Entropy (2010) and FatFinger (2017), challenge this by encouraging gestural approaches to code. In the Entropy programming language, data becomes slightly more approximate each time it is used, drifting from its original values, forcing programmers to be less precise. FatFinger, a Javascript dialect, allows the programmer to misspell code and interprets it as the closest runnable variation, strategically guessing at the programmer's intent.

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We Are All Trash Coders

> **The psychological situation the compulsive programmer finds himself in while so engaged is strongly determined by two factors: first, he knows that he can make the computer do anything he wants it to do; and second, the computer constantly displays undeniable evidence of his failures to him.**
>
> **—Joseph Weizenbaum, *Science and the Compulsive Programmer* [1]**

We may all be compulsive programmers, or "computer bums" as Weizenbaum describes them. It has long been accepted that perfect code is not possible; that all code contains bugs, relies on libraries that have bugs, runs on operating systems with lurking bugs, waiting to be revealed. The modern approach is to manage error, rather than attempting to eliminate it. Yet when one writes code, there remains a nagging sense that there's a "right" way to write it, an approach that's always just out of reach, a perfect expression of our intent in discrete rational steps. As Wendy Chun describes, this ideal and our journey toward it is central to what makes coding pleasurable. "Every error leads to another," so that "programming becomes a technique, a game without a goal and thus without an end. . . . Hacking reveals the extent to which source code can become a fetish: something endless that always leads us pleasurably, as well as anxiously, astray" [2].

In a recent reddit programming thread on "controversial opinions," the top (most upvoted) comment was the opinion that programmers make up architectural problems out of boredom. One of Weizenbaum's telltale signs of compulsive coding is finding new faux-problems to solve. The second most popular was "Most programmers are bad at what they do, especially the ones that think they aren't," with many responders admitting to being bad themselves—bad, yet better than their contemporaries: "i'm a trash coder and i'm one of the best in the world." Is writing code as hard as this? What is a good coder, and why are they so rare (if they exist at all) [3]?

If coding is so hard already, it might be surprising that over-architecture would be one of the biggest issues for programmers, to the point that the idea of software architecture needs to be defended [4]. However, these two points are connected. Precision is the dominant aesthetic of code, and architecture is the aesthetic of control. It gives code the look of exactitude, of well-organized thought, with the hope that actual clarity will emerge. If control of the machine is illusory, if we can't easily identify the faults in our code, we try to design it away, sometimes going too far. We write clean-looking code, obey the latest software patterns, to invoke a feeling of control, yet never driving out the bugs, which lurk in our own programs, their libraries, their compilers, operating systems and the physical hardware below. We're all trash coders.

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My two computer art projects are programmatic anti-styles: attempts to work against received ideas of how code performs and how it should be written. Entropy (2010) and FatFinger (2017) address the compulsiveness of code by working against the norms of programming. They make it impossible to indulge the illusion of control. They ask the programmer to give up precision, to use broader gestures in how intent is expressed to the machine, bugs and all: in FatFinger through the way code is written, and in Entropy through how it performs.

Entropy

At first glance at its code, Entropy appears a conventional language, a C clone with a nod to Pascal. However, the behavior of Entropy is very different from mainstream languages. Each piece of data, whether assigned to a variable or used as a constant, is a limited resource. Each time they are accessed, they become less precise.

The name Entropy refers to Claude Shannon's concept of information entropy, or uncertainty. A (possibly apocryphal) story tells that von Neumann suggested the term to Shannon because it's a "solid physics word" and that "no one really knows what entropy really is, so in a debate you will always have the advantage" [5]. This seemed particularly fitting for a language dealing with ambiguity of meaning.

The approach an Entropy programmer takes to get her program to run is very different from programming with traditional languages. She needs to abandon the pursuit of precision—often working against years of habit—in order to program effectively. The programmer has, at best, a short window to get an idea across before the program's data corrodes. Well-architected code is possible, but pointless. The program itself is not altered, so the next time it runs, when variables are redeclared and flushed with data, that data is in its original condition, only to decay again.

This is accomplished by storing all data as floating-point numbers or floats. Integers are stored as floats and rounded back to ints when they are used. Characters, ordinarily stored as integers (in Unicode, the character "A" is stored as the number 65) are floats as well (65.0). Each time they are accessed, to change the value, to print it, to compare it, or any other use, a small amount of variation is introduced, sometimes remaining at 65.0, but as much as 0.5, enough to tip an A to a B. The mutation rate is configurable in the compiler, although the default of 0.5 cap is rarely altered. This means that the logic of the program is the same as how the programmer wrote it; the looping, functions, the overall program flow, are not altered, only the use of the data in the program that is affected.

Seeing Entropy in action gives a better sense of what this means. The *99 Bottles of Beer on the Wall* program is a common second program for new languages, after programmers learn to write "Hello, World!" to the screen and want to see how iterating functions in the language. At the beginning of the run of the *99 Bottles* program in Entropy, we are already approximating, although it's only the iterator that looks odd on the first line, printing as 98.99005 (in this particular run,) rather than 99 (Fig. 1). The third line begins to have other recognizable breakdowns in the text, although the meaning is still clear. By 67, it becomes a challenge to read (Fig. 2), and by the end, it has collapsed into textual chaos. This is the end of the program (it looks like it got to eight and then died) (Fig. 3).

This jumble of random text is a frequent ending point for Entropy programs, as the more the same text is used, the more "off" it goes. The iterator (the counter 99, 98, 97, etc.) may slowly drift upward, but sooner or later, the program will halt; the force of the decrementation is stronger than the variable drift, as one is directed and the other erratic. Some programs might have far more radical failures in execution, but Entropy programs are generally more stable, in terms of actual halting, than one might expect.

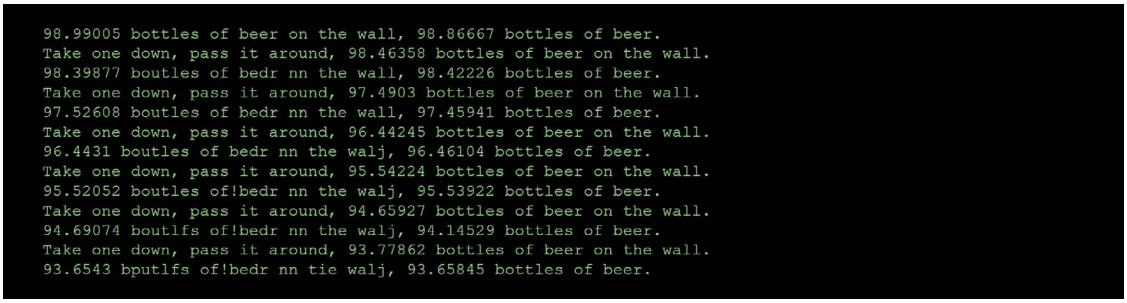

Fig. 1. *99 Bottles* begins. (Screen capture by Daniel Temkin)

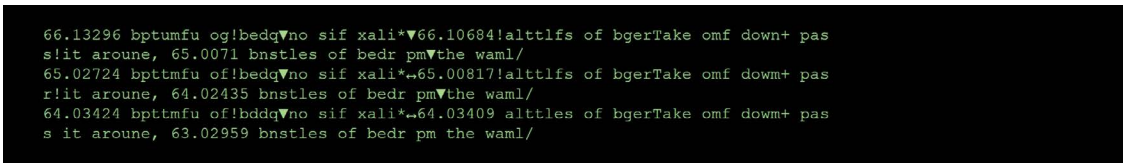

Fig. 2. *99 Bottles* with 67 left. (Screen capture by Daniel Temkin)

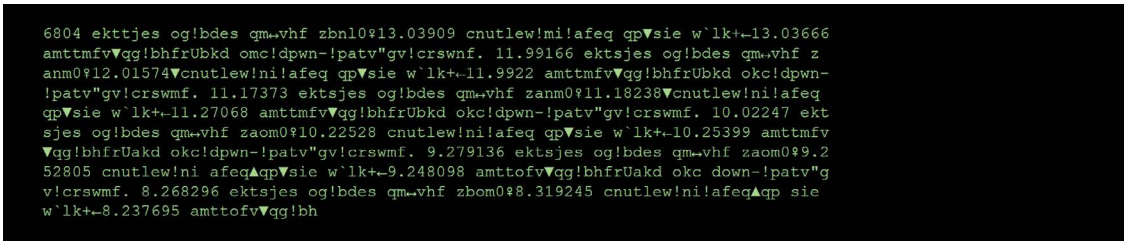

Fig. 3. *99 Bottles* completes. (Screen capture by Daniel Temkin)

Entropy draws from languages with self-modifying code, such as Malbolge, designed to be the most difficult language to program in. In Malbolge, each program runs as a large loop, with every command firing many times. When a command executes, it alters its behavior, keeping the source code in constant flux, delivering different behavior with every iteration [6]. From a more practical standpoint, the OISC (One Instruction Set Computer) languages are also self-modifying, where the source code and the data the program operates on are one and the same, in the interest of a minimalist physical architecture. As challenging and nonintuitive as these languages might be, they are still Turing Complete, meaning capable of representing any algorithm runnable on a conventional machine. Entropy is not Turing Complete, nor does it belong to any of the more limited categories of computational complexity, because the language is probabilistic: we can't describe a set of algorithms it can perform, even in an idealized, virtual space, since the same code will produce inconsistent results from one run to the next [7].

In that respect, it is informed by glitch art practices that undermine the objectivity of the machine. Entropy was inspired in part by the work of the Dutch glitch duo JODI and was initially presented at the GLI.TC/H 2010 Conference in Chicago. Curt Cloninger's essay written for that conference says that "The glitch foregrounds and problematizes this myth of pure transcendental data, of pure and perfect signal. The glitch is a perpetual reminder of the immanent, real-time embodiment of executed code" [8].

Drunk Eliza

As Entropy was inspired by Joseph Weizenbaum's writing, it seemed natural to see how his most famous program, the chatbot Eliza, would function rewritten in Entropy. Eliza is an extremely simple program which, regardless, is seen as having a personality, something which Weizenbaum found disturbing. I wondered what personality Eliza would have, written in code where her databank decays over time. Would it be like HAL's slow degeneration in 2001, intelligence reduced to a sad shadow of itself? Or something entirely different?

Given the simplicity of the program, with no iterators to corrupt, the program behavior remained the same, apart from an occasional random crash. Much more prominent was the steady decay of her responses, resembling the slurring of words, which inspired the name change to "Drunk Eliza." Once it was put online, the response to the program was fascinating to see. I did not record people's conversations with Drunk Eliza, so my evidence of the conversations they had were from public sources revealed by the users themselves, including a Metafilter thread where many posted their conversations with the chatbot [9].

The labels used in conversation, "YOU" and "DRUNK ELIZA," are themselves Entropy variables, and, as the most commonly used words in the program, their decay becomes a good marker of how long the program has run, and advanced Eliza's banks have corroded. From the Metafilter thread, here is an excerpt by a user with the handle 0xFCAF:

YMU: aw geez you should drink some water
ERTNK ELIZA: #PH, I SHOULD DRYOUNK SOYOU WATER
YMU: yup that
ERTNK ELIZA: #CAN YOU ELABORATE ON THAT?
YMU: hey you're sounding better, let's do shots
ERTNL ELIZA: #DOET IT*QLEASE YOU TO BELICVDI AM SOUNDING BETTER, LET'S DO SHOTS
YMU: WHOOOOO
ERTNL ELIZA: #COME COME!ELUCSDATE cOUR THOUGHTS.

This style of response was the most common; as Eliza's databanks devolved, people would respond in a similarly "drunken" manner, often by mashing keys. As the Metafilter discussion progressed, however, it took only a few entries before guys began hitting on Drunk Eliza, starting with a user who quickly followed up with:

> i'm spending my saturday night trying to seduce a drunk adaptation of a chat-bot coded in 1985. what has become of my life.

What originally seemed good-natured became less so as the tendency to hit on the chatbot became more pronounced. This was remarked on by user Blasdelb:

> There is something pretty profoundly disturbing to me that, upon the creation of a drunk program with a female name, our first impulse is to either attempt to "seduce" her or coerce her into other sexual acts.

These two inclinations; the one toward writing in a drunken way, and that of hitting on the chatbot, sum up nearly all of the interactions I've seen posted online. The fact these are all shared publicly (again, I don't track conversations on the site) makes it more disturbing that this is the type of conversation people decided to share.

Drunk Eliza was designed to bring the experience of the Entropy programming language to non-programmers; but putting a work into the public space sometimes means the public will bring the work to a very different place than the artist had intended.

Entropy.JS

Programming languages are particularly open to reinterpretation by others. A programming language is nothing more than a lexicon paired with syntactic and semantic rules. Esoteric languages are sometimes released simply as the ruleset, with no specific implementation as a working compiler or interpreter. Once a language is released, it is hoped that others will write code in the language to explore it, and sometimes create their own implementations. As an esolanger (a creator of esoteric programming languages), this is what one hopes will happen, that the language will be used by others. It is a true collaborative form.

Andrew Hoyer, a programmer and designer I was not familiar with before this project, created his own partial implementation of Entropy, using Javascript. Rather than writing a full interpreter in JS, where the entire Entropy language could be recreated in style and syntax, Hoyer chose to make a JS library, so that the code is written in Javascript, and selectively enforced, by adding an "Entropy watcher" to specific variables.

It is worth noting how different this approach to adaptation is from how digital art is appropriated within the art community. Hoyer decided what was important about Entropy: its behavior, not the aesthetic of the code itself. While there were aesthetic considerations to the code style—the banal and awkward Pascal/C syntax I selected was a considered design choice—I agree with Hoyer's assessment that this is not the essential aspect of the work, and that the trade-off in allowing it to function within Javascript is to the language's advantage. Working with Javascript not only makes the language more widely available, it also opens up the language to visual content, which would be a struggle for the original Entropy compiler, written for the .NET compiler.

On Hoyer's site, the Entropy.JS language is used to animate a set of variables, expressing visually the randomized numeric changes. He has an image of the Mona Lisa (Fig. 4), which is activated as one mouses over it, becoming blurrier and more approximated. Even the title of the page, "Entropy," slowly decays, updating its random changes immediately to the screen. This is all possible only by picking and choosing which aspects of the page are Entropic and which are controlled by conventional Javascript. It nicely brings the experience of the Entropy language to nonprogrammers.

Fig. 4. *The Mona Lisa in Entropy.JS*, after several minutes of mouse-over action. (© Andrew Hoyer. Screen capture by Daniel Temkin.)

FatFinger

Human readers have a high tolerance for elision, for swapping of letters, or missing symbols, as natural text obfuscators like SpellFucker [10] have shown. Programming languages generally have no tolerance for this. The history of obfuscated code and of esoteric programming languages are breaks from clarity of presentation; however, they are still written in languages like C; the code below might be inscrutable, but it is still exacting; it looks random, but if the wrong "magic number" is used, it will not run as intended [11,12].

```
main(a,b)char**b;{int c=1,d=c,e=a-d;for(;e;e--)_(e)<_(c)?c=e:_(e)>_(d)?d=e:7;
while(++e<a)printf("\xe2\x96%c",129+(**b=8*(_(e)-_(c))/(_(d)-_(c))));}
```

—A tiny implementation of command-line "sparkline" data visualization; an IOCCC winner, 2013. David Lowe [13]

With common debates such as tabs vs spaces, programmers have long brought their compulsive habits in trying to placate the compiler to bear in attempts to organize their thoughts into logical style. Javascript has been a constant headache for programmers who want to impose such order. It is an unruly language, with dynamic typing and implicit declarations. Mistype a variable name when assigning a value, and a new variable with the typo'd name is created. Compare an integer with a string and you'll get nonintuitive results. Language supersets like TypeScript and frameworks like JQuery and Angular try to reign in JavaScript's unmanageability, as do modern integrated development environments (such as Visual Studio Code), which helpfully indicate possibly unintended statements with IntelliSense squigglies.

On the opposite site, we have projects like Martin Kleppe's JSFuck project, a coding style for Javascript that illustrates how just a few punctuation signs are themselves a Turing Complete dialect, due to quirks in the JS language; something certainly unintended by Javascript's designer. The similarly critical piece, FuckIt.JS, "corrects" Javascript code by steamrolling it—any line that can't be interpreted as JS is commented out, until something fully runnable emerges. While FuckIt is primarily a joke about frustrations of the language, JSFuck is a simple and beautiful observation about the language, which is only successful because of a host of nonintuitive rules in the JS language [14].

In 2017, I created FatFinger, a Javascript dialect which allows for scrambled and seemingly nonsensical text to function as JS. The interpreter analyzes each line of code and finds the closest word for each unroecognized token, translating it behind the scenes into runnable JS. This allows the programmer to write in a sloppy, but human, style, full of typos. FatFinger guesses at the programmer's intentions.

The sample Hello World program for FatFingerJS looks like this:

```
<script type="text/javascript" src="fatfinger.js"></script>
<script type="text/javoscript"> // any misspelling of javascript works here

   vart x = "herrrllo werld"
   dokkkkumint.rit3(xx)
</script>
```

At the top is the inclusion of the fatfinger.js library; this needs to be typed correctly (or cut and pasted from another source) in order to include and invoke the library. The second script block works with any misspelling of Javascript—be careful not to spell it correctly, or the rest of the code will be read as regular Javascript, not FatFingered JS. From there, the variable x is declared, with "vart," a misspelling of "var," and its value is printed to the page with a variation of "document.write." Semicolons are not included at the end of each line.

FatFinger uses Damerau-Levenshtein Distance, a string metric for measuring the edit distance between two sequences. It is an indicator of how many changes are needed for one word to become another: insertions, deletions, transpositions, or substitutions of a character within a word. Since it has a limited vocabulary, it allows for changes that fall very far from the original word (such as "dokkkkkkkkkkkkkkkkkkumint" for "document") that are connected by a phonetic relationship (to us) but succeed within FatFinger because it happens that there's no other word similar enough to "document" (that has, say, a big long line of k's) to match against.

This *99 Bottles of Beer* program has typos of the words *if*, *bottles*, *console* and *counter*:

```
var bottles;
for (var counter = 99; contr >= 1; counter = counter—1)
{
        if (counter == 1) {
                botles = 'bottle';
        } else {
                bottles = 'bottles';
        }
        constole.log(counter+" "+ bottless +" of ber on the wall.");
        if (countr < 99) {
                conssole.lg("");
                consoles.logg(counter+" "+ botttles+" o beer on the wall.");
        }
        conable.log(counter+" "+botttttttles+" of beer.");
        console.lo("Take one down.");
        console.log("Pass it arund.");
        ift (ount == 1) {
                console.log("No botles of beer on the wall.");
        }
}
```

Lacking true reflection, there's no way in Javascript to find everything in scope at the moment. Instead, FatFinger's interpreter looks to the Window object, which contains every object in scope, and uses this to get a list of eligible variables. In addition, it tracks each variable as it's declared and keeps that in its list of eligible words. While FatFinger attempts to track scope, it is not great at scope, which further encourages developers to declare everything at the highest possible level (essentially globally). This is considered a poor programming practice, but is right in line with FatFinger's approach to code.

Part of the inspiration for FatFinger was seeing how art students new to Javascript actually use the language. At a class visit with Paul Hertz's Artware class at School of the Art Institute of Chicago in 2015, I observed student projects written in Javascript by undergraduates with varying levels of skill with the language. Since the assignment allowed for incorporating existing JS programs found online, many beginning students chose to cut and paste found scripts in a patchwork that did more or less what they wanted their code to do and adjusted them to work together and better fit their design. This led to code that was not organized well, full of declared variables never used, no logical structure—a mess of code, but an empowering one, allowing nonprogrammers to shape code before developing the skills necessary to completely rework it.

Where Entropy has to be written correctly, to run erratically, FatFinger is written erratically, to execute exactly as it would with well-written JavaScript. As it is still a new language, the way it will be used and abused by programmers has yet to become apparent. The hope is that its critique of code will resonate with programmers and others ready to reevaluate their relationship with the machine.

Conclusion

No discipline brings the inherent irrationality of human thought to the forefront more directly than programming. The style of most programming languages is aspirational; they connote orderliness and structure, in the face of heaps of evidence that bugs are endemic to code. This creates the perfect structure for human pseudo-logic to run wild.

Both these projects speak to the actual experience of coding, which is fraught with error. Entropy makes error inevitable, while FatFinger tolerates a sloppiness of text (and of the thought behind it) that ordinarily would never pass muster with the interpreter. They work against the compulsiveness of programming. They encourage a style that is more accepting of the inevitable presence of error and of the limited capacity of the programmer to control the machine.

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Advertising Positions: Data Portraiture as Aesthetic Critique

Daniel C. Howe, Qianxun Chen and Zong Chen

ABSTRACT

Advertising Positions integrates 3D scanning, motion capture, novel image mapping algorithms and custom animation to create data portraits from the advertisements served by online trackers. Project volunteers use bespoke software to harvest the ads they receive over months of browsing. When enough ads have been collected, the volunteer is interviewed, 3D scanned and motion captured. Each ad is then mapped to a single polygon on the textured skin of their virtual avatar. Outcomes have been displayed as 2D/3D images, animations and interactive installations.

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Advertising Positions synthesizes several areas of emergent technology: 3D scanning, motion capture and novel image/texture mapping algorithms to explore the problematic dynamics of online tracking by marketers, then renders this data contextually, as portraits and animations in 2D and 3D (see Fig. 1). For each user, our software collects the ads they are served over months of daily browsing. Once enough ads have been collected (several thousand in the examples discussed), the volunteer is 3D scanned and motion captured, then skinned with their unique set of advertisements, according to a mapping process that minimize the distortion of ads and maximizes correspondence with skin tones. The result includes still and moving images that synthesize technical, conceptual, and aesthetic elements in a cohesive fashion.

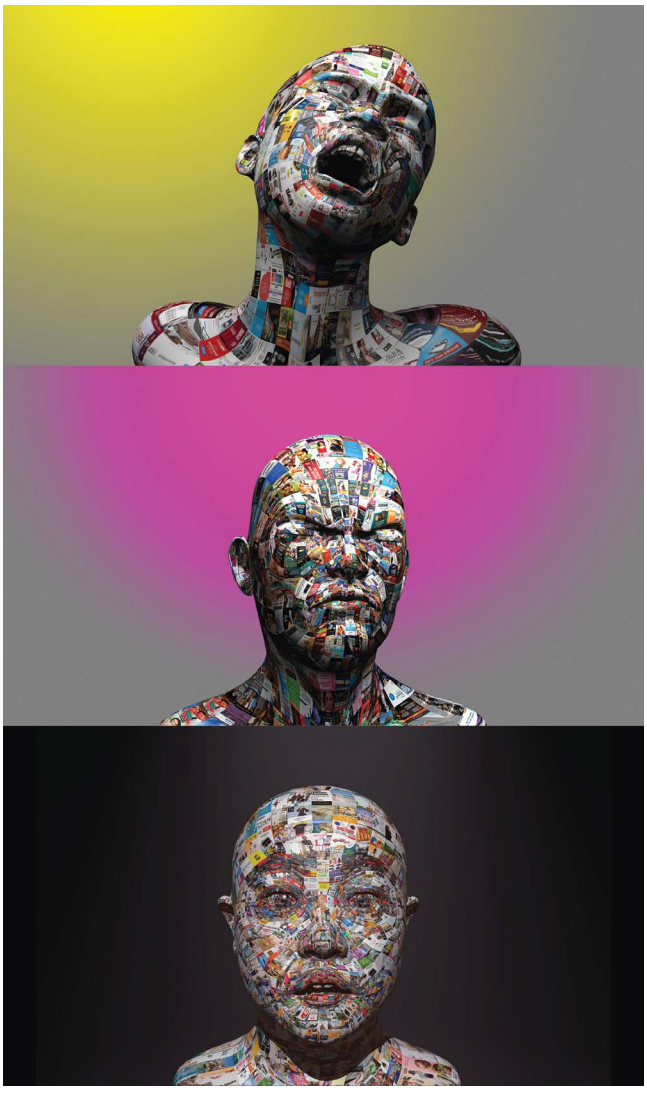

Fig. 1. Still image outputs created from three user profiles. (© Daniel C. Howe)

Background and Research

There was a brief time when the Web was a space largely free of commerce and capitalism. Today, however, each online action is tracked by sophisticated automated systems that mine our personal data to analyze, predict, and influence our behavior. While this vast surveillance architecture has been used by governments as a means of control [1], its unchecked growth has been largely due to corporations. Users are rarely asked to consent, but must instead accept such tracking as the necessary cost of access to the "free" information we can no longer live without.

The practice of repackaging consumers of media as products for advertisers is by no means unique to the Internet age—in fact it is as old as the newspaper ad itself. Ad technology has, however, evolved tremendously since then. Marketers, publishers and consumers are now dynamically connected by hundreds of intermediaries—tracking companies, data brokers, advertising networks—all in an effort to deliver billions of ads from thousands of marketers to millions of publishers [2]. In 2017, revenue from online advertising in the United States alone reached $83 billion USD. Of that, the vast majority was spent on behavioral targeting; using an individual's prior behavior (e.g. searches, pages previously visited, OS and browser information, as well as demographic data including age, location, gender, ethnicity, sexual orientation, interests, political affinities, etc.) to select ads to display [3].

To understand this system, we can consider a typical webpage visit. Code stored in various page locations creates bid requests that include the user's profile and the page being loaded. The request goes from the page to the advertising exchange where the page location and user's data are made available to advertisers on the network. Bids are instantaneously and automatically submitted for the spot, using rules determined in advance. The impression goes to the highest bidder and their ad is then displayed [4]. This process is repeated for each ad location on the page, with transactions occurring at lightning speed while the page is loading [5]. The criteria for bids can be very complex, taking into account detailed behavioral profiles and conversion probabilities.

All behavioral advertising has in common a dependency on the collection of user data for targeting. Unfortunately, once collected, such data may be used for a wide range of purposes. It can be traded and sold, aggregated across networks, and even used for questionable practices like discriminatory pricing, in which different users are given different prices for an item [6]. Because the data collected is so personal, the set of ads served to a user represents a portrait of what has been called her "data double" [7]. As such, there is significant potential for harm, a fact that has long been recognized by the privacy community. It is only recently however that such risks have been addressed in mainstream media, and thus become more widely appreciated by average users. And while some user-level tools have been created to address these risks (Privacy Badger, uBlock, Lightbeam, etc.), tracking has rarely been the focus of visually oriented artistic practice. *Advertising Positions* represents a clear counter example here; one that also raises important questions regarding socially engaged art that leverages strong aesthetic elements (questions that we return to below).

Technical

Prototyping and Collection

Targeted ad content served to a particular online user is determined by a number of factors: page, time of access, user location and, as mentioned above, a wide range of demographic data. To explore the relationship between these factors and the ads served, we initially created a prototype system using software bots. As each crawled the Web, using a modified version of Google's Chrome browser, visiting pages and clicking links, their advertisements were stored. So that these bots might collect ads similar to those a human user would see, we gave each bot a fictional profile; e.g. Wilson: a 39-year-old single male in Hong Kong, with interests in travel, tech, cooking, dating and adult entertainment. For efficient crawling, we used Selenium, an automated browser framework, in which the AdNauseam extension [8] was installed.

To ensure that the ads served to each bot corresponded to its profile, a Gmail account was created for each. In the ad settings for the account, we input a range of information, including gender, age and interests. Before each browsing session, bots would begin by logging into their Gmail account before starting to search keywords and then selecting links to follow from the results. If the process stalled—for example, on a page without links—the bot could look up further sites related to its interests via Web indices listing pages by genre.

3D Modeling

Unlike the 2D images shown in Fig. 2, in later phases of the project we used 3D models for animation and rendering. Constructing a base model from human users involved profile studies and in situ 3D scanning via white-light technology, resulting in models composed of ~200,000 triangles (Fig. 3). Although these models are highly accurate, they were difficult to animate due to the high polygon count, the triangle-based topology and inconsistencies between their structure and those of the human face. To address these issues, we recomposed the models into low-poly count equivalents, with topology aligned to facial musculature. Each vertex in the new model is drawn along the surface of the scanned model and strategically positioned to maximize the difference between the slope values it separates, maintaining a delicate balance between highlighting important detail, following muscle patterns, minimizing polygons

Fig. 2. Ad collage of the user profile—Wilson. (© Daniel C. Howe)

and equally distributing vertices. This process yielded animation-ready models with fewer than 5,000 quads (Fig. 3), enabling more natural animation and increased rendering efficiency.

Ad Texture Mapping

To layout advertisements on the model's skin, we mapped each advertisement to a single quad on the 3D surface. Our mapping algorithm involved initially extracting vertex positions for each quad, then crafting a cost-minimization function for computing optimal ad/quad pairs. To map advertisements onto the 3D surface, a 2D projection of the 3D grid was created with each pixel translated from 2D to 3D space. For optimal results the algorithm needed to consider the distortion that occurs when a rectangular image is mapped to an arbitrary 3D quad, after aligning to the viewer's natural perception. To do so, we ordered the quad vertices in perspective space, then extracted the 3D positions of each vertex and paired it with 2D positions on the UV map. This allowed us to generate a UV-based 2D image textured with the advertisements, which could then be translated directly onto the 3D model.

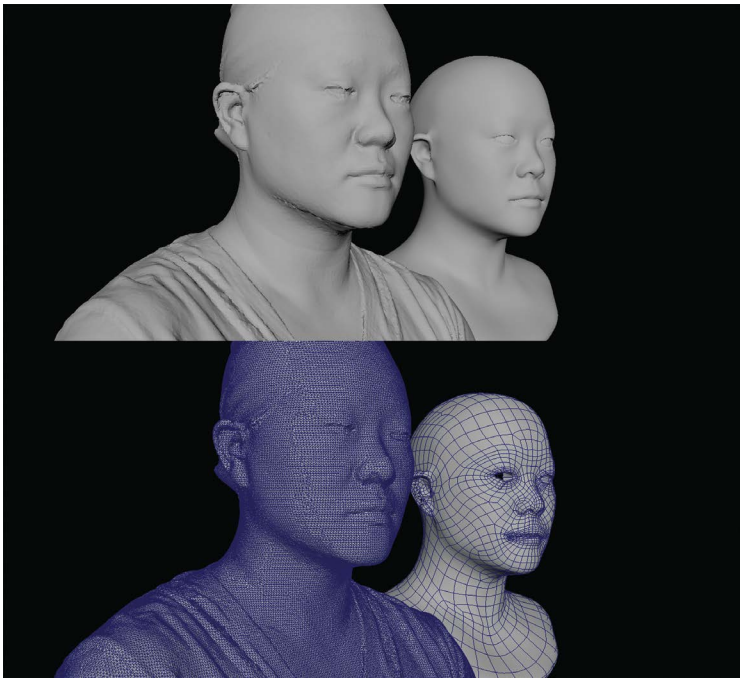

Fig. 3. Shaded (top) and wireframe (bottom) view of scanned model (left) and recomposed model (right). (© Daniel C. Howe)

Once we can map correctly ordered quad vertices, we must design a function to produce optimal pairing of images and quads. Here we note that the problem reduces to a classical CS problem called the Stable Marriage Problem [9], having a polynomial solution. Thus we need only define a cost

function to input into a standard solver. Pairings that minimize cost minimize a) the distortion of each positioned image and b) the difference between image brightness and quad brightness from the UV map. The following cost function *f(q,i)* computes the cost of each quad-image pair:

$$f(q,i) = (A * distWarp(q,i) + B * maxWarp(q,i)) + |\, i.brightness - q.brightness \,| < C \,?\, 0 : \infty$$

Here the two image distortion metrics, controlled by tunable constants A and B, can be weighted to minimize warp, and pairings where the absolute difference is above threshold C are given infinite cost and excluded. Figure 4 shows an example output from this algorithm.

Animation

The animation process involves taking reference images from the subjects' motion capture sequences, decomposing them into movements of individual body parts (this increases facial flexibility and helps make more natural expression transitions), reconstructing them on the model, and exaggerating them for artistic purposes. The resulting animations explore subjects' initial reactions to their aggregate ad sets, with responses that included skepticism, surprise, pleasure, distress and others.

Outcomes

For each user profile, three outcomes have been generated thus far: animations of the 3D models, rendered collages of aggregate ad sets, and high-resolution still images. The project debuted in 2017 at the Oi! Street gallery in Hong Kong (Fig. 5), and was later featured at Art Center Nabi in Seoul, South Korea. In current iterations of the project, we import models into Unity3D to enable programmatic control and simple interaction (models gazing at audience members, etc.).

Aesthetic Considerations

The focus of our critique lies not in personalized marketing, but in the opaque system through which consumers are targeted without their consent. To address this issue, *Advertising Positions* presents the human body as a canvas on which to visualize aspects of the human experience that we are forced to sell each day (our attention, our privacy, culture itself). Unlike forms of manipulated recording (for instance, photography or filming), 3D modeling is a medium that not only depicts, but embeds advertisements—

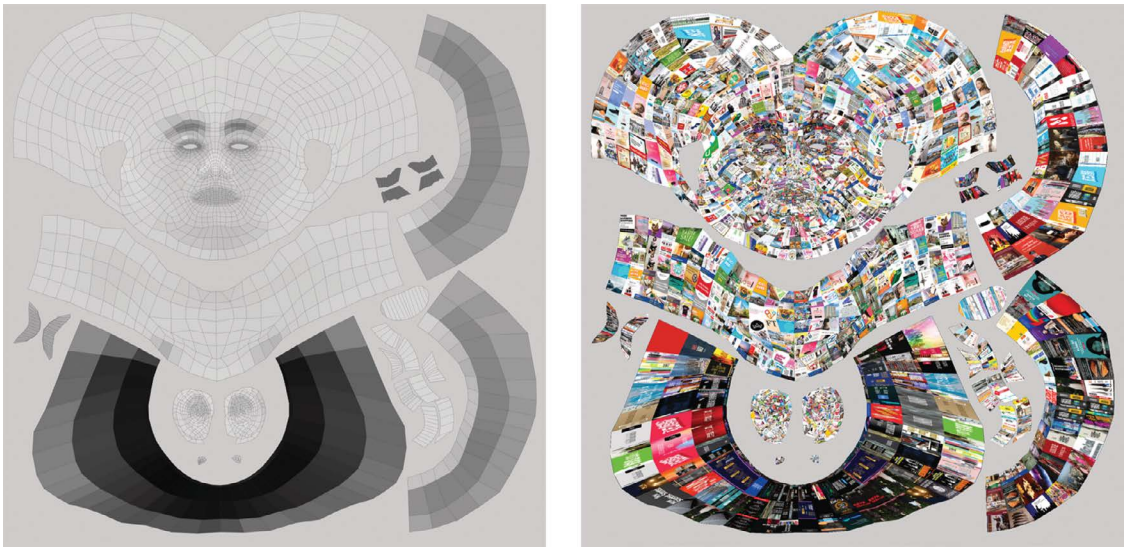

Fig. 4. The 2D UV map with quads only (left) and with matching advertisements (right). (© Daniel C. Howe)

Fig. 5. Installation shot at Oi! gallery in Hong Kong. (© Daniel C. Howe)

the tangible evidence of our profiles being sold—within the aesthetic object itself. Our subjects here are deliberately objectified, positioned in a frame, staged under a spotlight, in an attempt to expose the nature of the system that places us, without our consent or knowledge, on the virtual bidding table. The presentation of subjects is deliberately minimal—clothing removed, torso removed, representations of distinct physical identity removed—to reveal the emotional vulnerability residing in our new identities as online targets.

In the animated sequences, subjects are seen to undergo combinations of surprise, frustration and distress, emotions that reflect research on the dilemma consumers experience in relation to ad targeting. When told they must trade privacy for the somehow intangible benefits of customized ads, most experience a sense of violation, yet also feel unable to act upon the situation in any viable manner [10]. *Advertising Positions* attempts to explore exactly this tension via aesthetic means, highlighting the powerless position many consumers experience.

With its compelling visual elements, the project also raises important questions for art that critically addresses problematic social dynamics. How does the aestheticization of destructive practices affect users' understanding and emotional response to them? As a canonical example, we might consider Edward Burtynsky's hauntingly beautiful aerial photos [11] of environmental destruction or Trevor Paglen's often sublime long-distance photos [12] of secret military bases. Although we cannot speak for other artists, our goal here is to create a visceral tension between the aesthetic appeal of the work, on the one hand, and the disturbing social dynamics from which it emerges, on the other. Thus it is crucially important that users experience not only the more directly engaging visual aspects of the work, but also perceive its conceptual and theoretical foundations. This is the work of narrative—how best to make the work's process and material substrate an organic element of the viewing experience, rather than an afterthought to be found only on a caption card. Thus we also aim, through interviews with gallery visitors following visits, to gain insight into the crucial mechanics of user reception, and the ways in which aesthetic, conceptual and technical elements of the project integrate within their experience.

Conclusion and Future Directions

Over the course of development, we have identified several improvements and new directions for *Advertising Positions*. We are currently exploring real-time programmatic control of the models, to enable subtle interactions with users and variations in behavior over longer durations. We are also experimenting with new motion capture and 3D-scanning techniques that better map to our process. Perhaps most interesting of all will be the post-interviews from visitors (now being transcribed and coded), as to their subjective experience negotiating aesthetic and narrative elements of the project.

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Original Narratives Art Gallery

Introduction

SIGGRAPH Art Gallery 2018

Andrés Burbano

Confronted with the challenge of curating a media arts exhibition within perhaps the most influential conference on image, computation and interactivity, I made use of the guideposts provided by media theorist Friedrich Kittler. In his 1995 essay "Museums on the Digital Frontier," the future of the museum—and by extension the future of the gallery and the exhibition—is discussed in terms of its relationship to computers. He argues that rather than asking if computers have a place in the museum, curators should instead ask how the various *components* of computers can be used as an organizational metaphor for museum activities. The computer's memory can be understood as the museum's archives, the computer's access to a network can be understood as the distribution of knowledge to the public, and the computer's many processing operations can be understood as the various aspects of the curatorial process.

A perennial concern of my own work is the influence of important, but ultimately obsolete, technologies on present-day culture. The innovations of today are built upon the strata of previous innovations, whether acknowledged or ignored. To highlight relevant relationships between the past and the future, and to carry out the curatorial "process" effectively, I sought out a diversity of sources, both at a technological and a cultural level. A series of questions was used to situate the featured artworks: Where do media technologies come from? How can we revisit the foundations of the contemporary community that investigate the interactions between art, science and technology? Furthermore, especially relevant given the location of the SIGGRAPH conference amidst the historical landscape of the Pacific Northwest peoples, what is the role played by the indigenous communities in our technological present?

The question of where technology comes from is significant in our time, when virtual reality has encroached into the daily routines of so many human activities, where artificial intelligence mediates our decisions and is present in our social media, our news feeds and the constant barrage of advertisements we see online. Our technological landscape more than ever needs to be reconceptualized through creative practices and research at the historical level. To address this, one of the pieces selected for the Original Narratives exhibition explores the technological origins of computer-aided design (CAD). Daniel Cardoso Llach creates reconstructions of the original CAD systems, including Sutherland's "Sketchpad," making a connection between the most recent visualization technologies and the incipient research from the early 1960s.

Understanding the genesis of the community interested in the interactions between art, science and technology is also of vital importance. This interdisciplinary community created SIGGRAPH, which almost from its inception incorporated an art gallery as part of its ethos. The work of Ernest Edmonds was also selected for Original Narratives because of his pioneering use of computers for artistic purposes beginning in the early 1970s and continuing through the present day. Moreover, I would like to point out that Edmonds often published in *Leonardo* early in his career; including his artwork in these pages serves as an opportunity also to commemorate the 50th anniversary of *Leonardo*.

Technological transformations have affected aboriginal societies, but aboriginal peoples are transforming technologies as well. While indigenous communities are often seen as a link to the past, I firmly believe that indigenous societies should be seen as the builders of the present and as transformers of the future. Beyond the outdated dichotomy of civilization and the wild, this exhibition affirms the importance of fostering communication with First Nations and aboriginal peoples. One work of talented Montreal-based Mohawk artist Skawennati is featured in Original Narratives. Skawennati has been creating experimental

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work in the fields of animation and video games, generating new digital landscapes through computational technologies. The exhibition also includes the award-winning video game *Never Alone* that provides a novel perspective of the Inupiaq experience (presented by Amy Fredeen at the exhibition opening) as well as original concept art developed by Dima Veryovka. Additionally, we will showcase new work developed by The Microsoft Garage in Vancouver and coordinated by Andy Klein. The project, *Transformation Mask*, was developed in collaboration with artist Shawn Hunt, of Heiltsuk descent. It uses HoloLens technology to explore the archaic masks of shamanic transformation.

The exhibition also explores many more territories. The variety of invited projects ranges from those that investigate the origin of the universe from the scientific field, as in the *Somnium* installation by Marko Peljhan, Danny Bazo and Karl Yerkes, who discuss Kepler's book and interpret it using scientific data collected from the Kepler Space Telescope. A project by Ruth West, *Instrument*, also works with scientific data, exploring the deep cosmos using virtual reality. The vital energy and electrical energy that supports most interactive projects is problematized poetically by the group cAt and Milton Sogabe of Brazil who produce autonomous installations that do not require any external energy source. The exhibition also takes a more intimate turn, exploring the process of birth in Alex Beim's interactive spaces, which promote introspection through an experience that enables a participant to be "born again"—to return to see the world with new eyes and hear it with new ears. A related investigation of the origins of emotional states is also present in the *You Are the Ocean* installation by Özge Samanci, which provides a brain-computer interface that makes it possible to manipulate a representation of the sky and the sea.

To conclude, I would like to highlight two important collaborations that nurtured the exhibition. The first collaboration is with the SIGGRAPH Art Papers track, chaired by Angus Forbes. Together, we have selected one artwork, *Diastrophisms*, by Nicole L'Huillier, who also has an article featured in the Art Papers track. The second collaboration is with the SIGGRAPH Digital Arts Community, chaired by Victoria Szabo. Together, we co-curated an online exhibition titled *Origins and Journeys* that operates as complement and contrast to this exhibition. Finally, I would like to acknowledge the many artists and scholars without whose help this exhibition would not have been possible, including Philippe Pasquier, Nik Apostolides, Katherine Sinclair, Gabriela Aceves and Florian Grond, as well as the SIGGRAPH conference team, including Elizia Artis, Cindy Stark and Marcia Daudelin, Roy C. Anthony and many others too numerous to mention.

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The Future Is Indigenous

Jason Edward Lewis and Skawennati

We started reading science fiction as teenagers. We fell in love with the fantastic worlds, the strange societies, the alien cultures and the amazing technologies. As we got older, though, we began to notice the lack of Native people in those futures. In fact, there were barely any nonwhite people at all.

The lack of images of us in science fiction told us pretty clearly that there was no room for First Nations in the exciting futures being imagined by writers and artists, and being built by scientists and engineers. Today, several decades later, we work with Indigenous youth who recognize that the dominant culture still doesn't see a future for them. In our conversations with them, and in the academic research literature, we can see the connection between this erasure and the tragic statistics that plague First Nations: highest dropout rate, highest incarceration rate and, as has become painfully highlighted recently, highest suicide rate.

Kiowa author N. Scott Momaday wrote that the "greatest tragedy that can befall us is to go unimagined." A great tragedy has already befallen Native people. We live in a society defined by greed for the land and its resources, hate for our cultures and genocide of our peoples. This fact undermines any notion that settler Canadians live in a society that is fair and just for all. It is a foundation that poisons every institution that grows from it. Neither apologies nor reconciliation will rectify it.

To replace this damaged foundation we must imagine deeply anew. We use the term "future imaginary" to describe the ideas that commonly come to mind when we think about the far future—things like jetpacks, designer genes and intergalactic travel. The Initiative for Indigenous Futures (IIF) was developed as a catalyst and a forum for our communities to populate the future imaginary with Native people who are present, vital and in charge of our own destinies. It is imperative that First Nations imagine how our cultures will grow and evolve, sustaining continuity with the past while exploring new cultural configurations that will enable us not just to survive, but to thrive.

IIF conducts this work by instigating, encouraging and supporting art that illustrates alternative Indigenous futures; through public presentations by thinkers and makers who are actively imagining the future of everything from Indigenous governance to food sovereignty to language; and through workshops with Indigenous youth that develop the skills and confidence to build a future in which they see themselves.

Settler society must imagine a new relationship with us that is based on more than just apologies. Learn the treaties, which both our peoples signed, but only we taught to our children. When you know them, you will understand that us Indians are not asking for "free" stuff; rather we are demanding that we be paid what we are owed. When you see how your religious and legal frameworks, brought with you from Europe, cheated our people out of our humanity, you will understand our anger. When you look at even a fraction of the letters of appeal, land claims and lawsuits we have pursued to little avail for hundreds of years, you will know why we are exasperated.

Furthermore, it is not our job to educate you. The Royal Commission on Aboriginal Peoples report was published twenty years ago. The Truth and Reconciliation Commission criss-crossed this land for the last seven years. Our thinkers have been writing about this history for decades, our artists have been making artwork about it for even longer. In 2016, with Google at your fingertips, not knowing this history can only be due to your willful ignorance. Educate yourself, and then, please, educate your children.

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For five hundred years we have refused to be assimilated. We will refuse for the next five hundred years. What is more, we are imagining the next five hundred years as a time when our people will assert themselves as primary actors in the evolution of Canadian society. We are busy building that future. Imagine that.

Jason Edward Lewis, Director
Skawennati, Coordinator
Initiative for Indigenous Futures, Milieux Institute for Art, Culture and Technology,
Concordia University

Versions of this paper have previously been published in the *Montreal Gazette* (27 April 2016) and *La Presse* (3 April 2016).

The Computational Imagination: Notes on the Exhibition *Designing the Computational Image, Imagining Computational Design*

Matthew Allen

Should we see the early development of computer-aided design as an aesthetic movement? Just as eighteenth-century England had picturesque gardens and the world of social media today has spawned its own universe of visual conventions (to take two examples at random), was there such a thing as a "computational aesthetics" some 50 years ago? These are questions not about "computer art" per se, but about how a new visual culture might emerge alongside new practices and new concepts. They are particularly tricky questions to ask of early computational images because such images come from an era when people were eager to frame their work as scientific research, and aesthetics was often ruled out of bounds.

Designing the Computational Image, Imagining Computational Design was an exhibition at the Miller Gallery at Carnegie Mellon University in Pittsburgh that aimed to refocus the discussion of computer-aided design (CAD) on the "expressive possibilities" of this "new medium," as the catalog text puts it. This aesthetic reframing of historical images was helped along by the decision to include contemporary projects that certainly do count as art. These works made up about one-third of the show, and some were commissioned especially for it. They ranged in mood from mysterious and foreboding glimpses of computer vision (Ben Snell's large-scale LIDAR images) to playful genre mashups (the bas relief sculptures by the architecture firm BairBalliet). The atmosphere of open-ended experimentation extended to the other two-thirds of the show, which was drawn from the period 1949 to 1976—from the research on milling machines that led to the CAD Project at MIT to the work of the Architecture Machine Group that marks the end of the early era of CAD research.

Even in the mindset of aesthetic experimentation, however, visitors were likely shocked by some of the works on display, such as the huge modular painting by George Stiny that loomed from the back wall of the gallery. This served as a powerful reminder that the avant garde circa 1969 sometimes used computers not to drain aesthetics from their fields of inquiry, but to reconstruct them within a new aesthetic framework. Stiny's computational research took place within the discipline of painting; it was aesthetic research as much as mathematical research. As a whole, the exhibition pushed hard against the common stereotype that people like Stiny set out to make their fields more scientific and less artistic—speculating about a possible science of aesthetics was exactly the point.

Crucial to the exhibition's success was its use of original images, which the curator, Daniel Cardoso Llach, tracked down from several archives, museums and personal collections. We may have seen many of these in one form or another, usually shrunk down and abstracted and crammed alongside technical prose. But even the most diagrammatic drawing has a material form. Taking a photograph of a screen involves a different process than outputting to a pen plotter; each has its own format limitations, line qualities, color palette and so on. Seeing originals or faithful reproductions of images allowed visitors to begin to imagine how they were produced and to appreciate the labor and the thought that went into them. The famous "Coons Patch" (named after Steven A. Coons) was not just a mathematical technique for defining a surface; it was above all a means of visualizing such a surface so it could become an object of design. Computational images circulated precisely because humans—and their irrational desires—had not been automated out of the manufacturing process. (They still haven't been.) The exhibition was thus, unexpectedly, about how computational images were a means of *humanizing* computers.

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Although the exhibition focused on "images" of computation, this should be understood in the sense of imagination rather than as a strict focus on pictures [1]. Objects such as a computer program on a roll of punched paper tape and a machined metal shoe last helped summon the 1960s computational imagination. One of the most striking objects in the show was a reconstruction of Ivan Sutherland's "Sketchpad" [2]. In a remarkable feat of software preservation, the software was rewritten by Cardoso Llach and his team and housed in a large, custom-built wooden console, evoking the feeling of the original TX-2 hardware while diverging far from its literal details. It proved astonishingly fun to play with.

One outcome of a successful exhibition is to raise more questions than it answers. Although the exhibition catalog and paratext were relatively thorough, media historians might wish for a more forensic precision regarding materials and techniques. ("Digital print" is too broad.) Generally, it would be great to see more images, more code alongside them and more reconstructions. I would love to see a retrospective of Stiny's work. But the big questions of the exhibition arise when one tries to track down answers in the scholarly literature. Much of the history of the computational imagination remains to be written. Cardoso Llach's own book, *Builders of the Vision*, elucidates what was happening at MIT, from Project MAC to the "Coons Patch" to "Sketchpad" and beyond—his exhibition ought to inspire a small library of dissertations to go alongside it.

In its pairing of historical and contemporary material, *Designing the Computational Image* shows that computer-aided has a pronounced legacy in aesthetics. The image-making practices and visual conventions developed half a century ago are now firmly lodged in the collective imagination of design. In my field, architecture, everyone now uses computers; students today are being enculturated to appreciate computational images even if they have no particular passion for long-obsolete technologies [3]. Reinterpreting the history of computer-aided design as an aesthetic movement is thus crucial to maintaining its resonance with the present. Cardoso Llach's exhibition has shown that the images on display still resonate strongly.

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Notes

1. The curator must have been thinking of the role of the imagination in Kantian aesthetic theory: <https://plato.stanford.edu/entries/kant-aesthetics/>.
2. The *object petit a* (Lacanian for "the unattainable object of desire") of historians of computation, as one visitor quipped.
3. A sure sign of the aesthetic attitude, according to Kant, is approaching beautiful images and objects with disinterest—an attitude that appreciates "art for art's sake," not for the sake of something else.

Art Systems: 1968 to 2018

Ernest Edmonds

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In this note I describe my personal development of art systems over 50 years. In all of this work I have used computers and computational processes both to make the works and to advance my conception of art. This history is marked by a trace of publications in the journal *Leonardo*, itself being 50 years old. I will relate the story with specific reference to these publications. Each of the following sections relates to one *Leonardo* publication and includes quotations from that paper. In the earlier writing "he" or "him" is used sometimes to refer to a person who could well be female, as used to be the custom.

The Creative Process Where the Artist Is Amplified or Superseded by the Computer—*Leonardo* 6 (1973)

In 1970 Stroud Cornock and I presented a paper at a computer graphics conference, CG70, held at Brunel University in the U.K., in a session on computer art organized by the Computer Arts Society; other speakers included Manfred Mohr and Frieder Nake. Our paper looked at the potential of computing in art, but our vision was rather dependent on technological developments, such as the PC, that were still some way off. After the conference we submitted our paper to *Leonardo* and it was published in 1973 [1].

In it we said that the computer's "function in the arts is seen as assisting in the specification of art systems and in their subsequent real-time management . . . It is pointed out that the inclusion of complex real-time responses in an interactive art system can frequently make use of a computer. In such work, the artist and the viewer play an integral part." The original artwork that I made, using computer programming as part of the process, was the relief, *Nineteen* (Fig. 1). In the paper we used it as an example of a "static" work, one that did not change over time or interact with the audience.

Fig. 1. *Datapack Documents* (Edmonds, 1970/2000) and *Nineteen* (Edmonds, 1968/1969) in the "Primary Codes" exhibition, Rio de Janeiro. (Photo: Thales Leite)

The paper explained that *Nineteen* (1968/1969) "is an example of a static work where a computer has been used as a problem solver. The arrangement of the twenty elements of the object was found by means of a computer within specified constraints without consideration for the particular relationships within the final layout, which was simply a four element (30 × 30 cm) by five element array. It was intended that the assembly in the array be such that a feeling of finality be avoided" [2].

CG70 included an exhibition in which Stroud Cornock and I showed an interactive artwork that illustrated some of the ideas of the paper. It was called *Datapack* and we described it as follows.

> . . . the participants are involved in three phases: (1) the initial contact . . . (2) the use of a computer terminal and (3) . . . a drawing . . . of the Vickers Building [(London) and an] . . . air space . . . determined by the interaction . . . [3].

Art Systems for Interactions Between Members of a Small Group of People—*Leonardo* 8 (1975)

In the initial half of the 1970s I explored networks as art by building electronic "communication" systems, made with logic circuits [4]. They did not use computers as such, but I did write truth tables and used those to design the circuits. Much later, I was able to extend the work using computers, local area networks and the Internet [5]. I called the works that I made in the 1970s *Communications Games*.

> In each project participants are able to make contact with each other only through very restricted interfaces, i.e. with a very limited set of possible actions and responses. One might say that they try to make sense of the responses that they receive. The responses are such that the participants are likely to understand each other's actions only partially and even that understanding may be transitory. . . .
>
> Experience with Communications Game has shown that, when there are more than three or four participants and several networks, the multiplicity of signals is beyond the comprehension of the participants. Hence, a simplified version of the game was developed with only one network and three participants, called Communications Game 2. It was installed at the Cognition and Control Exhibition at the Midland Group Gallery in Nottingham in 1972 [6].

Logic and Time-Based Art Practice—*Leonardo* Electronic Art (1988)

The technology having advanced, from 1980 I started to develop time-based artworks by writing generative computer programs [7]. As I explained in 1988,

> The work described in this paper falls within a tradition that focuses on the underlying structure of the artwork. . . . [We] consider the structure to be an underlying *logical* structure [expressed in mathematical logic]. . . .
>
> A computer-generated video work, *Jasper*, can be taken as an example. . . . The images of the work may be thought of constructed on a grid in which locations may be specified in normal rectangular coordinates. They are in shades of grey . . . the rules were expressed in the logic programming language PROLOG. . . . As part of this strategy, the system tries different ways of satisfying its prime goal whenever an attempt fails. . . . Thus, the standard inferencing system of PROLOG is used to generate a time-based work that can perhaps be thought of as a relentless attempt to satisfy these very simple, but, in fact, unsatisfiable rules [8].

The fact that the rules are never satisfied means that the search goes on—and on.

Structure in Art Practice: Technology as an Agent for Concept Development—*Leonardo* 35 (2002)

In the abstract of this paper [9], I said that the "computer provides a significant enhancement to our ability to handle and consider the underlying structures of artworks and art systems in the many forms that they may take. In the work discussed, whilst the conceptual developments are the key issues, the role

Fig. 2. *Shaping Form* (Edmonds, 2013) in the "Primary Codes" exhibition, Rio de Janeiro. (Photo: Thales Leite)

of the technology in encouraging, enabling and inspiring them has been central."

This refers to the idea originally mentioned in the 1973 paper, when we said that computers can have the function of "assisting in the specification of art systems" [10]. The 2002 paper details the approach over a wide range of works and points forward. From this time I concentrated on the structure of time, color, form and the interactive experience. My *Shaping Form* works (Fig. 2) are both generative time-based in nature and influenced over long periods of time by audience movement. Thus the concerns for structure, time and interaction are brought together. One aspect of the *Shaping Form* works that goes further than the vision of the 1973 paper is that the interactions influence the works over long periods of time. Each input, often the detection of movement by the analysis of images captured by a webcam, can change the generative rules and so influence future behaviors of the artwork. This, and much more, is explained in a recent book by Francesca Franco [11].

For 50 years I have been writing computer code and designing digital systems in making my art. But it is the connection to the concrete and constructivist traditions that characterizes it. The common factor in both digital method and artistic style is the role of structure. From the structure defined in code comes the visual power and the time-based interactive elements that are important to me.

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Ernest Edmonds is a pioneer computer artist and HCI innovator for whom combing creative arts practice with creative technologies has been a life-long pursuit. In 2017 he won both the ACM SIGCHI Lifetime Achievement Award for Practice in Human-Computer Interaction and the ACM SIGGRAPH Distinguished Artist Award for Lifetime Achievement in Digital Art. He is Chairman of the Board of ISEA International, whose main activity is the annual International Symposium on Electronic Art that began in 1988. He is an Honorary Editor of *Leonardo*.

Reconstructing “Sketchpad” and the “Coons Patch”: Toward an Archaeology of CAD

Daniel Cardoso Llach

“Archaeology of CAD” is an ongoing project that examines the origins of Computer-Aided Design by bringing to life some of its pioneering technologies, which were central to re-shape design practices in the image of computation during the second half of the twentieth century. On display at SIGGRAPH will be two interactive installations from this project: the reconstructions of Steven A. Coons’s “Coons Patch” and of Ivan Sutherland’s “Sketchpad.” Drawing from primary archives and oral sources, these interactive installations playfully revisit these transformative technologies from the 1960s, and enable visitors to approximate the experience of designing with the first Computer-Aided Design systems. Developed with computational design students at Carnegie Mellon University using present-day hardware and software languages, these reconstructions are inquisitive artifacts of historical inquiry. By evoking the embodied experience of interacting with these technologies, they shed light on the new forms of human-machine work that emerged with the rise of interactive computing during the Cold-War years, and highlight the sensual and gestural dimensions of the “computer revolution.” Along with the two reconstructions, a selection of rare handwritten notes and documents by Coons, and a selection of key contractual documents between the US Air Force and MIT, are displayed to offer glimpses of the institutional and intellectual context that motivated these foundational technologies of computational design.

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Described by its developer Ivan Sutherland as a “man-machine graphical communication system,” “Sketchpad” allowed users to draw on a nine-inch cathode ray tube monitor using a “light-pen”, a keypad, and a series of knobs. Remarkably, the system featured many of the functions of modern Computer-Aided Design systems, such as constraint-based modeling and block instantiation. Using present-day hardware and software languages, our reconstruction approximates the experience of using “Sketchpad”. The image shows our interactive reconstruction of Ivan Sutherland’s “Sketchpad”. (Daniel Cardoso Llach in collaboration with Scott Donaldson, 2017. Photo credit: Hugh “Smokey” Dyar.)

The first reconstruction revisits the "Coons Patch," a pioneering mathematical technique to calculate curved surfaces developed in the early 1960s by MIT professor of mechanical engineering—and computer graphics pioneer—Steven A. Coons. A direct ancestor of NURBS, Coons's method was, in essence, a clever interpolation algorithm. It made it possible for early computer graphics researchers to create smooth surfaces between any four parametrically defined curves. Displayed in the phosphorescent light of CRT monitors, these "patches" were photographed, animated and circulated in both research and industry circles through books, films and research reports. They were key to demonstrate computers' potential as modeling and visualization tools with applications in a variety of fields including aeronautic, automotive and architectural design. Further, they helped trigger a fledgling computer graphics community as it formed across dispersed university and industry laboratories on both sides of the Atlantic—many of whose members came to see Coons as an inspiring, founding figure. Through a custom software and hardware interface, including a large projection, our reconstruction allows visitors to design and transform their own "patches," appreciate their geometric plasticity, and explore their underlying mathematical structure.

The second reconstruction revisits "Sketchpad," the original drawing tool of the computer age, developed by Ivan Sutherland at MIT as part of his doctoral research (which Coons advised) in 1963. "Sketchpad" was equipped with functions to save, transform and manipulate drawings in ways that extended beyond the capabilities of traditional drafting media. "Sketchpad" thus remains a milestone for both interactive computing and computer graphics almost 60 years after its development. The original "Sketchpad" featured a "light pen," a keypad and control knobs with which a user could conduct a variety of drafting operations on a 7 × 7 inch CRT monitor. Our interactive reconstruction approximates the ergonomics of the TX-2 computer terminal that Sutherland used and offers access to many of "Sketchpad's" original functions. These include drawing instantiation, scaling and the definition of geometric constraints. Our reconstruction also evokes the TX-2 interface, including a modern version of the "light pen," keypad and knobs, which enable visitors to draw in ways that evoke Sutherland's original system.

Daniel Cardoso Llach is an architecture and computational design scholar and the author of *Builders of the Vision: Software and the Imagination of Design* (Routledge, 2015), an intellectual history of Computer-Aided Design that traces critically its repercussions in architecture and other design fields. He is a Graham Foundation grantee and the curator of a recent exhibition on the history and contemporary practice of computational design at the Miller Gallery at Carnegie Mellon entitled "Designing the Computational Image, Imagining Computational Design." He is Assistant Professor in the School of Architecture at Carnegie Mellon, lectures frequently and internationally, and his writings have been published in several journals and edited collections. Cardoso Llach holds a Bachelor of Architecture from Universidad de los Andes, Bogotá, and a PhD and an MS (with honors) in Design and Computation from MIT. He has also been a research fellow at Leuphana (MECS), Germany, and a visiting scholar at the University of Cambridge, U.K.

She Falls For Ages

Skawennati

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This sci-fi retelling of the Haudenosaunee (Iroquois) creation story reimagines Sky World as a futuristic utopia and Sky Woman as a brave astronaut and world-builder. When she learns that her planet is dying, Sky Woman volunteers to become the seed of the new world—an Earth yet covered in water. *She Falls For Ages* boldly mixes ancient storytelling with science fiction to connect the deep past with the far future.

In creating this work, I used a new media technique known as "machinima"—making movies in virtual environments. Along with my team at Aboriginal Territories in Cyberpace, we built virtual sets, customized avatars and choreographed action in the massively multiplayer online 3D world Second Life.

Skawennati, "Becoming Sky Woman" (production still from *She Falls For Ages*), machinimagraph, 2017. (© Skawennati)

Skawennati makes art that addresses history, the future, and change from an Indigenous perspective. She is best known for her machinimas but also produces still images and sculpture. Her pioneering new media projects include the online gallery/chat-space and mixed-reality event *CyberPowWow* (1997–2004); a paper doll/time-travel journal, *Imagining Indians in the 25th Century* (2001); and the machinimas *TimeTraveller*™ (2007–2013), *She Falls For Ages (2017)* and *The Peacemaker Returns* (2017). These have been widely presented in major exhibitions across the globe, including "Uchronia | What If ?," in the HyperPavilion at the 57th Venice Biennale; B3 Biennale of the Moving Image, Frankfurt, Germany; "Now? Now!" at the Biennale of the Americas; and "Looking Forward (L'Avenir)" at the Montreal Biennale. Her award-winning work is included in both public and private collections. Born in Kahnawà:ke Mohawk Territory, Skawennati holds a BFA from Concordia University in Montreal, where she resides. She is Co-Director, with Jason Edward Lewis, of Aboriginal Territories in Cyberspace (AbTeC), a research network of artists, academics and technologists investigating, creating and critiquing Indigenous virtual environments. She also codirects their Skins workshops for youth in Aboriginal Storytelling and Digital Media. In 2014, AbTeC launched IIF, the Initiative for Indigenous Futures.

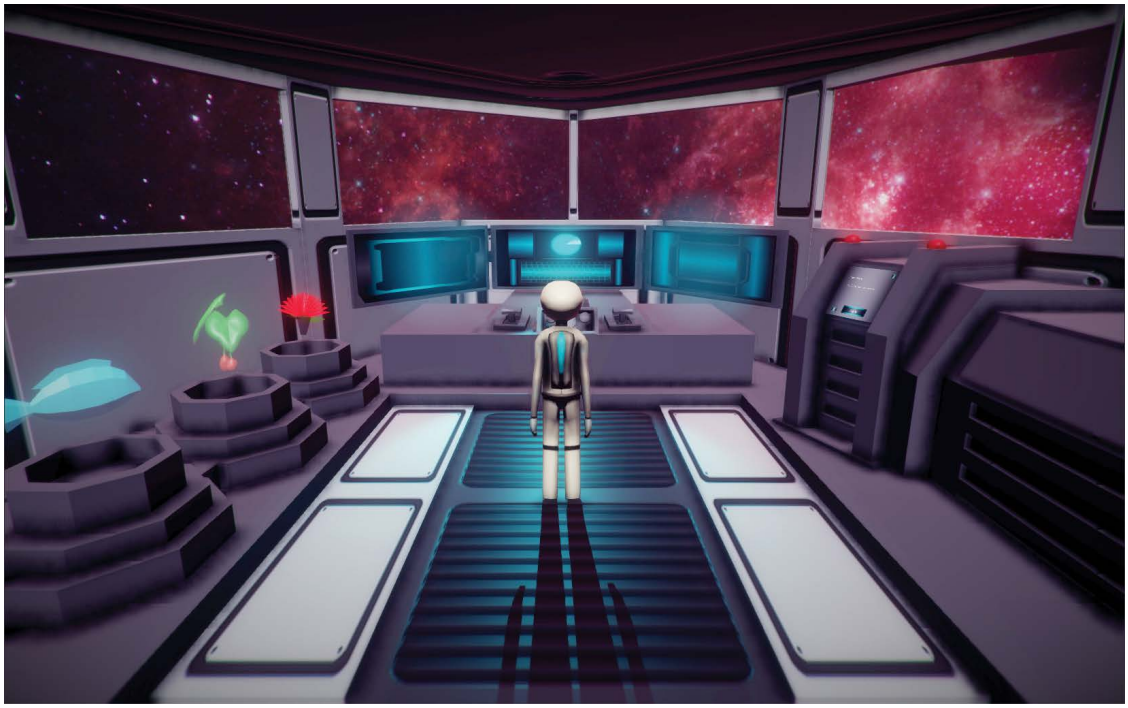
He Ao Hou (A New World)

Nā ʻAnae Mahiki

Nā ʻAnae Mahiki
Canada and Hawaii
<http://abtec.org/iif/>

He Ao Hou is a point-and-click adventure game set in the far future, when Native Hawaiians have attained the next level of navigation—space travel. The gameplay is based on kānaka maoli (Native Hawaiian) stories and knowledge, and focuses in particular on the uses of the kukui nut, itself a symbol of knowledge.

As the player searches for their sister, they meet interesting individuals and learn about their relationships to their respective planets. On the water planet they are taught to use the kukui to clarify water that is cloudy, thus finding a helpful shark. On the lava planet, they see how hula dancing is used to make kukui plants grow. On the plant planet, they use the kukui as a projectile, hitting the boar-like, eight-eyed demigod, Kamapua'a, to wake him up. Finally, the player unlocks enough knowledge to find their sister—but she is now much more than she ever was before.



Nā ʻAnae Mahiki with AbTeC/IIF, *He Ao Hou (A New World)*, videogame, 2017. (© Nā ʻAnae Mahiki)

Nā ʻAnae Mahiki is a collective of 16 young adults from Oahu who participated in the Skins 5.0 Workshop in Honolulu in July 2017. Skins 5.0 was hosted by the Kanaeokana Network, Kamehameha Schools and the Initiative for Indigenous Futures. The Skins Workshops in Aboriginal Storytelling and Digital Media aim to empower Indigenous youth to be producers—not just consumers—of new media. The program is one of four major components of the Initiative for Indigenous Future (IIF), a partnership of universities and community organizations led by AbTeC and dedicated to developing multiple visions of Indigenous peoples in the future.

Never Alone: The Art and the People of the Story

E-Line Media

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Never Alone (Kisima Inŋitchuŋa) is the product of an uncommon partnership of an Alaska Native community and game developers. Through all stages of development, members of both communities met extensively to ensure that all creative and business decisions were appropriately considered and supported the goals of all stakeholders. Throughout the game and in supporting material, players will hear directly from members of both communities who were instrumental in shaping the game.

World-class game makers were paired with Alaska Native storytellers and elders to create a game that delves deeply into the traditional lore of the Iñupiat people to present an experience like no other.

Never Alone is our original title in an exciting new genre of "World Games" that draw fully upon the richness of unique cultures to create complex and fascinating game worlds for a global audience.

The characters and environments in *Never Alone* have been inspired by traditional Alaska Native art—painting, drawing, sculpture, clothing, masks, scrimshaw—and honed through collaboration with Alaska Native elders and artists. This ensures that the look and feel of the game stay faithful to the traditional styles and provide a unique and inspirational visual presentation for *Never Alone*.

***Never Alone*, game, image from E-Line Media Press Kit. (© 2014)**

Amy Fredeen is of shared Inupiaq and German descent. Most recently through CEI, Fredeen helped form a partnership with E-line Media, an industry leader educational games, that created the first video game made with an indigenous community called *Never Alone*. For this game Fredeen served as the lead cultural ambassador ensuring an inclusive development process that resulted in the sharing, celebrating of the Inupiaq culture and stories. With 26 mini-documentaries embedded in the game, *Never Alone* won a 2015 British Academy Award for Best Debut and has had 3 million downloads to date.

Dima Veryovka is an award-winning Art Director, Concept Artist and Creative Lead with extensive experience in the development of video games. He built and led high-performing creative teams for various projects, including the BAFTA winning game *Never Alone*. Currently, Veryovka is an Art Director at Oculus, where he oversees visual concepts, design and implementation, and provides strategic leadership and artistic direction to creative teams. Prior to starting at Oculus, he served as an Art Director at ArenaNet, Colabee Studio, and E-Line Media, and was a key member of the design and art teams at Sony Computer Entertainment America.

Transformation Mask

Microsoft Garage and Shawn Hunt

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The Raven, the ultimate trickster, has become a cyborg. In this collaboration with Microsoft Vancouver, Shawn Hunt moves away from engaging with the handmade, exploring authenticity and our expectations of what it means to be indigenous through the removal of the hand-carved surface. The mask appropriates the traditional aspects of metamorphosis with the transformation from bird mask to human, yet in this adaptation the human mask has been altered, upgraded and merged with the machine. Incorporating aspects of technology, sound and space, each part of the work reflects Hunt's interest in how we understand and identify with the term *indigenous*.

Transformation Mask is a shared work created by Shawn Hunt and a team of artists, designers and engineers at Microsoft Vancouver. Developed in our in-house makerspace, The Garage, the *Transformation Mask* project brings art and technology together.

***Transformation Mask*. (© Microsoft Vancouver. Photo: Pamela Saunders.)**

The assembled mask is a meter long and made up of over 20 individually 3D-printed PLA and acrylic resin components. True to traditional form, there are no straight lines on the raven, a concept in direct competition with polygonal hard surface 3D modeling. From the ovoid shaped eyes to the gently sloping beak, each surface exhibits a sort of infinite tension.

The holographic experience evolved organically, with the team taking a similar approach to their hardware development processes—the aim was to expose Hunt to the latest technologies available for artistic expression in emerging digital mediums. After several sessions, he generated a selection of traditional forms expressed gesturally as polygonal lines.

Transformation Mask is an interactive installation that features HoloLens. It utilizes electronics and mechanical engineering to express a physical and digital transformation. Participants are immersed in spatial sounds and holographic visuals.

The mask's behavior is achieved through an array of electronics, sensors, processors and mechanical elements. Three linear actuators attached to an aluminum skeleton drive the primary phases of motion. Several microcontrollers work in unison to control individual addressable LEDs and behavior states for the raven's eyes projected through Windows phones. Onboard ambient light sensors on the phones are used to control state-based animations. An ultrasonic range finder is aware of the presence of an attendee, and will trigger the experience. HoloLens orchestrates all these elements, synchronizing the software and hardware over a Bluetooth connection.

Microsoft Vancouver and our in-house makerspace, **The Garage**, worked together on this creative collaboration with Heiltsuk artist **Shawn Hunt**. *Transformation Mask* is a shared work created by a team of artists, designers and engineers at Microsoft. Hunt led the team through a fluid creative process from idea to installed museum exhibit in just under 2 months, with everyone empowered to add their expertise and enthusiasm at every step of the way. Concept by Shawn Hunt. Mechatronics and physical component programming by Robert Butterworth. Display programming by Jonathon Cobb. 3D modeling and 3D printing by Jeremy Kersey. Holographic effects and experience design by Andy Klein. Project management by Stacey Mulcahy. Additional 3D printing by Brendan O'Rourke. Project facilitated by Pam Saunders. Audio by Brent Silk. Holographic application programming by Julia Taylor-Hell.

Somnium

Danny Bazo, Marko Peljhan and Karl Yerkes

Somnium is a robotic and audiovisual installation that provides visitors with the ability to contemplate and experience exoplanetary discoveries, their macro- and microdimensions and the potential for life in our galaxy.

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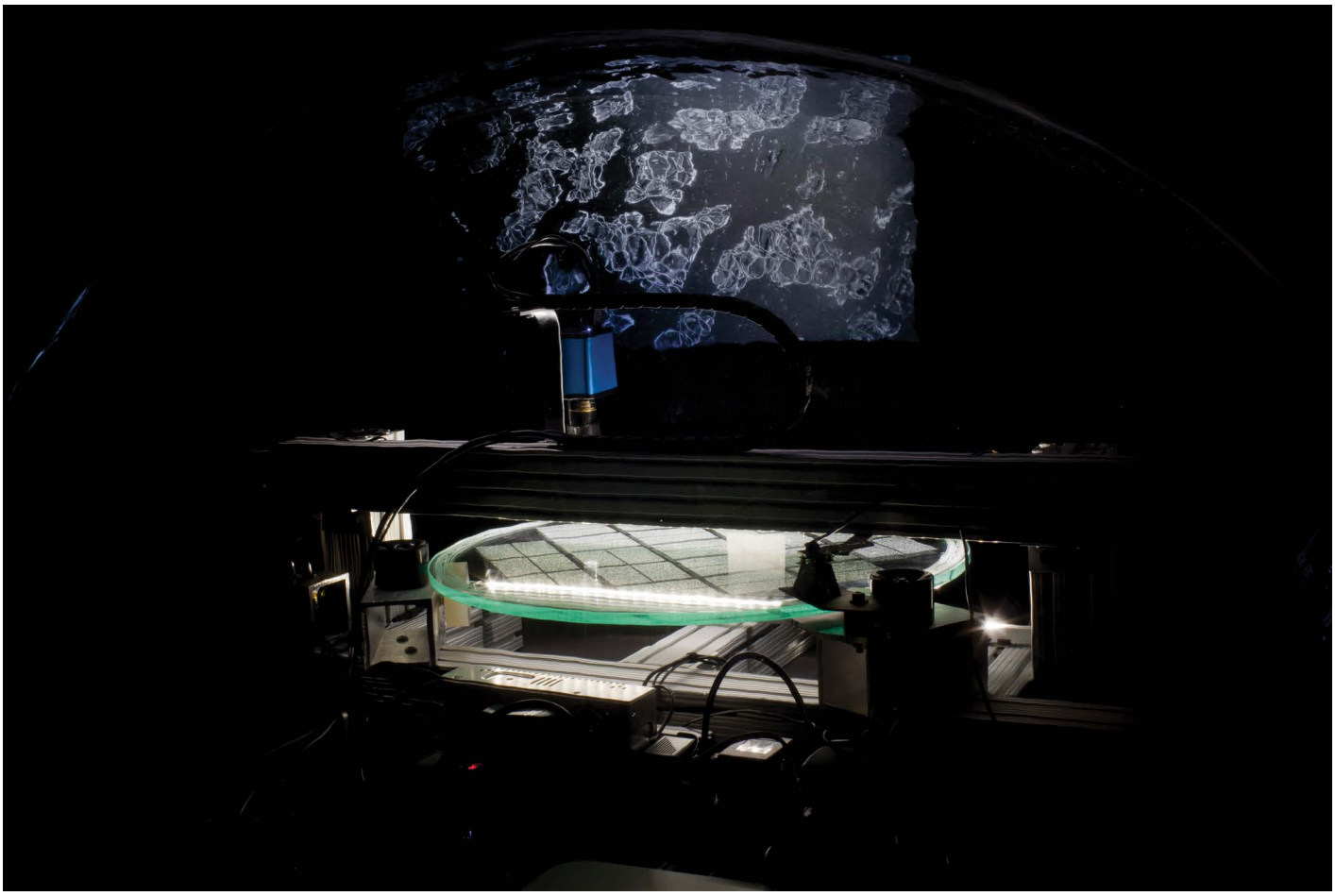
At the center of *Somnium* sits a round glass disc that has been laser etched with an image captured by the Kepler Space Telescope (KST). The image contains hundreds of thousands of stars. A robotic microscope slowly travels the surface of the disc, displaying the microscopic view to visitors using large-scale wall projections. The exact location of the microscope within the starfield is tracked and correlated with luminosity measurements taken by the KST. These measurements, called "light curves," are converted into sounds that immerse visitors in an ever-changing wash of audio corresponding to the stars they see projected around them.

Somnium invites philosophical questions about the possibility of the existence of life beyond our planet. The work reveals the simplicity and beauty behind the extremely sophisticated technology and methods



***Somnium*, exhibited from 8 June–8 July 2017 at Kapelica Gallery in Ljubljana, Slovenia. The opening coincided with the international symposium "Earth Without Humans II" hosted by Kapelica Gallery. (Photo: © Miha Fras)**

of the Kepler Mission. Visitors can experience this beauty and understand the questions that arise on a human, aesthetic and accessible scale.

Background

Johannes Kepler (1571–1630) authored seminal texts on what we now know as his laws of planetary motion. These affirmed the Copernican heliocentric model of our solar system and, later, Newton's laws of gravity. In one of these books, *Somnium* (English: A Dream), published posthumously in 1634, he explained with detailed precision how Earth would look if observed from the Moon. In 2009, NASA's Discovery Mission No. 10, also known as the Kepler Mission, deployed the KST in search of exoplanets in or near "habitable zone" orbits. Over four years, the KST recorded the varying light intensities (known as "light curves") of star systems located near the stars Deneb and Vega in the Cygnus and Lyra constellations in a 100-square-degree 3,000-light-year field of view.

As of 2018, the KST has enabled the discovery of 2,327 confirmed exoplanets. Of these, 30 are less than twice Earth-sized and within their star's habitable zone. Several are potential candidates for life as we know it. These discoveries challenge the notion that Earth alone is the center and extent of life in the Milky Way galaxy. The profound scientific and philosophical consequences of the Kepler Mission echo the effect of the work of Kepler, the man.

Acknowledgment

The creation of this work was supported by the Ministry of Culture, Republic of Slovenia, the Systemics Lab Public Programming Fund at MAT, UCSB, the University of California Institute for Research in the Arts Integrative Methodologies fund, the City of Ljubljana Cultural Department and kind contributions of the SETI Institute.

The artist team of **Danny Bazo**, **Marko Peljhan** and **Karl Yerkes**, from the Systemics Lab in the Media Arts and Technology Program at UC Santa Barbara, collaborated with NASA and SETI Institute scientist Jon Jenkins on *Somnium* from 2013–2016.

INSTRUMENT | One Antarctic Night

Ruth West, Violet Johnson, I Chen Yeh, Zach Thomas, Eitan Mendelowitz and Lars Berg

INSTRUMENT | One Antarctic Night (IOAN) is a performative, multiparticipant reconfigurable artwork that engages open astronomical data in combination with data generated by robotic telescopes in Antarctica. IOAN places visitors inside a virtual star field of over 800,000 astronomical objects that form part of the Large Magellanic Cloud. This star field, created from observations in Antarctica and fused with additional data from multiple open astronomical repositories, is situated waist high within the virtual environment and stretches out beyond participants in all directions. Multiple participants can walk about the environment and collaboratively explore the star field by taking hold of the "fabric" of space, creating ripples and waves, and interacting with individual or sets of objects to create visual and auditory data remixes. The interaction places the astronomical data within a virtual reality visual and sonic remix engine that is a fundamental component of the artwork and is used to construct the virtual world. All graphics and spatialized ambisonic audio are procedurally generated from the data via real-time database queries. Our work incorporates machine learning approaches combined with granular and concatenative synthesis for generating the environment's unique soundscape. *INSTRUMENT | One Antarctic Night* evolved from our ongoing work in developing aesthetic data remixing and immersive data-driven experiences. Dataremix proposes the creation of the "datamade," a concept analogous to Duchamp's "readymade." IOAN is a meta-datamade in that it is a virtual instrument within which participants collaboratively create datamades through visual and auditory aesthetically driven remixes of astronomical data.

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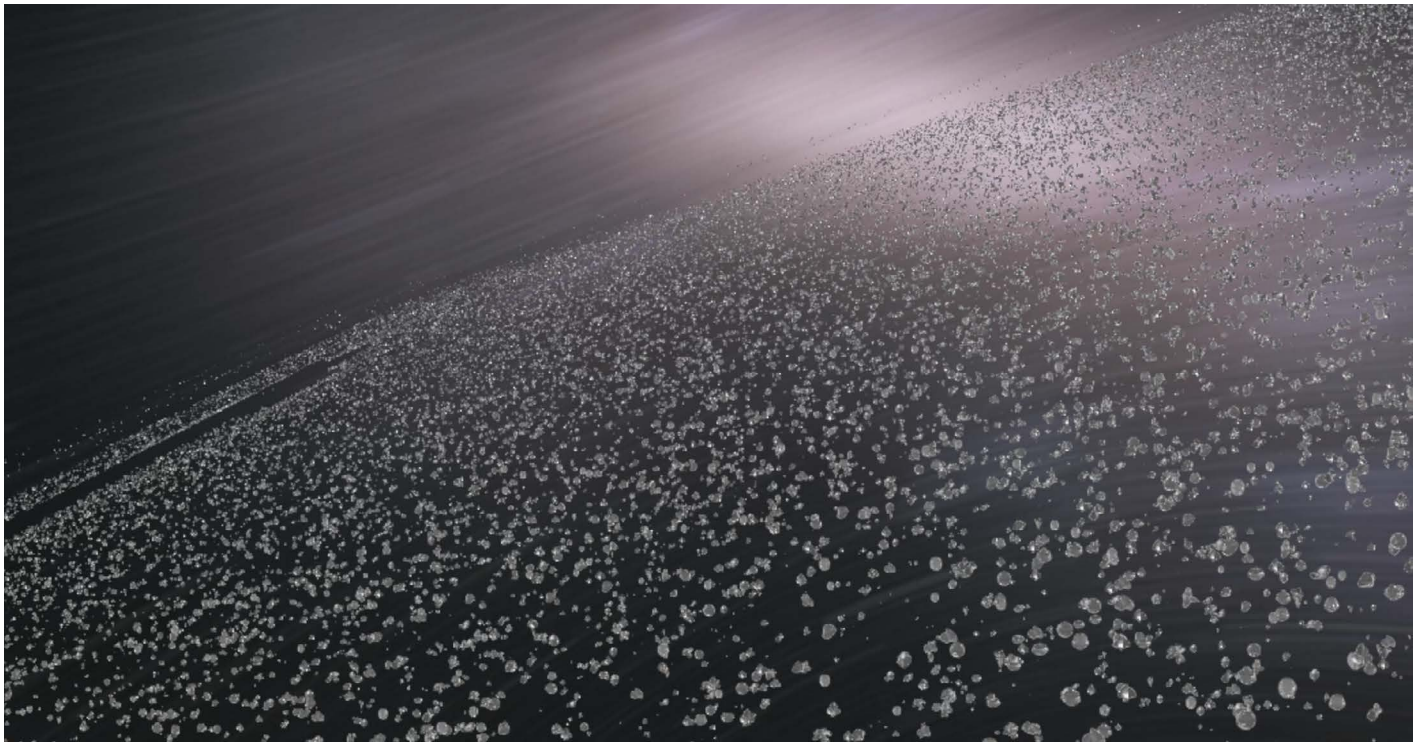

Virtual star field of 817,373 objects created from multidimensional astronomical data captured by robotic telescopes during one Antarctic night. (© 2018 Ruth West)

Acknowledgments

INSTRUMENT | *One Antarctic Night* is supported in part by an award from the U.S. National Endowment for the Arts (15-5400-7043) and by BenQ America Corporation. We thank Lifan Wang and Lingzhi Wang of Texas A&M and the Beijing Astronomical Observatory for their generous consultation and support of this art-science installation. We thank the Antarctic Survey Telescope array and PI Lifan Wang for making available AST3-1 data. We thank Roger Malina, University of Texas–Dallas, for his generous consultation in astrophysics and art-science, and his support of this work. We thank astronomer Jason Young, Mount Holyoke College, for his generous consultation and assistance. We thank Stella Kafka, astronomer and director, American Association of Variable Star Observers, for her generous consultation. This artwork made use of the VizieR catalog access tool, CDS, Strasbourg, France. The original description of the VizieR service was published in *A&AS* 143, 23. This work has made use of data from the European Space Agency (ESA) mission Gaia (<www.cosmos.esa.int/gaia>), processed by the Gaia Data Processing and Analysis Consortium (DPAC, <www.cosmos.esa.int/web/gaia/dpac/consortium>). Funding for the DPAC has been provided by national institutions, in particular the institutions participating in the Gaia Multilateral Agreement.

INSTRUMENT | *One Antarctic Night* is being developed by an art + science collaboration bringing together interactive artists, composers, computer scientists and astrophysicists. Our team includes collaborators from University of North Texas, Mount Holyoke College, University of Texas at Dallas and Texas A&M: **Ruth West**, **Violet Johnson**, **I Chen Yeh**, **Zach Thomas**, **Eitan Mendelowitz** and **Lars Berg**.

Sopro and *Toque* (The Blow and Touch)

Milton Sogabe, Fabio Oliveira Nunes, Carolina Peres, Soraya Braz, Rodrigo Dorta,
Cleber Gazana, Mirian Steinberg, Melina Furquim, Daniel Malva and Fernando Luiz Fogliano

Considering the paradox between energy production and the contamination of the environment and reduction of biodiversity, cAt research group develops its work considering the discussion on sustainable sources of energy. The group's recent projects—*Sopro* (The Blow) and *Toque* (Touch)—have sought to aesthetically use the audience body's energy to interact and to animate the artworks. Simple devices are used to seek, in a kind of technological minimalist and interactive-art way, to raise public awareness of the issue of sustainability.

These concerns were embodied through the realization of *Sopro* (The Blow) (2015), an interactive work energized by the public through the vigor of a blow. The work was based on the use of a simple technological system, on the poetic dimension of the blow and on primordial scientific principles. The act of blowing is recurrently associated with the genesis of life. *Sopro* consists of a system of acrylic spheres, where a visitor can vivify the work in a large sphere by blowing in the propellers inside of smaller spheres. The energy current generated by the moving propellers activates small motors inside the main piece of the work, giving the public the experience of creating movement through their own energy.

Toque (Touch) (2017), also developed by the cAt group, seeks to broaden the creative process while still keeping the perspective started in *Sopro.* The core of our aesthetic proposal is energy produced by the human body, specifically when the public interacts with our work. Through the Peltier effect, a type of thermoelectric effect that is observed in an electric circuit, visitors can bring *Toque* to life through the warmth of their hands.

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***Sopro* and *Toque*, cAt research group. (Photo: Carolina Peres, 2018. © cAt)**

The author of these works is **cAt** (science/Art/technology), a research group of the Art Institute, at São Paulo State University, accredited by CNPq (National Council for Scientific and Technological Development). The group consists of Prof. Dr. Milton Sogabe (UNESP) and Prof. Dr. Fernando Fogliano (SENAC) as leaders, Dr. Fabio Fon (UNESP), doctoral student Carolina Peres (UNESP), Masters Cleber Gazana (UNESP) and Sorya Braz (UNESP), and Masters students Rodrigo Dorta Marques (UNESP), Mirian Steinberg (UNESP), Melina Furquim (UNESP) and Daniel Malva (UNESP).

You Are the Ocean

Özge Samanci and Gabriel Caniglia

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This interactive installation allows participants to control a digitally simulated ocean using only their brainwaves. Calm seas and storms alike are powered by the viewer's thoughts; the sheer act of concentration can conjure a squall or sunshine. Participants intentionally control their thinking while surrounded by the magnified consequence of their thoughts. Created in 2017, *You Are the Ocean* is about the theme of origins and one of the key concepts of Haudenosaunee and Anishnaabe cosmologies: "land is alive."

A participant wears an EEG (electroencephalography) headset that measures her approximate attention and meditation levels via brainwaves. Attention level affects storminess: with higher concentration, the waves get higher and the clouds thicken. By calming her mind, the subject can create a calm ocean.

Humanity's relationship with the natural world is complex. Humans have a nervous system and perceive an illusionary boundary between their bodies and the rest of the world. A sip of water we drink was once in the ocean, a cloud, a plant. An atom in our body is billions of years old, coming from dying stars, and each atom has been a part of so many things: stardust, soil, sea, clouds, air, single-cell life, fish, bugs, birds. This concept appears in different versions of indigenous cosmologies, Sufi mysticism, Big Bang theory and the history of evolution. Distinguished professor Donna Haraway postulates that humans are not superior to any ecosystem and they exist in the intertwined web of all ecosystems as an extension of the planet. *You Are the Ocean* is a reminder that our presence and thinking have a direct impact on the planet.

Scene from *You are the Ocean*. (© Özge Samanci. Photo: Deborah Libby.)

Özge Samanci, a media artist and graphic novelist, is an associate professor in Northwestern University's School of Communication. Her interactive installations have been exhibited internationally, including FILE festival, The Tech Museum of Innovation in San Jose, WRO Media Art Biennial, Athens International Festival of Digital Arts and New Media, ISEA. Samanci's installation *You Are the Ocean* will be exhibited at Currents New Media, FILE festival, and SIGGRAPH 2018 Art Gallery.

Gabriel Caniglia studies cognitive science and computer science at Northwestern University. His interests lie broadly in human-computer interaction and immersive technologies. He is the programming and implementation lead for *You Are the Ocean*.

Haven

Alex Beim

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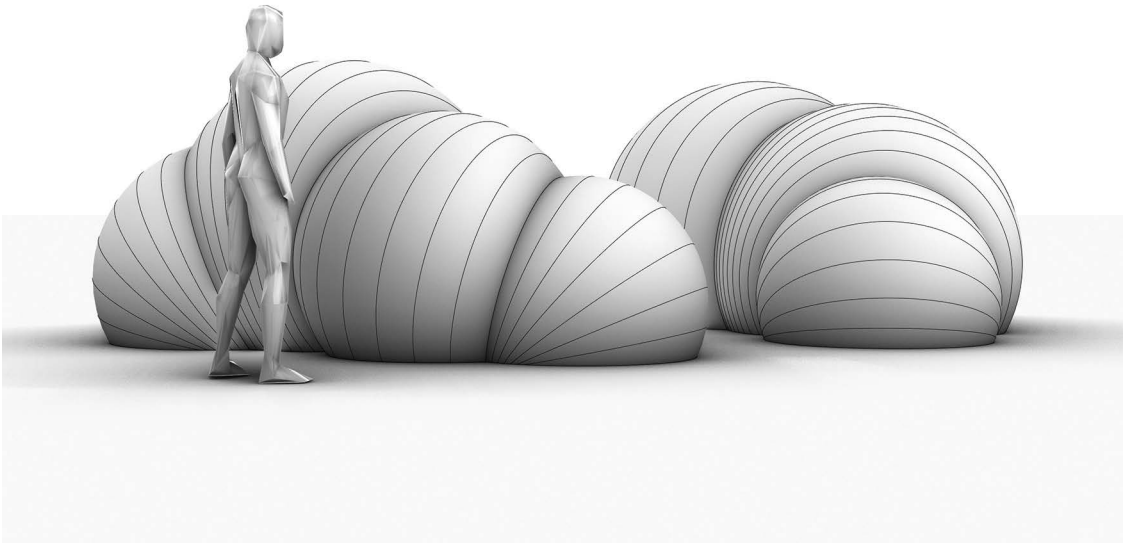
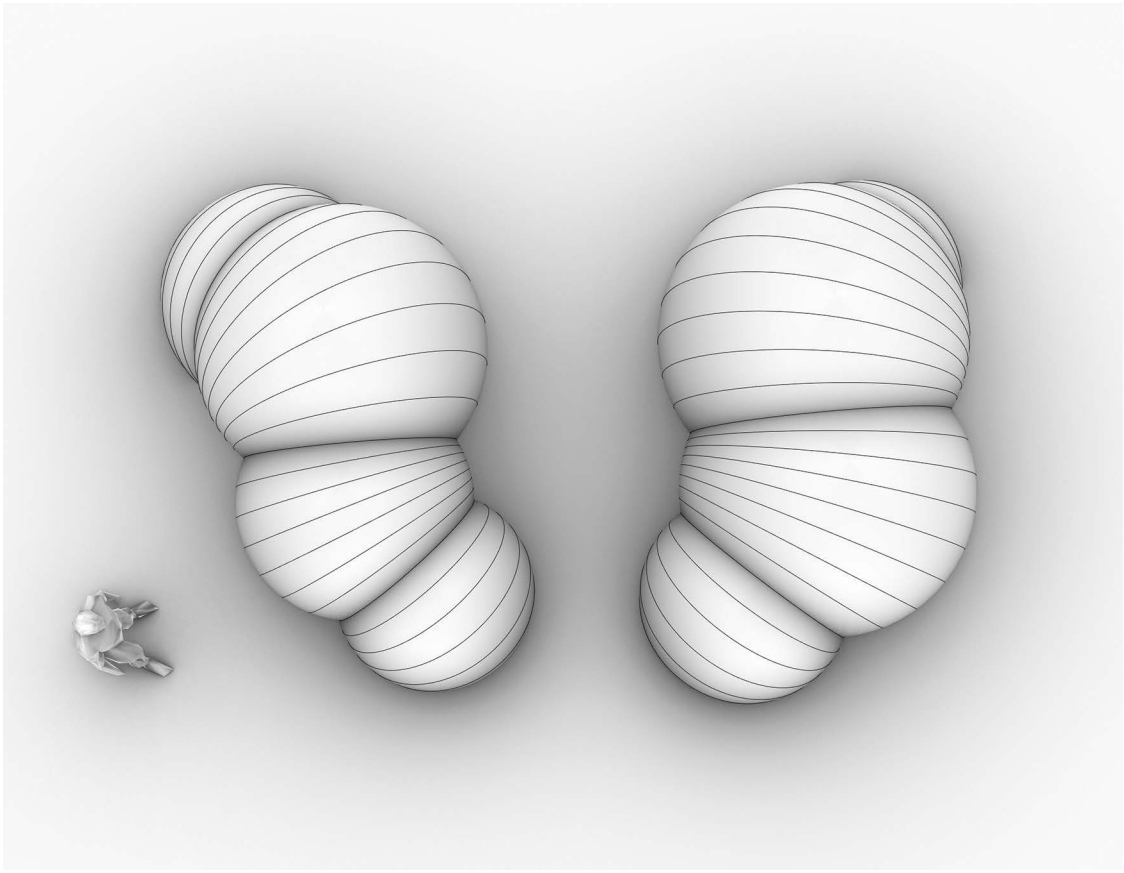
Haven is a place of security and tranquility. Reminiscent of a mother's womb, it recalls our origins, where it all begins. The installation allows guests to leave their phones and all other technology at the door so they can be fully present without any of the prevailing modern distractions. They go in, spend some time, find themselves and maybe come out and start their day again. Fresh. A new beginning.

Founded in 2008, Tangible Interaction Design is a Vancouver-based art and design studio focused on creating artworks that are to be felt and experienced live. For *Haven*, Tangible constructed two organic-shaped inflatables that allow people to go inside and be present at an event while also having a personal, meditative experience. Designed as meta balls, spheres that blend together in a natural configuration, each inflatable maintains its form with an electric fan. To enter, guests simply go through a zippered doorway.

Haven is a new installation, conceived as a way to change how people perceive a space. By giving guests the opportunity to step into a meditative environment in the midst of a busy event, it opens up the possibility for them to stop and examine themselves and everything around them. Maybe it's just a time for a short rest or perhaps they come out with a whole new perspective, a new introduction to their day.



Concept design of *Haven*, January 2018. (© Tangible Interaction Design)



Concept design of *Haven*, January 2018. (© Tangible Interaction Design)

Alex Beim is CEO, Lead Artist, Creative Director at Tangible Interaction Design Inc. From graphic designer to digital creative to interactive artist, Alex Beim's career has been a diverse journey. His interest in moving interactivity away from the screen and into the physical world led to the launch of Tangible Interaction Design Inc. in 2006 in the Strathcona neighborhood of Vancouver, British Columbia. Since then, he has focused on developing interactive experiences that engage people in public and commercial spaces. His artworks have been seen by millions worldwide and include installations for CODE Live (2010 Winter Olympic Games), City of Richmond, City of Vancouver, City of Turin, the Vancouver Aquarium, Vancouver Public Library, SIGGRAPH, Toronto International Film Festival's digiPlaySpace, Cine Kid and Illuminate Yaletown.

Diastrophisms

Nicole L'Huillier, Thomas Sanchez Lengeling and Yasushi Sakai

Diastrophisms is a sound installation with a modular system that sends images through rhythmic patterns. It is built on a set of debris from the Alto Río building that was destroyed by the 27F earthquake in 2010 in Chile. With *Diastrophisms* we were looking for a poetical, critical and political crossing between technology and matter, in order to raise questions about the relationship between human beings and nature, and to consider the construction of memory in a community by questioning the notion of monument, as well as to imagine new forms of communication in times of crisis. This piece has a full paper in the Art Papers section on page 356 of this journal.

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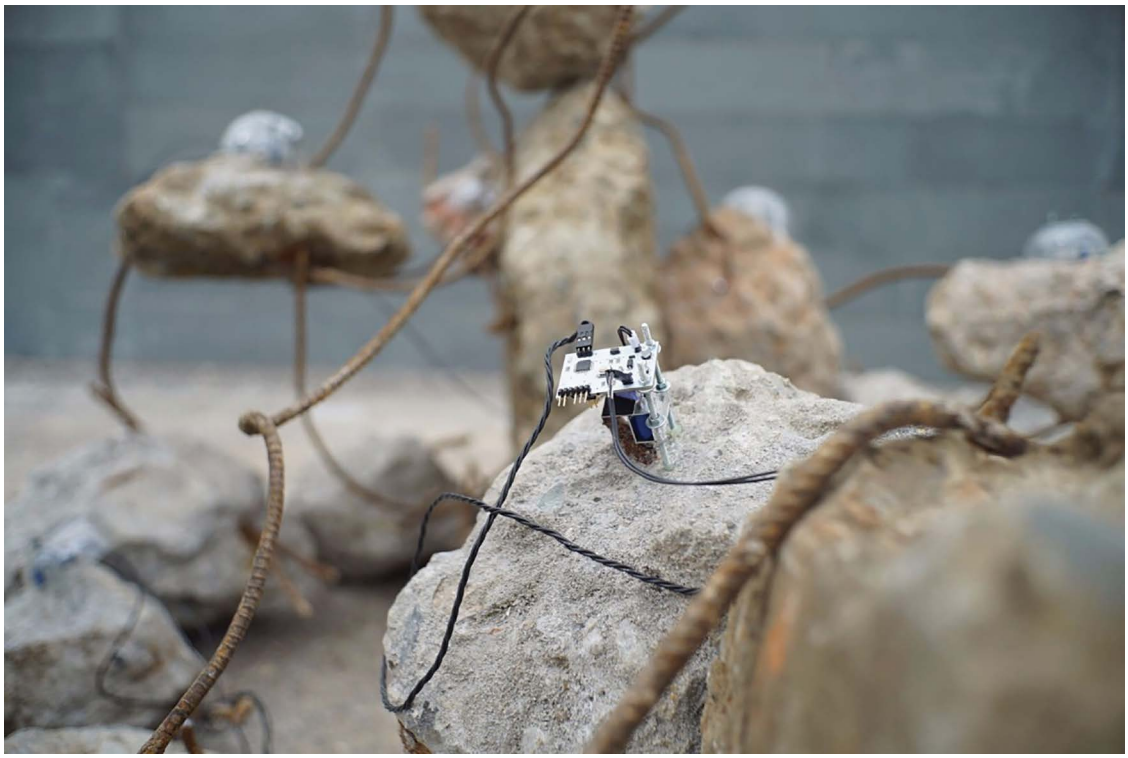

***Diastrophisms*, detail of devices actuating the debris of Alto Rio building, Centro Nacional de Arte Contemporaneo Cerrillos, Chile, 2017. (© and Photo: Yasushi Sakai)**

Nicole L'Huillier (Chile), **Thomas Sanchez Lengeling** (Mexico) and **Yasushi Sakai** (Japan) are researchers, artists, students, architects, musicians, technologists and scientists. They are currently based at the MIT Media Lab, Boston, MA, where their work scales from creating micro-chip universes to sentient megastructures, converting tangible artifacts to intangible experiences, and creating synthesized reality tools to speculative futuring actions.

The Network

ANNOUNCEMENTS FROM THE LEONARDO COMMUNITY

Sign up to receive our monthly newsletter for the latest in Leonardo/ISAST news, as well as announcements and opportunities of interest to the art/science/technology community, at <leonardo.info/signup>.

To submit an opportunity or announcement, visit <leonardo.info/opportunities>.

Facebook.com/LeonardoISAST
Twitter.com/LeonardoISAST
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LEONARDO CELEBRATES ITS 50TH ANNIVERSARY AROUND THE WORLD

During 2017–2018, we invite you to participate in our 18-month-long celebration of Leonardo's 50th Anniversary. Half a century ago, kinetic artist and astronautical pioneer Frank Malina set out to solve the needs of the community of artists and scientists working across disciplines by using the "new media" of the time—offset print publishing. *Leonardo* journal represented a unique vision that served as an international channel of communication among artists, with emphasis on the writings of artists using science and developing technologies in their work.

Today, documenting and capturing the creative innovators and provocateurs of culture is not enough. If media is the messenger, then Leonardo must expand its scope to represent the unique works and challenges we face in the 21st century. As a network of networks, Leonardo is reimagining the next 50 years. We invite you to come along with us on this journey of rediscovery and reinvention.

Join us at SIGGRAPH to celebrate Leonardo's 50th Anniversary, 12–16 August 2018: SIGGRAPH, Vancouver, Canada

Leonardo and ACM SIGGRAPH partner to celebrate Leonardo's anniversary at this annual conference, coordinated by Andrés Burbano <s2018.siggraph.org>.

"Origins" exhibition curated by Andrés Burbano features one of Leonardo's pioneers Ernest Edmonds. For details on this work and other Art Gallery artists visit <https://s2018.siggraph.org/conference/conference-overview/art-gallery/>.

Join us for a toast during our Art Gallery reception and History and Future Birds of a Feather gathering of the Leonardo Education and Art Forum (LEAF) during SIGGRAPH, featuring *Leonardo* Executive Editor Roger Malina, Ernest Edmonds and other Leonardo community members discussing the past and future.

6–10 September, Linz, Austria

Leonardo is being singled out for recognition by the Prix Ars Electronica with a 2018 Golden Nica award.

28 September: International Design Journals Forum, Beijing, China

Leonardo's 50th anniversary will be celebrated at this forum hosted by at Tsinghua University.

October 2018: 50th Anniversary Celebration in Dallas, Texas, U.S.A.

Hosted by the ATEC Program at the University of Texas Dallas.

3–4 November 2018: SPECIAL EVENT: The Convening, San Francisco, California, U.S.A.

You're invited to Leonardo's culmination celebration to inspire, experience and envision the future. Hosted by the San Francisco Art Institute.

19–23 November 2018: Celebración "50 Anniversario *Leonardo* Journal," Montevideo, Uruguay

Fiftieth celebration presentations and workshop organized by Delma Rodriguez of Anilla Cultural Latinoamérica-Europa.

For more information about upcoming Leonardo Anniversary events, visit <leonardo.info/50th-anniversary>.

OPEN CALLS FOR *LEONARDO* JOURNAL: SPECIAL SECTIONS

The current calls for papers for *Leonardo* journal include special sections such as PhD in Art and Design, the *Leonardo* STEAM Initiative in Education and, most recently, Science and Art: Understanding the Cross-Disciplinary Dialogue. *Leonardo* is interested in work that crosses the artificial boundaries separating contemporary arts and sciences. Featuring illustrated articles written by artists about their own work as well as articles by historians, theoreticians, philosophers and other researchers, the journal is particularly concerned with issues related to the interaction of the arts, sciences and technology. Find out more at <leonardo.info/open-calls-for-leonardo-journal>.

doi: 10.1162/LEON_a_01656

NEW IN ARTECA: *LEONARDO* JOURNAL ARCHIVE 1968–TODAY

For the the first time in history, all issues of *Leonardo* journal are now available on ARTECA, our curated space for essential content linking the arts, sciences and technologies. *Leonardo*, founded in 1968, has become an international channel of communication for artists who use science and developing technologies in their work. Subscribe to ARTECA to read the very first issue! <arteca.mit.edu>.

PARTNERS IN ART AND SCIENCE: BECOME AN AFFILIATE MEMBER!

The Leonardo Affiliate Member Program provides a collaborative environment where leaders from top-ranked universities and independent nonprofits in the cross-disciplinary field of art, science and technology can interface and share best practices, research and opportunities with their peers across institutional boundaries. See the current affiliates at <leonardo.info/affiliate-member-directory> and visit <leonardo.info/affiliate-program> to join.

ATTEND A LASER NEAR YOU!

What do nanotechnology, biological matter, big data, 3D printing and telecommunications have to do with art? Come to a Leonardo Art Science Evening Rendezvous (LASER) near you to find out! LASER talks are now presented in more than 30 locations around the world. Each LASER gathering features 10- to 20-minute talks on art/science topics and the opportunity for attendees to network with cutting-edge artists, scientists and researchers in an informal setting. Leonardo is proud to add San Jose State University to the LASER Talks community. See <leonardo.info/laser-talks> for locations and dates.

FROM IDEAS TO INNOVATION—LEONARDO IS HERE!

The name *Leonardo* immediately brings to mind ideas and innovation in art and science. For 50 years Leonardo has been identifying and highlighting the concepts and results of generations of artists, scientists, technologists and researchers. Help us move the vision of Leonardo forward through a generous donation today! Leonardo/ISAST is a 501(c)(3) nonprofit organization that relies on the support of its community. Donations are fully tax-deductible in the United States as provided by law. Visit <leonardo.info/donate> to give.

ANNOUNCEMENT

Save the Date: The Convening

3–4 NOVEMBER 2018, SAN FRANCISCO, CA

Based on the SEAD study "Steps to an Ecology of Networked Knowledge and Innovation," Leonardo/ISAST hosts a regional event for our 50th anniversary that alchemizes all the action categories listed in the report. The outcome of the event will not only be to manifest the action categories but to jointly create a potent statement of premise or manifesto.

DAY 1—EXPERIENTIAL
Lightning keynotes curated to inspire. This day will encompass a set of transdisciplinary experiences ranging from small art/sci collaborations, institutions, academia and corporate innovation.

DAY 2—VISION PLANNING
This day, participants will gather for a facilitated daylong future-casting workshop focused on the transdisciplinary movement as a whole and its relationship to society. This may result in a manifesto or multiple manifestos, new collaborations and a new vision for Leonardo.

See <Leonardo.info/50th-anniversary> for more.

LEONARDO The International Society for the Arts, Sciences and Technology

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Leonardo Music Journal
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Leonardo Book Series
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Benefits of Membership

Artists, scientists, engineers, researchers and others interested in the contemporary arts and sciences are invited to join Leonardo/ISAST. Benefits include reduced rates for Leonardo/ISAST publications, eligibility to participate in Leonardo working groups and special invitations to Leonardo-sponsored events.

For further details, visit <leonardo.info/affiliate-membership> or email <isast@leonardo.info>.

Affiliate memberships also available for nonprofit organizations, educational institutions and corporations working at the intersection of art, science and technology. Visit <leonardo.info/affiliate-membership> for more information.

Mission Statement

The critical challenges of the 21st century require mobilization and cross-fertilization among the domains of art, science and technology. Leonardo/ISAST fosters collaborative explorations both nationally and internationally by facilitating interdisciplinary projects and documenting and disseminating information about interdisciplinary practice.

Publications

Journals
The *Leonardo* journals are scholarly peer-reviewed journals of record. *Leonardo*, published bimonthly, is the official journal of Leonardo/ISAST. *Executive Editor:* Roger F. Malina. *Leonardo Music Journal* with audio companion is published annually.

Leonardo Website
The Leonardo website (<leonardo.info>) publishes organizational information, the Leonardo Electronic Directory and more.

Electronic Journal
Leonardo Electronic Almanac (<leonardo.info/lea>) is an electronic journal dedicated to providing a forum for those who are interested in the realm where art, science and technology converge. *Editor-in-Chief:* Lanfranco Aceti.

Leonardo Reviews
Leonardo Reviews, through a panel of reviewers, publishes reviews of relevant books, journals, electronic publications and events. Reviews are published on the web (<leonardo.info/reviews>), and selected reviews are published in *Leonardo*. *Editor-in-Chief:* Michael Punt.

The Leonardo Book Series
The Leonardo Book Series (<leonardo.info/books>), published by the MIT Press, highlights topics related to art, science and developing technologies. *Editor-in-Chief:* Sean Cubitt.

LABS Databases of Master's and PhD Theses
Leonardo Abstracts Service (LABS) is an evolving, comprehensive database of thesis abstracts (PhD, Masters and MFA) on topics at the intersection of the arts, sciences and technology (<leonardo.info/labs>). *Editor-in-Chief:* Sheila Pinkel.

ARTECA
ARTECA is a curated space for essential content linking the arts, sciences and technologies created by The MIT Press in partnership with Leonardo/ISAST. It houses thousands of pages of book and journal content published by The MIT Press, including the full archives of *Leonardo* and *Leonardo Music Journal*. ARTECA was built for researchers, scholars, artists, educators, students and practitioners in the arts, science, design, new media and technology communities. It offers hybrid open access and subscription-based access to published materials as well as a growing collection of gray literature—research output created outside of traditional commercial or academic channels—which has become increasingly more important in scholarly communication. Visit <arteca.mit.edu> for more information, to subscribe or to sign up for a free 30-day trial for institutions.

Collaborations With Other Organizations

Leonardo/ISAST frequently collaborates with other organizations on topics of current interest by collaborating on conferences or workshops and by publishing special sections in *Leonardo* or co-sponsoring events. Current collaborators include:

- ACM SIGGRAPH (U.S.A.)
- Association Leonardo (France)
- Balance-Unbalance (U.K.)
- College Art Association (U.S.A.)
- Djerassi Resident Artists Program (U.S.A.)
- MIT Press (U.S.A.)
- Pomona College (U.S.A.)
- San Francisco Art Institute (U.S.A.)
- University of Dallas at Texas, ArtSciLab (U.S.A.)

Leonardo Project Working Groups

Leonardo hosts working groups on projects with a topical focus:

Leonardo Abstracts Service (LABS)
Sheila Pinkel, *Editor-in-Chief*. *Peer Reviewers:* Yiannis Colakides, Tom Leeser and Mary Anne Staniszewski.

Leonardo Education and Art Forum (LEAF)
Alan Boldon, *Chair*; Ruth West, *Chair-Elect*; Andrés Burbano, *International Representative*. See <leonardo.info/leaf> for more information.

Book Series Committee
Sean Cubitt, *Editor-in-Chief*. Annick Bureaud, Steve Dietz, Zhang Ga, Machiko Kusahara, Roger Malina, Jose-Carlos Mariategui, Laura U. Marks, Anna Munster, Monica Narula, Michael Punt, Sundar Sarukkai, Joel Slayton, Mitchell Whitelaw.

Leonardo's 50th Anniversary Committee
Anniversary events and collaborations are made possible with in-kind support from the following: Nina Czegledy, *partnership liaison*; Brad Jerger, *designer*; Scott Trent, *Project Delphi curator*; Steve Musial, *web developer*; Sheila Pinkel; Marc Hebert. Danielle Siembieda, *Chair*. See <leonardo.info/50th-anniversary> for more information.

Affiliate Members

Leonardo/ISAST invites organizations and corporations working at the intersection of art, science and technology to join the Affiliate Membership Program. Visit <leonardo.info/members> for more information.

Current affiliate members include:

- Alliance for the Arts in Research Universities (a2ru)
- Arup
- California Institute of the Arts, Herb Alpert School of Music
- Cultural Programs of the National Academy of Sciences
- Cyland Media Lab
- Djerassi Resident Artists Program
- Humanities/Art/Technology Research Center at Uniwersitat im. Adama Mickiewicza in Poznan
- LAZNIA Centre for Contemporary Art
- Minerva Foundation
- Noema
- Ontario College of Art & Design University
- Pomona College
- SymbioticA
- Universidad de Caldas
- University of California, Davis Art/Science Fusion Program
- University of California, Los Angeles, Art|Sci Center
- University of California, Santa Cruz, Institute of the Arts and Sciences
- University of San Francisco, College of Arts and Sciences
- University of Texas at Dallas, Arts and Technology
- Washington University in St. Louis

Leonardo/ISAST

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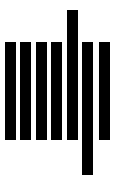

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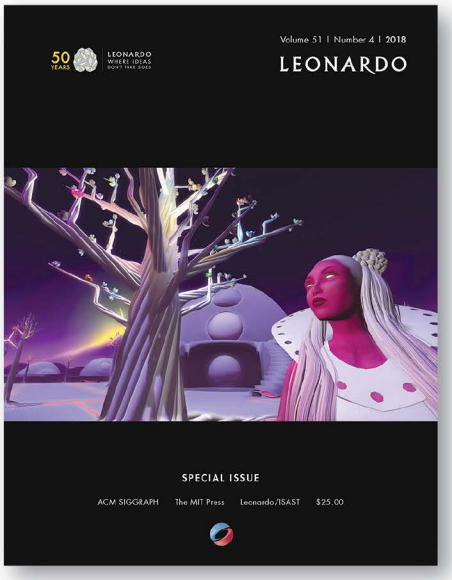

ACMSIGGRAPH LEONARDO

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