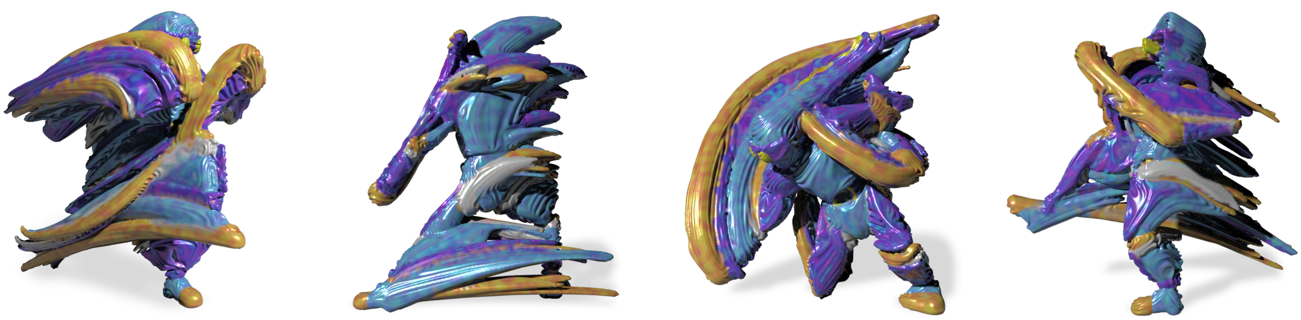
Animated Futurist Sculpting as Dynamic Implicit Shapes

Pablo Vielma
Department of Visualization, Texas A&M University
College Station, Texas, USA
pablom.vielma@tamu.edu

Ergun Akleman
Departments of Visualization & Computer Science and Engineering, Texas A&M University
College Station, Texas, USA
ergun.akleman@gmail.com



(a) Frame 5. (b) Frame 7. (c) Frame 8. (d) Frame 10.

Figure 1: *Examples of animated futurist sculpting. The process creates a set of futurist sculptures that can be considered as the frames of a sculptural animation.*

ABSTRACT

In this work, we present an approach to obtain futurist sculptures. Our approach is inspired by the works of Italian Futurist artists such as Umberto Boccioni. Futurism, as an art movement, aims to achieve to define forms that are a product of time but is permanent in space. In this work, we have developed a methodology to produce a set of futurist sculptures from any given animation of any object that is defined as a triangular mesh. Each produced futurist sculpture is a still frame of what can be rendered as a sculpture animation. Our method is based on the conversion of a given polygonal mesh and its motion into an implicit shape in 4D space which consists of 3-spatial and one temporal dimension. To create each specific futurist sculpture, we compute a subset of this 4D implicit shape in a given time interval. The resulting immersion of 4D structure into the 3D spatial domain provides us desired futurist sculpture for the given time interval. The most important aspect of our methodology is the conversion of animated polygonal mesh into a 4D implicit shape. We first convert a polygonal mesh into a set of particles. Each particle can have its own color. All the points that are closer to the trajectory of the particle form an implicitly defined swept volume [Kim et al. 2004]. These swept volumes appear to be similar to the extrusion of a circle along a curve, but they are guaranteed to be free of artifacts caused by intersections.

SIGGRAPH '21 Posters, August 09-13, 2021, Virtual Event, USA

ACM ISBN 978-1-4503-8371-4/21/08.
https://doi.org/10.1145/3450618.3469148

CCS CONCEPTS

• **Computing methodologies → Non-Photorealistic Rendering**.

KEYWORDS

Abstract Sculpting, Futurism

ACM Reference Format:
Pablo Vielma and Ergun Akleman . 2021. Animated Futurist Sculpting as Dynamic Implicit Shapes. In *Special Interest Group on Computer Graphics and Interactive Techniques Conference Posters (SIGGRAPH '21 Posters), August 09-13, 2021.* ACM, New York, NY, USA, 2 pages. https://doi.org/10.1145/3450618.3469148

1 EXTENDED ABSTRACT

The Futurist art movement was born to describe motion in painting, sculpture and photography [Apollonio et al. 1973]. The focus of Futurism was on representing speed, dynamism and energy. Artists experimented with various techniques to show "vitality of matter". One of the most well-known Futurist painters is Boccioni and one of the best examples of Futurism is Boccioni's sculpture of a walking man, whose body is distorted by his movement. Boccioni began working as a painter, later used sculptures "to construct complex forms in space and light [Coen et al. 1988]."

Futurism as an art form was probably born out of Jules-Etienne Marey's research. Marey invented Chronophotography to record multiple photographic exposures on a single glass plate [Braun 1994]. He used Chronophotography for scientific purposes to study human motion by producing single-image representations that depict the "relationship in time and space between various body parts." One of the earliest examples of Futurism is Nude Descending a Staircase, a painting by Marcel Duchamp. That painting bears strong

resemblance to Marey's chronophotographic studies. Marey's influence is also visible in another famous Futurist painter Giacomo Balla's "Violinist", showing multiple overlapping images of a violinist's hands during a performance [Apollonio et al. 1973].

The Futurist movement also impacted animation. The well-known animation principle "Squash and Stretch" can be considered as an example of Futurism's impact. In Squash and Stretch, we deform an object to provide a sense of speed and to reduce temporal aliasing [Lasseter 1987]. In 1940's, Tex Avery and Chuck Jones independently developed futurist type limited animation techniques to obtain sudden movements. They outrageously smear the shapes from one pose to another to obtain extreme motion in a few number of frames [Cavalier and Chomet 2011]. Motion smears are also used in 3D computer games by swapping out deformed meshes to match the style of the game's previous iteration made using hand-drawn sprites with smears in 2D [Motomura 2015]. In computer graphics a wide variety of techniques have been developed to stylize motion blur and in computer animations and games a wide variety of stylized motion blur techniques such as motion lines are used [Haller et al. 2004; Masuch et al. 1999; Schmid et al. 2010].

Stylized motion has also been used to create sculptural shapes in motion [He et al. 2019; Kazi et al. 2016; Krawczyk 2006]. In particular, Futurist Sculpting extended Futurism to 3D animation and modeling, by introducing the techniques of Motion Snapshot, Surface Differentiation, and Motion Elasticity [Krawczyk 2006]. One of the key problems in Futurist Sculpting is that the swept volumes can overlap in space, which can result in self-intersected 3D structures. There is a need for eliminating these self-intersections since they cause visual artifacts. In this work, we represent shape and motion as 4D Implicit Volumes, that are obtained in two steps. The first step takes inspiration from animation smears in Chuck Jones's animation style to deform the object's surface along its motion. The second step converts the surface into a volume of particles being manipulated before converting back into an implicit surface.

Our process consists of five steps: (1) Creation of Control Points; (2) Creation of Sweeping Curves; (3) Vertex Displacement; (4) 4D Implicit Shape Creation; (5) Individual Frames as Implicit Shapes; and (6) Removing Disconnected Pieces. This process is general enough and it can be tweaked for a variety of applications to obtain various styles. The following process provides an overview of the implementation details to obtain styles such as the one shown in Figure 1.

(1) Creation of Control Points: We use the positions of the vertices of the original polygonal mesh at different time steps as control points to produce sweeping curves.
(2) Creation of Sweeping Curves: We first use Kochanek-Bartels curves to interpolate control points that comes from the trajectory of the same vertex [Kochanek and Bartels 1984]. The advantage of Kochanek-Bartels is that it allows to manipulate the local properties as a generalization of Catmull-Rom splines.
(3) Vertex Displacement: We manipulate vertex positions by moving them in the direction of motion established by the curves by an amount based on the dot product of the normals at vertices and curve tangent direction. In our case, the normals facing away from the motion are minimally affected for a trail-like appearance similar to Chuck Jones's animation smears. This step is computationally simple and can be done in run-time [Gelzenleuchter 2021].
(4) 4D Implicit Shape Creation: We then populate the space with particles by sampling the surface. 4D implicit shapes are defined using signed distance functions to all the particles. Vertex data such as shading normals and displacement amounts are estimated and transferred to the particles for stylistic detail manipulation. The particles are then smoothed using a low-pass filter.
(5) Individual Frames as Implicit Shapes: Any futurist sculpture is a subset of 4D implicit shape. Each individual frame is obtained by only considering particles at the given time interval. The cloud of particles for each implicit shape are converted back into a polygon mesh using signed distance functions. Colors are transferred from the displacement model to the generated model based on proximity and were manipulated stylistically using shading normals of vertices and displacement attributes.
(6) Removing Disconnected Pieces: The resulting virtual sculptures can have disconnected parts. For 3D printing purposes, we also added a simple step to remove all disconnected pieces. Therefore, these sculptures are ready to be 3D printed.

REFERENCES

Umbro Apollonio, Robert Brain, RW Flint, JC Higgitt, and Caroline Tisdall. 1973. *Futurist manifestos.* Thames and Hudson London.

Marta Braun. 1994. *Picturing time: the work of Etienne-Jules Marey (1830-1904).* University of Chicago Press.

Stephen Cavalier and Sylvain Chomet. 2011. *The world history of animation.* Vol. 416. University of California Press Berkeley.

Ester Coen et al. 1988. *Umberto Boccioni.* Metropolitan Museum of Art New York.

Florian Gelzenleuchter. 2021. Animation Smear Frames via shader! https://twitter.com/flogelz/status/1345029634283474945.

Michael Haller, Christian Hanl, and Jeremiah Diephuis. 2004. Non-photorealistic rendering techniques for motion in computer games. *Computers in Entertainment (CIE)* 2, 4 (2004), 11–11.

Liang He, Huaishu Peng, Michelle Lin, Ravikanth Konjeti, François Guimbretière, and Jon E Froehlich. 2019. Ondulé: Designing and controlling 3D printable springs. In *Proceedings of the 32nd Annual ACM Symposium on User Interface Software and Technology.* 739–750.

Rubaiat Habib Kazi, Tovi Grossman, Cory Mogk, Ryan Schmidt, and George Fitzmaurice. 2016. ChronoFab: fabricating motion. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems.* 908–918.

Young J Kim, Gokul Varadhan, Ming C Lin, and Dinesh Manocha. 2004. Fast swept volume approximation of complex polyhedral models. *Computer-Aided Design* 36, 11 (2004), 1013–1027.

Doris HU Kochanek and Richard H Bartels. 1984. Interpolating splines with local tension, continuity, and bias control. In *Proceedings of the 11th annual conference on Computer graphics and interactive techniques.* 33–41.

Piotr Krawczyk. 2006. *Futurist sculpting: Modeling movement in 3D.* Master's thesis. Texas A&M University, College Station, TX. Retrieved from http://hdl.handle.net/1969.1/5014.

John Lasseter. 1987. Principles of traditional animation applied to 3D computer animation. In *Proceedings of the 14th annual conference on Computer graphics and interactive techniques.* 35–44.

Maic Masuch, Stefan Schlechtweg, and Ronny Schulz. 1999. Speedlines: Depicting motion in motionless pictures. In *In: Proceedings of SIGGRAPH 1999. Computer Graphics Proceedings, Annual Conference Series, ACM, ACM Press/ACM SIGGRAPH.* Citeseer.

Junya C Motomura. 2015. *GuiltyGearXrd's Art Style : The X Factor Between 2D and 3D.* Youtube, Game Developers Conference. https://youtu.be/yhGjCzxJV3E?t=2997

Johannes Schmid, Robert W Sumner, Huw Bowles, and Markus H Gross. 2010. Programmable motion effects. *ACM Trans. Graph.* 29, 4 (2010), 57–1.