Augmented and Virtual Reality Application Design for Immersive Learning Research Using Virtual Nature

Making Knowledge Beautiful and Accessible with Information Fidelity

Maria C. R. Harrington
Games and Interactive Media, University of Central Florida, Orlando, Florida, USA
maria.harrington@ucf.edu

Figure 1: Examples of Virtual Nature used for immersive, informal learning research; Far left image shows an AR app used in the context of a museum diorama; Left image shows an AR app used outside in the context of a garden; Right image shows a science center exhibit with VR desktop and HTC Vive headsets; Far right image shows an immersive VR wall and treadmill design.

ABSTRACT

Described are two applications using immersive augmented reality (AR) and virtual reality (VR) for informal learning research. A critical design factor resulting from the authentication process in sourcing all text, media, and data is the high information fidelity (truth) in all signals transmitted to the human. The AR Perpetual Garden App was developed to annotate the Carnegie Museum of Natural History's dioramas and gardens to bring learning to all visitors. The Virtual UCF Arboretum was developed to represent the real UCF Arboretum in VR for immersive learning research. More like a virtual diorama or virtual field trip, they are open to independent exploration and learning. Unlike fantasy games or creative animations, these environments used accurate content, high information fidelity, to enhance immersion and presence. As data visualizations or simulations, and not point-clouds or interactive 360 VR video, they can show past, present, and future scenarios from data. As an application intended for informal learning, the needs of learners as well as the institutional stakeholders were integrated in a participatory design process by extending traditional user-centered design with expert-learner-user-centered design. The design patterns will be of interest to a broad community concerned with perception, emotions, learning, immersion and presence, and any who are developing educational, training and certification, or decision support applications with respect to improving natural knowledge.

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CCS CONCEPTS

• **Computing methodologies** → Computer graphics; Graphics systems and interfaces; Perception; Computer graphics; Graphics systems and interfaces; Mixed / augmented reality; Computer graphics; Graphics systems and interfaces; Virtual reality; • **Human-centered computing** → Interaction design; Interaction design process and methods; Visualization; Visualization application domains; Geographic visualization.

KEYWORDS

Aesthetics, Augmented reality, Beauty, Bioacoustics, Data visualization, Geoinformation, Informal learning, Interactive, Immersive, Knowledge, Multimodal, Museums, User-centered design, Virtual nature, Virtual reality, Wayfinding

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1 INTRODUCTION

Field trips to museums, botanical gardens, and arboretums are activities used by educators to increase intrinsic motivation for

learning about science and the natural world. Informal learning is the norm in such environments, where families casually engage in exploration and discovery, often pausing at personally interesting artifacts to ask questions and wonder [Ash, 2010]. These emotional reactions, of increased arousal and pleasure, are exactly the types of motivating feelings designers of immersive, informal learning applications wish to create. Such salient events [Harrington, 2009] experienced as emotional reactions could be used as design factors. If known, we could use such factors to intentionally design immersive learning applications to achieve desired educational objectives.

2 VIRTUAL NATURE APPLICATIONS

Described are two applications designed and constructed for use in immersive, informal learning research. The first is a large VR arboretum implemented for a range of hardware (Figure 1): VR desktop, HTC Vive headsets, and an immersive projected wall display connected to a treadmill. The second is a woodland garden AR app used to annotate a historical diorama located inside a museum of natural history, and outside in a garden at the museum's biological field station. Both applications used novel data visualization processes of fusing sparse geographic information system (GIS) plant data and botanically correct, photorealistic 3D models, to combine information in a real-time, interactive, multimodal, game engine with multimedia web information to offer high information fidelity and factual content, and interpretive narrative, ideal for education. Both are examples of virtual nature. *The Virtual UCF Arboretum* [Harrington, 2018] released in October 2018, used the Unreal Engine to visualize native plants in the game engine, and accurately dispersed the models over ten natural communities found in the 100 hectare (247 acres) area. Unlike traditional GIS data visualizations that present information as abstract dots on a map, this solution places 3D botanically correct plant models in the corresponding and accurate virtual map locations. Unlike fantasy game environments, these visualizations are not art. The terrain, waterbodies, paths, and landmark plants are accurately displayed from data and fused with drone photographs (when the line of sight was clear) in order to increase accuracy, and more like a real-time Google Earth ground level experience. Each plant-object is a potential leaning opportunity, with the design supporting selection of each object-target at a click of a button to open a complementary website (e.g. embedded plant field guide) for access to educational facts and concepts, and at the moment of curiosity. *The Virtual UCF Arboretum website* features educational stories and gardening facts, photographs, and detailed AR, VR, 3D plant models, for each plant. All information has been vetted, approved, and authenticated by biologists and ecologists for factual and educational accuracy. The website is published separately on *PBS LearningMedia* and aligned with national educational assessment standards. The 3D models may be viewed on AR or VR enabled smartphones and Google Cardboard for use in any school or home. Similar design and construction methods were used in *The AR Perpetual Garden Apps* [Harrington et al., 2019], but built in the Unity Game Engine, with ARKit and ARCore, for distribution on Apple iTunes and Google Play App stores for broad impact.

3 INTERDISCIPLINARY CO-DESIGN PROCESS

Using a modified user-centered design (UCD) approach [Norman and Draper, 1986] our integrated ***expert-learner-user experience* (eLUX)** design process captured holistic requirements. This iterative co-design process required multiple feedback loops from different domain perspectives to insure accuracy, completeness, and frictionless learner-user experience. The interdisciplinary team consisted of scientists, artists, and programmers. Information accuracy was assured with the rigorous project management sign-off procedures: 1) *Scientific Review* – iterative source-review-validate process required to authenticate all data, information, facts, and concepts for approval and release; 2) *Aesthetic Review* – iterative creative process to construct 3D models reviewed relative to the scientific information requirements and the technical constraints of the AR and VR platforms; 3) *Aesthetic-Scientific Combined Review* – iterative artistic-scientific process of all digital media reviewed for information accuracy relative to the expression of those facts in the visualizations and collaborative correction of errors for an approved release; 4) *User and Stakeholder Usability Tests* – traditional iterative software application design and development process with attention to user experience, learner experience, technical constraints, and digital distribution standards. Accuracy was assured in this novel process, thus enhancing the *information fidelity.* The photorealistic graphical quality of the visual content displayed was a byproduct of the information fidelity, and is expected to increase the immersive quality and user experience of presence.

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REFERENCES

Doris Ash. 2010. How Families Use Questions at Dioramas: Ideas for Exhibit Design. Curator: The Museum Journal 47, 1 (Jan. 2010), 84–100.

Maria C. R. Harrington. 2009. An Ethnographic Comparison of Real and Virtual Reality Field Trips to Trillium Trail: The Salamander Find as a Salient Event. Children, Youth and Environments 19, 1 (2009), 74–101.

Maria C. R. Harrington. 2018. Improving Psychophysical Well-being and Performance in Isolated, Confined, and Extreme Environments with Head Mounted Virtual Reality Photorealistic Simulations of Earth Based Natural Environments. In Proceedings of the 2018 NASA Human Research Program Investigators' Workshop HRP RESEARCH: THE GATEWAY TO MARS, January 22-25, 2018, Galveston, TX.

Maria C. R. Harrington, Markus Tatzgern, Tom Langer, and John W. Wenzel. 2019. Augmented Reality Brings the Real World into Natural History Dioramas with Data Visualizations and Bioacoustics at the Carnegie Museum of Natural History. Curator: The Museum Journal 62, 2 (April 2019), 177-193.

Donald A. Norman and Stephen W. Draper (Eds.). 1986. User Centered System Design: New Perspectives on Human-Computer Interaction. Lawrence Erlbaum Associates, Inc., Hillsdale, New Jersey.