Labyrinths: Reimagining Exhibition Platforms for Artists in Virtual Reality

Johannes DeYoung Carnegie Mellon University, USA
Justin Berry Yale University, USA
Lance Chantiles-Wertz Yale University, USA
Jack Wesson Yale University, USA
Adam Moftah Yale University, USA

Abstract: Since its earliest inceptions in the late 1960s, Virtual Reality has long promised more immersive media experiences. With the introduction of Oculus VR hardware in 2012, VR technologies have reached new inflection points of access and availability. Ubiquitously available real- time graphics and gaming software, advancements in rendering hardware, and app-store distribution channels are spurring widespread innovation and development in the realms of AR and VR experience design. This paper examines how a team of faculty and students across multiple institutions worked together to create a controller-less, procedurally generated VR exhibition platform for electronic, time-based media art.

Our VR exhibition platform proposes a use case in collaborative design and a model for electronic art exhibition, independent of controller-based VR navigational hardware interfaces. Our platform utilizes a procedurally generated, real-time graphical environment as a foundation for a scalable exhibition space in the form of an expansive labyrinth. In its initial implementation, the works of twenty-two artists working in various forms of electronic time-based media and computer animation were exhibited in a VR exhibition titled Labyrinths. Because of the high graphical demands presented by computer animation and other forms of interactive electronic time-based media,Labyrinths utilized a custom built procedural platform in the Unity 3D gaming engine. Faculty and Students from Yale University, Carnegie Mellon University, the New School, Lehman College, and Stevens Institute of Technology collaborated with independent artists and game designers to create exhibition content, while the platform itself was built by students at Yale University's Center for Collaborative Arts and Media. The Labyrinths exhibition platform presents an innovative model for exhibition design, artistic collaboration, and artist collectives who work in electronic time-based media, motion graphics, and interactive design.

Keywords: Embodied Navigation; Active Locomotion; Virtual Environments; Interfaces; HCI

Detailed Outline

In 2018, five artists and researchers at Yale University collaborated on a mode of controller- less embodied VR navigation that built upon existing research in embodied VR lean mechanics [1] and alternative VR controller hardware [2][3]. In pursuit of a more intuitive mode of navigation, the team tested its model of controller-less embodied navigation against existing forms of game-controller based VR navigation methods to evaluate appeal and learnability of various navigation mechanics [4]. Testing utilized a simple procedural maze platform to evaluate the various navigation mechanics. As a byproduct of research, the combination of navigation mechanic and maze platform presented a unique model for creative collaboration and collective art production. Subsequently, the team commenced development of an efficient, customized procedural exhibition platform called Labyrinths.

Labyrinths have long symbolized psychic and spiritual journeys. Classically, the labyrinth is a space where serendipity, danger, and opportunity lurk around every corner. Archetypal narrative structures unfold in recursive rhythms, and the spiraling edifice of the maze is site for both self- reflection and projection. The labyrinth's architecture is resonant of the human inner ear, a biological driver of balance and proprioception. The Labyrinths exhibition platform draws upon existing research in VR navigation and proprioceptive VR hardware interfaces [2] through its implementation of a controller-less embodied navigation model that enables intuitive and fully embodied exploration of a procedurally generated gallery maze. Examples of hardware interfaces, at the time of writing, include the HTC Vive, Oculus Rift, and Oculus Quest. Individual artists works are populated in gallery plazas throughout the maze. As participants navigate the labyrinth, gallery plazas are procedurally generated as maze blocks—exiting a maze block

Figure 1: Labyrinths exhibition, artwork by Jonathan Ehrenberg. 2018

spawns generation of a new block, while entering a maze block triggers deletion of the exited block. Each maze block contains one artist's work, randomly indexed as new maze blocks spawn. In its initial inception, Labyrinths featured works by twenty-two individual artists.

Participants' experiences unfold upon surprising encounters with artists' works through a randomizing spawn algorithm. The randomizing agent presents the virtual space as a meta-cognitive site where poetic association happens through chance encounters. Each visit through the labyrinth is a unique experience, much in the same no two journeys through life are the same. As a participant steps out of their individual encounter with a work, the labyrinth randomly chooses which piece they are to encounter next in the labyrinth. This process is repeated for the entirety of the experience. Chance operations are built into the core structure of the exhibition, reflecting a structural model akin to the Dada cut method, rules-based art processes, Happenings, and Fluxus games. One significant point of departure afforded by our computational model is that a certain degree of chance operation can be applied to the curation and presentation of works with perceived monumental scale, inside a virtual environment. The exhibition platform itself presents a unique curatorial model, enabling participants a chance-based structural framework to explore themes self and embodiment, representation and materiality, time and space.

This paper explores both conceptual and technical underpinnings of the Labyrinths exhibition platform, as well as present a unique use case for collaborative design and curation.

Classical Progressions

In classical narrative, the labyrinth is a site of dislocation, a place where our senses of direction and our understanding of the world is interrupted. In myth, labyrinths often function as boundaries between the real and and the magical world, acting as either portals to the fantastic, or as liminal positions that straddle both the real and unreal. The classic denizen of the labyrinth in Greek mythology is the minotaur, a person stuck half way between human and animal form, a carnivore that devours human flesh and an uncanny representation, aberrant from the natural order. The concept of the labyrinth as interstitial state between worlds was particularly interesting to us as an exhibition site, specific to Virtual Reality. We sought to take advantage of the way that the labyrinth's structure disorients those inside it, specifically as a means to test the effectiveness of our navigation model. Additionally, since Virtual Reality sits at the edges of the physical world and the constructed world it seemed like an important opportunity to show artworks that exist in a similar state.

The traditional gallery context for artworks is itself an evocation of a magical world. It has white and unmarked walls with no references to outside culture or space, and it occupies a kind of formal vacuum, in the sense that it is often designed to be a large and pointedly empty space. Artworks inside the gallery are infused with auratic properties, even when they are formally banal. Marcel Duchamp's readymades are testaments to the power of the museum or gallery structure to imbue objects and images with additional poignancy or presence. What happens when the museum or the gallery itself becomes immaterial, and how do virtual experiences or objects, which are increasingly culturally relevant, participate in the narrative of art exhibition? By exploring alternative modes of exhibition in VR we are hoping to begin crafting a vocabulary which would be useful for the contextualization of emerging art practices in the context of historical art practices.

The labyrinth model is effective in that it attempts to serve two of the gallery's principal purposes. It acts as site of disorientation that unsettles the

visual and spatial expectations of the visitor, and it isolates the virtual experience in such a way that its presence is amplified and made more auratic. If the virtual context is one where the traditional model of exhibition can ultimately be superseded, and potentially improved upon, it is helpful to first isolate those qualities that make the traditional gallery model effective and try to emulate those effects in the virtual space by leveraging the qualities and properties that are unique to the virtual realm. A large white room in VR does not function the way it does in a physical setting. If the unnaturally large and empty space filled with a vacuum is an aberration in the material world, where space is precious and almost always filled, it is actually the default state of the virtual world. Emptiness in the virtual space depletes aura rather than infuses it because it implies a lack of concern rather than a sense of preciousness. One goal of this project is to better understand and navigate the challenges of crafting a particular and meaningful space for exhibition but doing so without distracting from the artworks themselves or imbuing them with contextual interpretations not intended by the artist.

In reaching out to artists to participate in the show we explained the exhibition format but did not demand examples of the work prior to inclusion. The goal of this was not to select works specific to the local context of the labyrinth but rather works which exist autonomously from it. Though each of the works may have an individual relationship to the context, that relationship is not shared across artworks. It is inevitable that the context of the exhibition will alter or disrupt the experience of the work for the viewer but our goal was to try and mitigate some of that disruption via structural means. We dislocated the viewer by having them navigate the maze between viewing artworks and, by having the artworks occupy central plazas where artists were able to choose the extent to which the work interacted or engaged with the surrounding maze, works were able to define their own proximity to the surrounding context.

One challenge to current VR technology is that it relies on the abstract mechanics of previous interfaces. Largely, it borrows from two preceding technologies, the television remote and the video game controller. Each of these interfaces uses an abstraction, such as a button with a symbol on it, to interact with a symbolic space. By symbolic space I mean to say that the flattened plane of the screen is not a depiction of reality but rather a surface on which images are rapidly sequenced to create the illusion

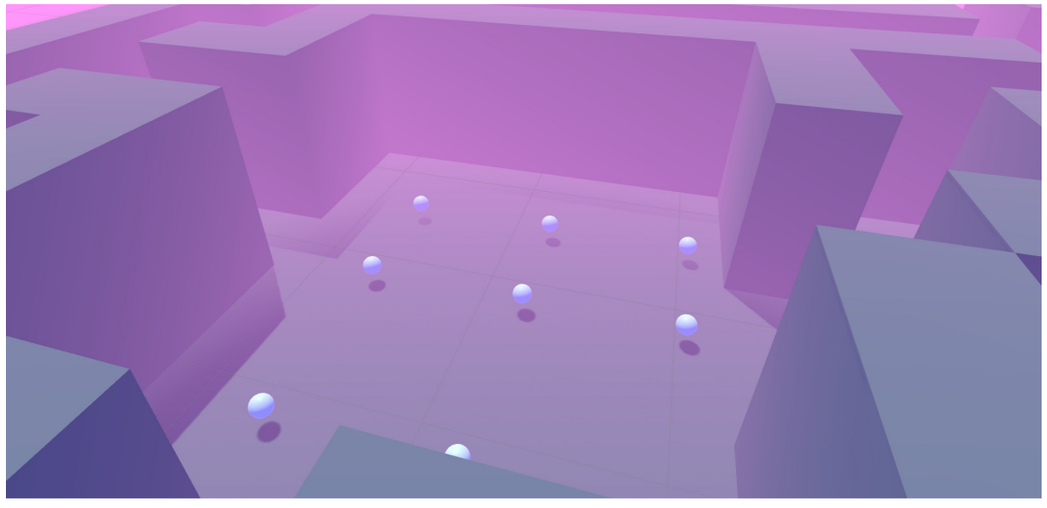

Figure 2: Labyrinths exhibition, maze plaza diagram.

of movement. Virtual space, by contrast, has depth and location and we are physically immersed in its alternate gravitational space. The illusion of virtual space is that it has weight. Ultimately, one of our hypothesis is that virtual reality is a concrete medium where it is less effective to use an interface if a concrete interaction is possible. Rather than have movement be operated by a remote control, we opted to utilize intuitive body mechanics that allow participants to move through the scene without relying on an interface. One source of motion sickness in VR is the disconnection that occurs when the experience of movement happens without the sensation of movement. By having participants actively moving as part of the process, there is greater correlation between the impression of movement and the expected physical response, a fact that we hypothesized might alleviate some of the discomfort associated with virtual experiences.

Embodied Navigation

The navigational mechanic in the Labyrinths platform is one of controller-less operation, built upon existing research in embodied VR lean mechanics [1] and alternative VR controller hardware [2][3]. Our model of embodied navigation enhances real world movement within the VR environment. A relative “zone of stillness” is generated around the participant in which movement in the virtual environment mimics real world movement. Within the “zone of stillness,” participants can interact with the virtual

environment however they please. The participant is able to move freely in the physical space created by the "bounding box," which is the maximum movement range created by the headset's sensors. Once the participant steps out of the "zone of stillness" their movement becomes amplified within the virtual environment. Their radial direction from the "zone of stillness" corresponds to their movement direction, while the distance from the "zone of stillness" corresponds to the rate at which the world moves by. Embodied navigation enables entire virtual environments to be traversed without use of a controller, but entirely within the physical limitations of the headset's sensors. Insomuch the participant has become the controller. If the virtual world is an ocean, the "bounding box" is a raft with a sail. If they were to step off the raft they would sink or in the real world run into an object. Their position on the raft determines the strength of the wind behind their sail. The closer to the edge of the raft the faster the wind will blow and thus how fast they move through the ocean.

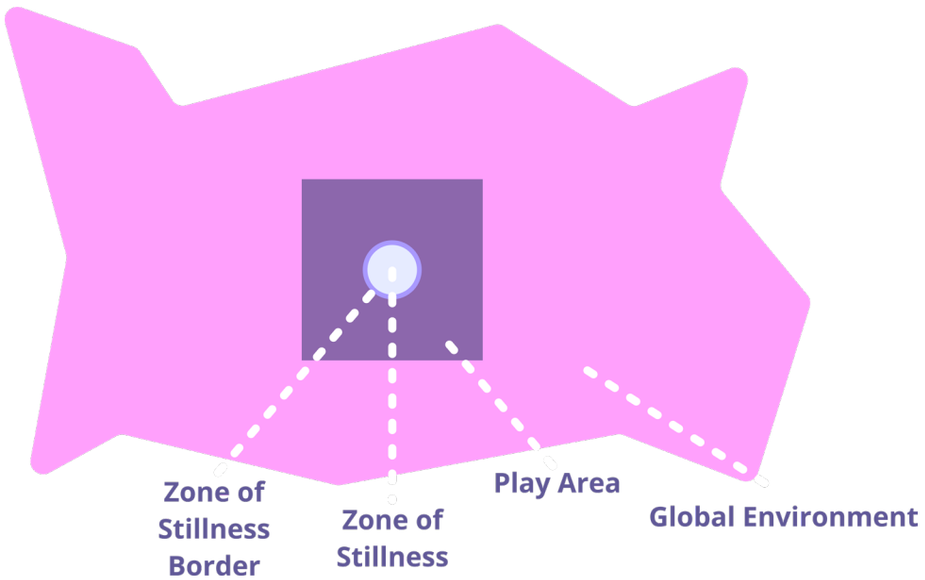

Figure 3: Labyrinths exhibition, embodied navigation diagram.

The embodied navigation algorithm uses the participant's radial distance from the center of the play space on both the x and y axis and then subtracts it by the "zone of stillness" radius. This distance is used as the speed of movement of the play area along the "x" and "z" axis (Unity Coordinate System).

In our algorithm, the participant's distance from the play space center is separated into its "x" and "z" vector components. The "x" and "z" vectors are normalized to retrieve vector magnitude regardless of positive or negative coordinate direction. This magnitude value is subtracted by the "zone of stillness" radius, in order to protect from acceleration jumping. To re-incorporate movement direction the sign of the original vector is multiplied onto this value.

$$\left(\frac{V_x^2}{|V_x|} - |s|\right)\frac{V_x}{|V_x|} \qquad (1)$$

From experimentation it is illustrated that participants show increased immersion without the use of controllers to help them navigate. Labyrinths is grounded by the quality of immersion to allow participants to engage with the art to its fullest extent. This conjures images of people strolling through galleries with hands behind their backs. Embodied navigation approximates the real world experience of exploration, letting the environment take you places. By using one's body, it allows one to experience the exhibitions somatically increasing one's memory and appreciation for the art they see.

Labyrinths also has the flexibility to be able to control the parameters in which artwork is viewed. The physics of the real world no longer need to be obeyed. Works of art can tower to the heavens and the maze module can adapt. Lighting, color, and sound of the module have the ability to be changed according to the artists preferences. These changes are all constantly manipulatable.

Designed for Motion

Conceptually, the labyrinth was designed to challenge and intrigue users by providing a powerful pairing: a connection between precisely designed content and its anticipated style of engagement. In determining the best principles of design to adhere to in order to create the overall effect we sought to achieve, the question of what two-factor system could best evoke this practical, yet artistic, dynamic between interaction and content was best addressed by looking at the way we had hoped our participants would

engage with our interaction system. Namely, considering the style of play and motion we had hoped to incite in the system of interaction, we wanted to maximize the user's embodiment of their navigational choices, and the best way to familiarize them with the system itself, thereby increasing their level of comfort with it, was to increase the amount of time that they were actively navigating. Insofar as we couldn't artificially demand that they explore the generated scene, nor expect them to actively engage with the intricacies of our embodied navigation system whenever the option to simply move straight indefinitely existed (not to mention, when moving straight forward could actively be rewarding them by continually allowing them to translationally glide across novel parts of a landscape without engaging with our system), we decided to create a more organic means to direct their engagement with our navigational interface. Through this line of inquiry, we finally settled upon our final, practical design for the environment for our experience: a labyrinth. Taking inspiration from the iconic form, we designed a seemingly infinite, procedurally generated labyrinth that would put Daedalus[1] to shame.

Collaborative development of the exhibition platform happened quickly, over the course of six weeks in the summer of 2018. Building off of four months of embodied navigation research at Yale University's Center for Collaborative Arts and Media, the team designed an extensible VR exhibition platform that was optimized for controller-less navigation and multi sensory perception, using the Unity 3D real-time graphics engine. The platform itself was designed modularly, with a series of maze blocks that would be physically navigable by participants in VR, and procedurally generated based upon the participants navigation. As participants navigate an individual maze block, new blocks are generated when the participant enters virtual trigger zones near the block's perimeter; hence, a participant experiences a seamless and endless journey inside a seemingly infinite labyrinth. This procedural dungeon model is nothing new to game designers; however, in the context of this project the metaphorical dungeon serves as a virtual art gallery.

Integral to the procedural labyrinth design is the concept of the plaza—an open space where participants can momentarily escape the narrow confines of the labyrinth passageways. The models of the plaza and the passageway naturally relate to the architectural vernaculars of the art institution. Contemporary art museums often feature a series of open, white-cube galleries sparsely interconnected by minimally designed passageways. In our model the gallery/plaza spaces serves important technical and conceptual functions: they are both sites to experience virtual artworks and zones of invisible interaction. To elaborate, the plaza serves as the primary trigger zone to cue generation of additional maze blocks—when a participant leaves a maze plaza by entering a labyrinth passageway, a new maze block is created. Only one block of the maze exists at time, while the new one is added before participants exit, in order to create a seamless experience. The previously current block vanishes once participants step into the new block. Additionally, the plazas act as randomized spawn points for new artwork — in this case, a selection from a defined index of artists works was randomly culled at the spawn point of a new plaza, as a new maze block is generated. The technical aspects of this design are described in the subsequent section on procedural design.

The team worked within simple design parameters to build an open exhibition model. To test the operability of the platform, the team invited twenty-two artists to create works specifically designed for VR experience. Artists were provided design parameters and an example maze plaza, which defined base environmental parameters like scale and lighting. Artists were encouraged to take advantage of the unique benefits that VR experience affords, namely interactivity and immersion. Artworks explored the qualities of form, movement, image, and sound, as well as the interactive capacity of the embodied navigation mechanic. For example, artworks were designed to be experienced sculpturally in the round, or from both interior and exterior perspectives; immersive sound pieces encouraged participants to physically move in accordance with spatial sound cues.

The platform was designed to be agnostic of a participant's physical abilities, increasing the range of those who can interact with art. In a physical exhibition space, visitors are constrained by the architecture of the building. In Labyrinths, the virtual space can be adapted to the needs of the participants. The lack of controllers eliminates the hindrance which is associated with other forms of navigation in virtual environments. All that is needed to navigate is a change in a person's position in virtual space.

Figure 4 (above): Labyrinths exhibition, artwork by Federico Solmi. 2018
Figure 5 (below): Labyrinths exhibition, artwork by Johannes DeYoung. 2018

The embodied navigation mechanic lowers the barrier of who has access to art viewership and exhibition. The beauty of the virtual environment is its transportability. With only a headset, whose prices continually become more affordable, a person can explore Labyrinths from anywhere in the world. Any age can engage with works of art and navigate with the intuitive aspect of embodied navigation. Labyrinths also changes how one can exhibit art. With its procedurally generated and modular nature an artist can publish their work and have it be viewed instantaneously. Artists from across cultures can have their works be displayed together. The exhibition can be changed as well depending on the goals of the curator.

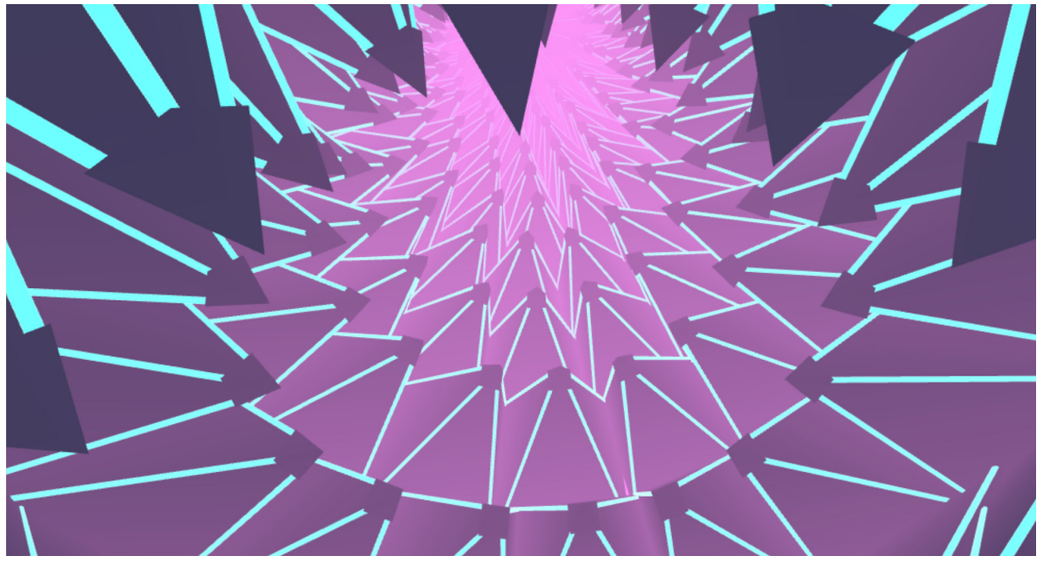

Figure 6: Labyrinths exhibition, artwork by Lance Chantiles-Wertz. 2018

The maze is designed using a tessellating grid structure that is structured to support continuous tiling of maze blocks, indefinitely. This architecture provides the ability to resize and recenter the entire environment around the individual participant as they navigate through the maze, allowing treadmill-like motion to carry the participants through the maze in any direction while creating the persistent illusion of the infinite maze. In more specific terms, this was achieved first and foremost by creating a 3x3 grid of identical maze tiles that obfuscated the borders of maze beyond this. The participant would begin in the center tile of this arrangement, and upon navigating into the collision box surrounding the borders of another tile, would trigger the de-spawning of any tiles that were more than a radial distance of a single full tile edge away, thereby reducing the possibility of overloading the overall environmental mesh load on the system, which had previously exhibited some processing speed challenges. After first attending to the reduction of the overall computational load, the manager scripts would construct new tile clones in advance of the player object in the same direction that they were traveling, to prevent the user from ever reaching the terminal tile of any particular 9-tile arrangement. Throughout this process, a single artwork was generated at the center of each arrangement, appearing to exist in a specific location in the labyrinth, similarly achieved this illusion through a similar, procedurally-generated system. In reality, there were no

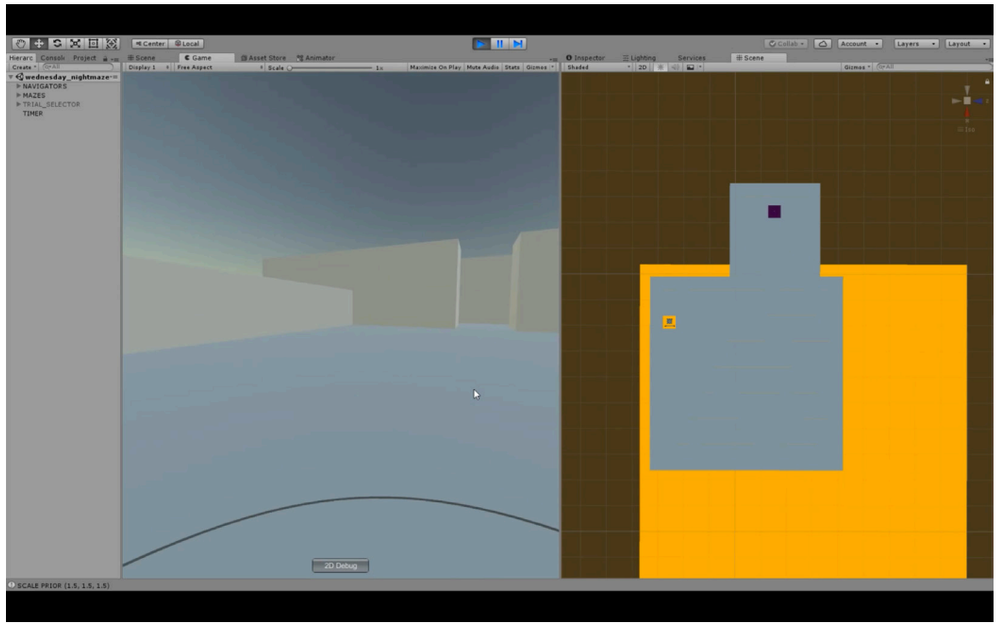

Figure 7: Labyrinths exhibition, tiling mechanic diagram

artworks propagated throughout the maze, despite their seeming preexistence—the manager scripts would actually load a single, random artwork from the gallery as soon as the user began moving towards the open plaza area of a new tile.

At the point of transition between two tiles, the prior artwork would unload itself and dissolve, while the artwork set to be presented next would detect the nearby presence of the user, and accordingly, begin to manifest itself in the center of a given tile, and complete its loading and prepare itself for viewing just before the user entered its vicinity. As they approached the plaza, the artwork was fully rendered, and would be present in their first moment that it entered their line of vision. This process allowed for the sequential visitation of each subsequent art installation, one after another, as the user was merely being given the illusion of control in navigating towards each of their visited artworks. In reality, they were being offered a creator- defined (albeit random) arrangements of artworks in an order that is intrinsically independent from their choice to venture left or right in any given navigational decision in their movement through the labyrinth. This fact also provided an interesting side benefit, which quickly evolved into an entirely distinct motive for this particular design: any user who chose to backtrack to a previous artwork (because of the spawning and de-spawning scripts acting in tandem with the sequential loading of artworks) would find themselves in an entirely novel plaza in the maze despite accurately backtracking to an appropriate location in the maze. An artwork that was previously in a particular location would suddenly be absent, and replaced with a previously unseen work. This created the additional layer of confusion that increased the appeal of the work, as the labyrinthine feel to the work was compounded with the fact that the maze wasn't just challenging to navigate in its own right, architecturally, but also manipulative psychologically, as correctly using the same paths would lead to different destinations. Such a feature created a very compelling maze, that felt genuinely complex and thrilling to explore.

Onward

The Labyrinths exhibition debuted in Galway, Ireland during the summer of 2018. To promote the exhibition, graphic design utilized the Banshee typeface, courtesy of Alexis Mark. The general guiding principle of the identity was typography emulating features of the labyrinth, with large lettering used to invoke the idea of the labyrinth's structure.

In principle and practice, the Labyrinths platform proved to be a successful model for exhibition. Its extensible structure enables easy adaptation to accommodate curatorial interests and artistic design. It's immaterial portability enables direct transferability of the exhibition space, enhancing accessibility, and its embodied navigation model eases operability.

While the underlying technology that drives the Labyrinths platform has many aforementioned virtues, the fundamental concept of the labyrinth itself may not be as easily transferable from a critical and curatorial standpoint. The labyrinth model involves such specific cultural and metaphorical context, that its architecture may not as easily transfer to other curatorial models, or may require curatorial models to adapt to its structure. In this way, the labyrinth's architecture does not solve the problem of overt architectural contextualization that we find in physical world art institutions, but rather reinforces such contextualization in the virtual space. In this way,

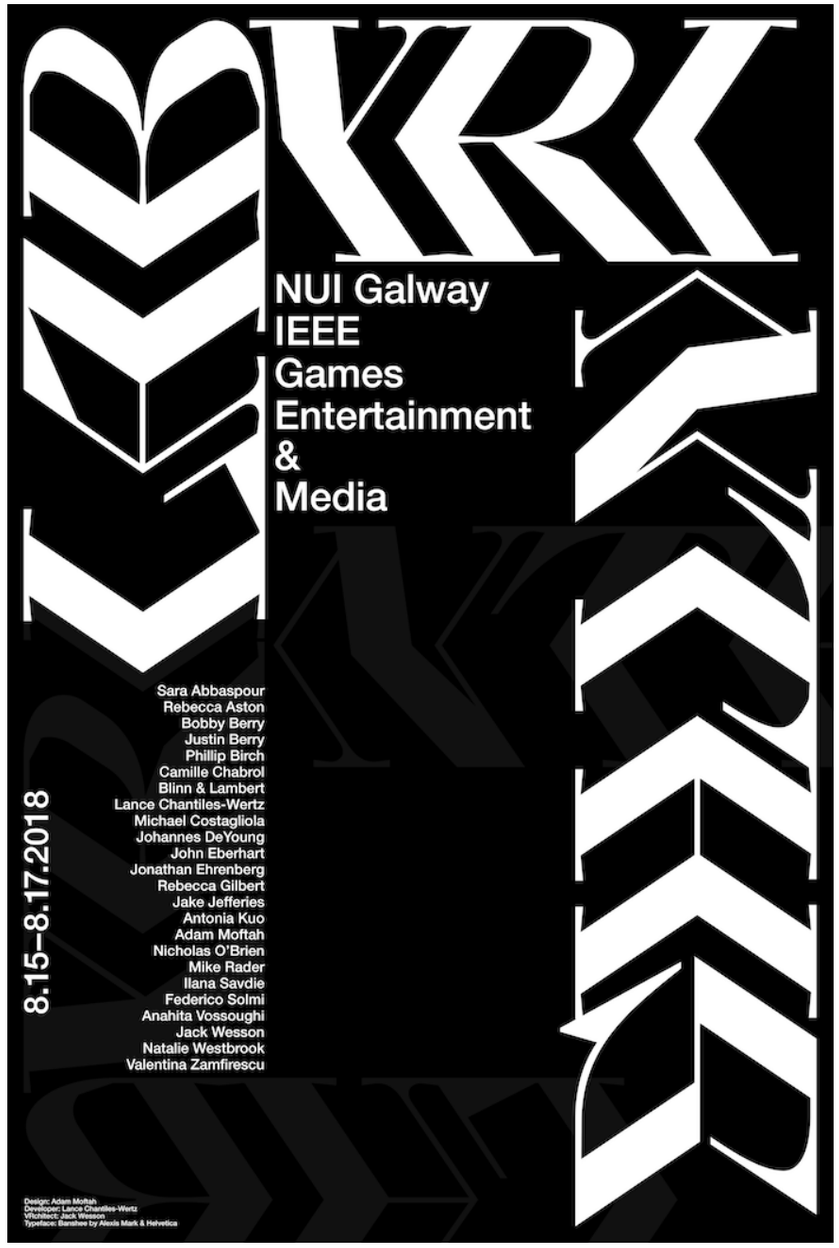

Figure 8: Labyrinths exhibition poster; Banshee typeface by Alexis Mark, design by Adam Moftah. 2018

the virtual exhibition space may be seen as a cube within a cube. Still, the underlying mechanics of embodied navigation and procedural generation present unique opportunities in the virtual that warrant further research and exploration. The virtual art space presents uncanny possibilities for experiences in multi-sensory perception, spatial dynamics, and accessibility that may enhance and expand our understanding of the real.

Footnote

1. In Greek mythology, Daedalus was a skilled craftsman and artist who created the Labyrinth on Crete to contain the Minotaur. See Robin Lane Fox, Travelling Heroes in the Epic Age of Homer. New York: Vintage Books. 2009:187, 178

Works cited

[1] Abraham.M. Hashemian and Bernhard.E..Riecke. "Rotate and Lean: Does Leaning towards the Target Direction Improve Virtual Reality Navigation?" Models and Representations in Spatial Cognition Workshop, Tübingen, Germany. iSpace Lab, School of Interactive Arts + Technology, Simon Fraser University. 2017.

[2] Alexandra Kitson, Abraham M. Hashemian, Ekaterina R. Stepanova, Ernst Kruijff, and Bernhard E. Riecke. "Lean Into It: Exploring Leaning-Based Motion Cueing Interfaces for Virtual Reality Movement". ACM IEEE Virtual Reality 2017. Bonn-Rhein-Sieg University of Applied Sciences, Sankt Augustin, Germany; Simon Fraser University, BC, Canada. 2017.

[3] Alexandra Kitson, Bernhard E. Riecke, Abraham Hashemian, and Carman Neustaedter. "NaviChair: Evaluating an Embodied Interface Using a Pointing Task to Navigate Virtual Reality". ACM SIGCHI Symposium on Spatial Participant Interaction (SUI '15). 2015.

[4] Johannes DeYoung, Justin Berry, Stephanie Riggs, Jack Wesson, and Lance Chantiles-Wertz. "Evaluating Embodied Navigation in Virtual Reality Environments". IEEE Games, Entertainment, and Media Conference (IEEE GEM '18). 2018.

AUTHOR(S) BIOGRAPHY

Johannes DeYoung is an artist whose work blends computer animation, algorithmic systems, and experimental material processes. His works are exhibited internationally and featured in publications, including The New York Times, The New York Post, The Huffington Post, and Dossier Journal. DeYoung is appointed Assistant Professor of Electronic and Time-Based Media at Carnegie Mellon University. From 2008–2018 he taught courses in animation and moving-image production at Yale University School of Art, where he was appointed Senior Critic and Director of the Center for Collaborative Arts and Media, and at the Yale School of Drama, where he was appointed Lecturer in Design. He is co-founder of the quarterly arts journal Lookie-Lookie. He has served on the New Foundations Board of Study for time-based media at Purchase College, State University of New York; the Lyme Academy College of Fine Arts Contemporary Art Council; and Pennsylvania Academy of the Fine Arts, as Digital Literacy Consultant. At Yale, he also served as Principal Investigator for the Blended Reality immersive media research program. He received his MFA from the Cranbrook Academy of Art.

Lance Chantiles-Wertz, Yale University, Class of 2019 B.S., graduated with a double major in Mechanical Engineering and Film & Media Studies with distinction in the major. Prior to college, Lance trained at the School of American Ballet at Lincoln Center in their professional division as well as working professionally as an actor. His academic path at Yale was determined by his interdisciplinary interests in the arts and sciences. While at Yale, he was a member of the D1 Varsity Fencing Team, Yale Undergraduate Ballet Company, co-founder of the sketch comedy group The Odd Ducks, TSAI OpenLab, Mellon Forum, and member of the TSAI CITY Student Advisory Board. He was awarded the Yale Center for Engineering Innovation and Design's Summer Fellowship for his work on a new museum navigation device, the Orb, which was initiated in partnership with the Smithsonian. A very recent graduate, Lance is continuing his work on the Orb as well as another project, "Clamshell," an open-source controller developed through the HP's Blended Reality grant at the Yale Center for Collaborative Arts and Media. Lance is a founder, with a fellow Yale student, of the app development company Kit Studios which has produced the apps "Kit: The Category Game" and "Kit: The Education Game." Lance also continues to act professionally having performed on Broadway, Film, and Television.