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

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

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.

doi: 10.1162/LEON_a_01641

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).

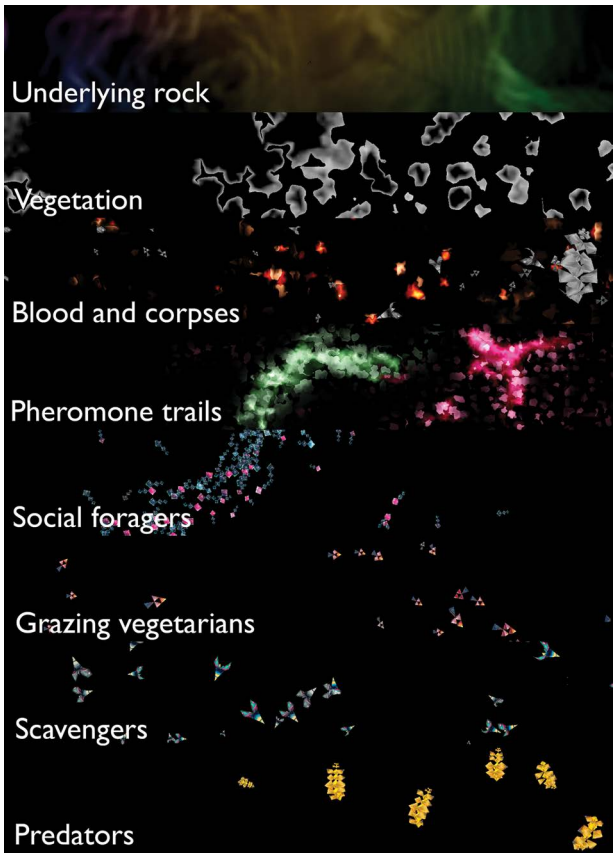

Fig. 2. How various components of the ecosystem are visually represented. (© 2018 Haru Hyunkyung Ji & Graham Wakefield)

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

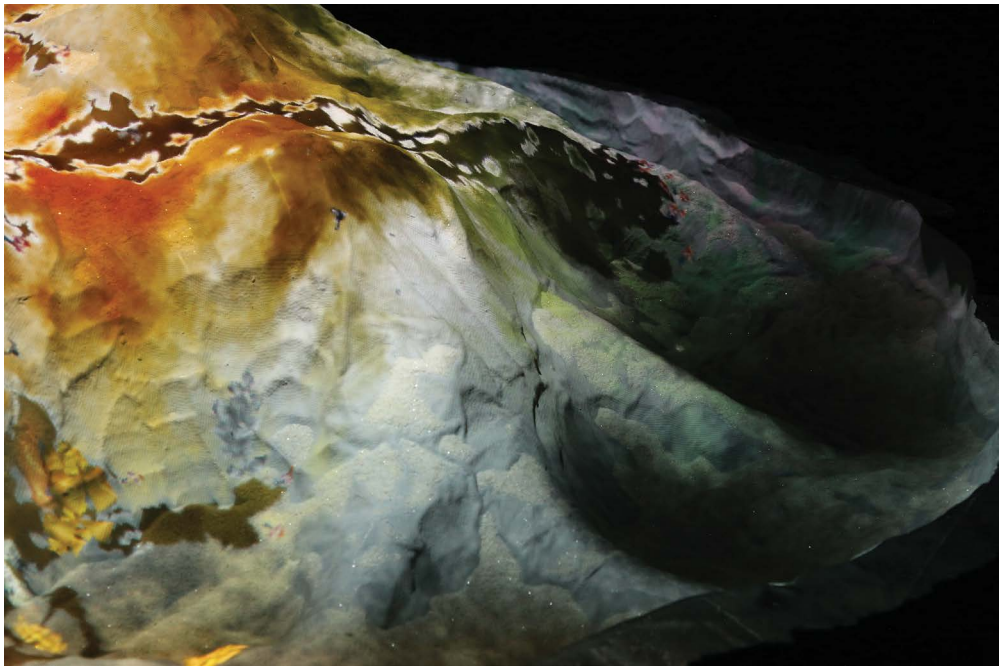

Fig. 3. The vegetation is darker in the lower valleys but grows more brightly and abundantly along ridgelines and peaks. (© 2018 Haru Hyunkyung Ji & Graham Wakefield)

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

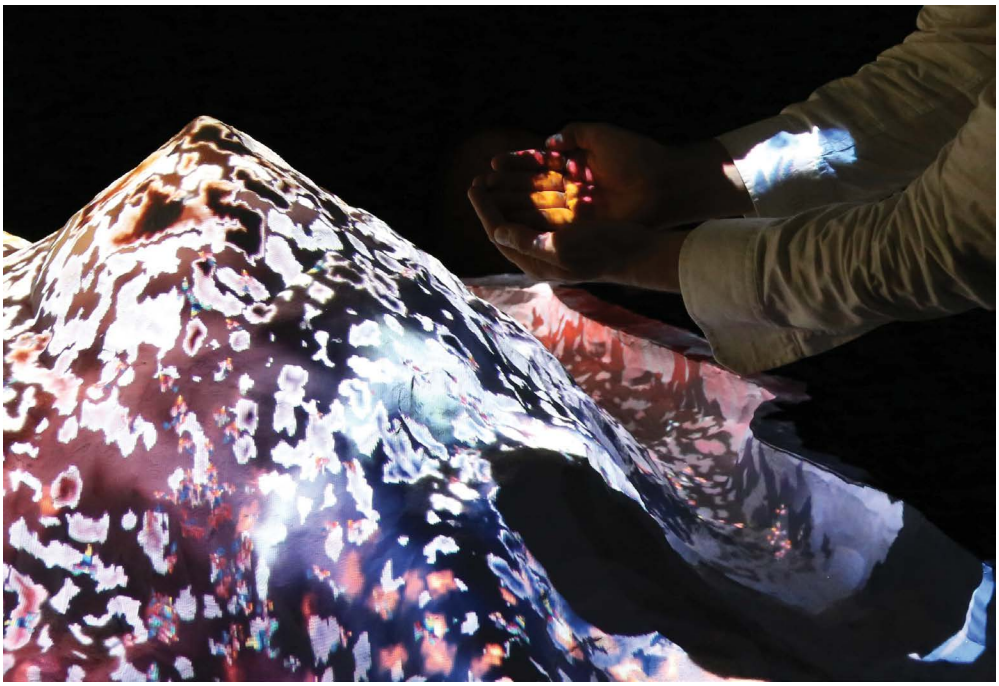

Fig. 5. Several organisms being carried by the hands they crawled onto, while vegetation is being destroyed by the shadow beneath. (© 2018 Haru Hyunkyung Ji & Graham Wakefield)

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

Generously supported by MOXI, The Wolf Museum of Innovation + Exploration, and by SandTastik (www.sandtastik.com).

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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).