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The Head-Mounted Displays (HMDs): Towards a Playful Approach to Architectural Space. Case Study of Augmented Grounds by Hahm, Jung, and Lee

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Abstract

This study explores the use of head-mounted displays (HMDs) as augmented fabrication interfaces within the fields of architecture and landscape design. It focuses on the analysis of *Augmented Grounds*, a landscape installation designed by Soomeen Hahm, Jaeheon Jung, and Yumi Lee.

The research is based on an in-depth literature review of this project and the art of gardens, particularly in the context of the *Métis* International Garden Festival, which serves as the backdrop for this creation. To enhance the analysis, photographic and video materials, as well as data obtained from online interviews, were incorporated.

The installation innovatively combines the traditional craft of hand-weaving with the digital precision enabled by HMDs. It offers a contemporary reinterpretation of the textile heritage of the North American *Métis* Nation by applying a parametric design approach to architecture and landscape.

This pioneering approach opens up new horizons in landscape art design by leveraging an innovative fabrication method that redefines the role of interfaces - particularly HMDs - beyond their conventional use in architecture, integrating them seamlessly into artistic and landscape creation.

Keywords

Head-mounted Displays; Landscape; Architecture; Augmented Reality

1. Introduction

The concept of an interface refers in the field of computing to a device that facilitates the transfer of information from one point to another (Giroud, 2021: 2). According to *Le Petit Robert*, the term is defined as a “surface of separation” (Rey, 1984: 1020). In other words, it signifies an intermediary zone, as implied by the prefix *inter-*: a “universal medium” (Chazal, 2017: 6), a sort of “mirror” (Chazal, 1995), an intermediary or boundary between two entities. It is also a shared limit, a place of interaction, coupling, separation, connection, or junction between the user and the software (Desjardins & Plante, 2022: 96).

Beyond computing contexts, the interface is understood as something that “connects while separating” (Hookway, 2014: 4 & Chazal, 2002: 269). Generally speaking, it “neither links nor delinks but resides at the core of every connection” (Giroud, 2021: 3). It is neither “a place” nor a “middle” nor a “mid-place” in the sense of moderation between two different spaces (Jullien, 2012: 61). As defined by dictionaries and various authors, the interface represents a shared boundary, an intermittent separation, and a point of connection between two distinct spaces, regardless of their nature or form. In our study, we focus on the relationship between real architectural space and its virtual equivalent as an example of such differentiation. Specifically, we will examine the augmented reality headset as an interfacing device that connects the human body equipped with the interface to the visualized digital world.

The headset is a portable sensory interface based on immersing the observer's gaze. Also known as a Head-mounted display (HMD), this device provides a stereoscopic view and simulates either virtual or augmented reality.[1]. This sophisticated headset covers the user's entire head, isolating them from the physical world and enabling interaction with a dreamlike environment. Equipped with a mini stereoscopic screen, an optical system adjusted to accommodate the eyes, and various motion-tracking sensors, the headset offers a unique immersive experience. These sensors include an accelerometer for detecting spatial movement, a gyroscope for angular displacement, and a magnetometer for tracking the head's position relative to the ground. The device also integrates immersive audio components and a processor for data processing, all housed in a compact and ergonomic design. The headset can operate autonomously using an integrated battery or connect to a computer, gaming console, or smartphone via wired or wireless connections (Fig. 1).

Although the idea of being immersed in an immersive environment is difficult to date precisely, devices such as the *Telesphere* Mask, patented in 1960, or the *Sensorama*, patented in 1962, are among the first to be developed. The *Telesphere Mask* (Fig. 2-1), resembling modern headsets, is considered a reference point or even a precursor. Meanwhile, the *Sensorama* (Fig. 2-2) enhanced realism by simulating experiences such as a bike ride through a Brooklyn neighborhood in the United States. The modern headset as we know it today appeared in the 1980s. Its development has been relatively slow, and currently, two main technologies dominate the market: cathode-ray tube (CRT)-based screens and liquid crystal displays (LCD). Today, augmented reality headsets have successfully entered many fields, including architecture and landscape design, areas we intend to explore further.

For nearly half a century, architecture has been influenced by spaces designed to be explored through immersive headsets. Among the leading figures was Marcos Novak and his theory of Transarchitecture, described as a "hybrid connection" (Novak, 1997) or a "continuum" (Roussel, 2012) that links the real and virtual worlds, creating a kind of spatial *interface* that transcends the limits of our imagination. Today, the augmented reality headset remains a viable technology, increasingly permeating our daily lives. In 1998, Asymptote Architecture developed *Virtual NYSE* (Fig. 3-1), featuring "Data Scapes" - virtual landscapes saturated with stock market data, information flows, statistics, and interactive immersive correlations - designed for traders to explore using advanced sensory devices. Similarly, starting in 2010, Keiichi Matsuda envisioned fictional scenarios in his short films, such as *Augmented (Hyper) Reality* (Fig. 3-2), where he anticipated an augmented reality, sometimes dystopian and distinctly gamified, made visible through augmented reality headsets in a near future. Along the same lines, the ScanLAB Projects team used 3D scanning lasers in exhibitions like *Italy's Invisible Cities* (Fig. 3-3), offering heritage immersion through life-sized landscape holograms with millimeter precision that create the sensation of being inside an immersive headset.

Today, augmented reality headsets have become more accessible and are widely used in art, design, and architecture, as exemplified by the work of Soomeen Hahm. In projects like *Augmented Grounds* (Fig. 3-4), created in 2020, Hahm successfully integrated this technology to merge the physical and virtual worlds within handcrafted *architectural* installations. Similarly, in the *Real Virtuality pavilion* (Fig. 3-5), designed in 2019, Gilles Retsin combined augmented reality technology with the assembly of plywood modules to create a complex interlocking wooden structure. Meanwhile, Japanese author Reki Kawahara explores the intersection of reality and virtuality through his *light novels*, imagining a science-fiction neural interface called *Nerve Gear Design* (Fig. 3-6). This fictional virtual reality headset connects directly to the user's nervous system, enabling full immersion in a fantastical, gamified universe.

Figure 1: Illustration of the internal components of the augmented reality headset. (Barrial, 2015)

Left, Figure 2-1: The *Telesphere Mask*, invented by Morton Heilig in 1960. **Right, Figure 2-2:** The *Sensorama*, built in 1962, was an immersive device designed to simulate a bike ride. (Scheinerman, 2009)

Left, Figure 3-1: *Virtual NYSE*, a virtual stock exchange project designed in New York in 1998 by Asymptote Architecture. (Brayer & Migayrou, 2000) **Right, Figure 3-2:** *Augmented (Hyper) Reality*, a short film challenging the use of digital technology, especially smartphones.

Top left, Figure 3-3: *Italy's Invisible Cities* is an audio-visual **documentary** revealing, through virtual models, the hidden remains of Naples, Venice, and Florence. (BBC Taster, 2017)

Top right, Figure 3-4: *Augmented Grounds* is a landscape installation made of colorful ropes assembled using an augmented reality headset. (Bühlbecker, 2020)

Bottom left, Figure 3-5: *Real Virtuality*, by Gilles Retsin, is an installation built using an immersive headset inside the architecture gallery of the Royal Academy. (Delpech & Caruana, 2019)

Bottom right, Figure 3-6: Image of *Nerve Gear Design.* (NerveGear)

2. Materials and Methods

This research explores *Augmented Grounds*, an installation created by Soomeen Hahm, Jaeheon Jung, and Yumi Lee. Developed in Quebec during an international landscape design festival in 2020, this installation utilized an augmented reality headset as a fabrication tool. Our methodology follows a qualitative and descriptive approach, structured around several axes of analysis: the historical and cultural dimension associated with the *Métis* Nation of Canada, the use of miscegenation techniques in the creation process, as well as its spatial, aesthetic, and technological approach, defined by the adoption of the parametric paradigm in architecture. To this end, we conducted an analysis of graphical documents, spatial and aesthetic descriptions from official sources, as well as open-access video recordings documenting the fabrication stages, prototyping, and in-situ testing. Finally, our approach aims to shed light on the synthesis and results obtained by intertwining aesthetic, architectural, and technological perspectives.

What form of architecture might emerge from this singular interplay between the real and virtual worlds in *Augmented* Grounds? What spatial, playful, and aesthetic dualities might result from this particular and constructive conceptual approach? What theses and antitheses might arise from such a coexistence of craftsmanship and digital technology? Finally, what risks and challenges, does this intersection between the tangible and the virtual pose for the future of architecture, landscape, and design?

3. Results

3.1. Augmented Grounds: An Inherited Symbol and a Landscape Festival Installation

Augmented Grounds (Fig. 4) is a landscape installation created for the 2020 edition of the International Garden Festival of the *Métis*, centered on the theme of miscegenation. Since its creation in 2000, this festival has been considered an open-air laboratory for landscape experimentation. Held annually in the Gaspésie region, within one of North America's largest gardens, the event showcases avant-garde installations that provide spectators with innovative ways to connect with nature. Horticulturists, designers, and landscape architects from around the world participate, creating singular and original works each year.

A Canadian National Historic Site and a Quebec heritage site, the *Métis* Gardens are located at the confluence of the St. Lawrence River and the Mitis River. These gardens were designed between 1926 and 1958 by Elsie Reford, a Montreal horticulturist and philanthropist, who devoted her time and energy to this charitable work during a period when British-influenced ornamental gardens were already well-established in the region (Von Baeyer, 1984: 100). It should be noted that the fashion for gardens in Canada in the early twentieth century was associated with social reform movements, which gave these spaces a psychological, moral and social mission in addition to their artistic vocation (Hébert, 2009: 302). In this sense, the *Métis* gardens were not just an aesthetic space of beauty and harmony, but also "a remedy for the ills of society, a vehicle for moral and material progress" (Von Baeyer, 1984: 1 & 2).

Among the 200 submissions received, *Augmented Grounds* was selected as one of five winning proposals, alongside: *Corps de résonance* (Fig. 4-2), an interactive musical folly that resonates with the sounds of the forest; *Entwine* (Fig. 4-3), an immersive spiral integrating hybridized plants to encourage horticultural exploration; *Forêt corallienne* (Fig. 4-4), a coral reef-inspired installation rooted in the woodland, creating a strikingly unusual landscape; and *(Mé)Tissages* (Fig. 4-5), an experimental garden embodied in an arrangement of colorful ropes. Due to the COVID-19 pandemic, the designers of these projects were unable to visit the site. However, the festival team managed the construction of all the installations, including *Augmented Grounds*.

Augmented Grounds draws inspiration from the traditional sash of the *Métis* Nation of Canada's plains, a symbol of "pride and identity" (Collectif). According to *Le Petit Robert*, the term *Métis* is defined as a mix, an alloy, a crossbreed, or as being part of something, more precisely, of a culture or race (Rey, 1984: 1192). In the North American context, particularly in Canada, it refers to people of mixed heritage, typically Indigenous and European (Lebel, 2003: 76). The origins of Canada's *Métis* are commonly traced back to the 19th century, though miscegenation is a much older phenomenon that began "nine months after the first Europeans set foot in America" (Lebel, 2003: 77). The *Métis* are also renowned for their Red River carts - ingeniously multifunctional vehicles and shelters - and their vividly colored, handwoven wool sashes, which hold deep historical and artistic significance. Though unable to visit the installation in person, we can appreciate how *Augmented Grounds* reinterprets the *Métis* sash's vibrant chromatic palette, translating it into a striking composition of intricately intertwined and sculpted ropes displayed on the exhibition site. As shown in a video by the designers, this space offers a unique and calming experience for spectators seeking to interact with the installation while reconnecting with nature.

The *Métis* sash, also known as the arrow sash or the colored wool belt, is a Quebec creation intimately tied to the province's history (Fig. 5). In 1924, historian Édouard-Zotique Massicotte described it as a "masterpiece of domestic industry in French Canada" (Massicotte, 1924), while ethnologist Marius Barbeau celebrated it in a dedicated work in 1973 (Barbeau, 1973). In 2016, the *Métis* sash was officially recognized as an intangible heritage of Quebec by the Ministry of Culture and Communications. Today, it is considered an iconic and widely recognized symbol of Quebecois culture. Its enduring influence lies in its aesthetic qualities, practicality, and versatility.

Traditionally, the sash served multiple purposes, functioning as a scarf, a rope, or a fastening tool for coats (Chartrand, and al., 2006: 173). Artisans crafted it from colorful wool, often incorporating materials such as silk, horsehair, plant fibers, or even human hair, using a finger-weaving technique. Its design featured intricate patterns, including arrow-shaped motifs that extended to its fringed ends. It also served as a marker of social distinction and prestige, even becoming "a quasi-ceremonial gesture widely practised in *Métis* political assemblies" (Simard & Rousseau, 2004: 15).

Figure 4-1: General view of the *Augmented Grounds* installation**.** (Hahm, 2020)

Top left, Figure 4-2: *Corps de résonance* by Charlotte Barbeau, Leila Desrosiers, Félix Roy, and Jean-Benoit Trudelle. **Top right, Figure 4-3:** *Entwine* by Waiyee Chou and Carlos Portillo. **Bottom left, Figure 4-4:** *Forêt corallienne* by Lucie Bulot and Dylan Collins. **Bottom right, Figure 4-5:** (*Mé)Tissages* by French architect Duc Truong. (Jardins des Métis, 2020)

Figure 5: The *Métis* sash of Canada. (Barbeau, 2016)

3.2. Parametrism in the Work of Augmented Grounds

Augmented Grounds is the product of teamwork involving three designers specializing in design and computing: Soomeen Hahm, Jaeheon Jung, and Yumi Lee. Soomeen Hahm, an architect trained at the Architectural Association Design Research Lab (DRL), is also a lecturer and robotics researcher at the Southern California Institute of Architecture. Her work reflects a concern for a symbiotic relationship - or “ecology”, as she describes it - between human intuition and the computational power of machines (Hahm, 2020). In 2016, she founded SoomeenHahm Design Ltd, a London-based design agency where she explores new architectural paradigms through innovative generative and algorithmic design approaches.

Jaeheon Jung, the second co-designer of this project, is an architect and urban planner who graduated in 2011 from the architecture program at the Southern California Institute of Architecture and, in 2009, from the M.S. in Urban Design and Planning program at the University of Seoul in South Korea. In 2013, he founded SLZ Inc., a company specializing in designing and constructing architectural and landscape projects using augmented reality. In 2020, he co-founded KOH SX Studio, a second company focused on software development in architecture, robotics, and pataphysics - a science exploring exceptions and imagination - in collaboration with Yumi Lee.

Yumi Lee, the third co-designer, holds a Master of Fine Arts from Boston University (1998) and a Master of Landscape Architecture from the University of Pennsylvania (2001). She has worked as a landscape architect in the United States and has lectured at the University of California, Los Angeles. For the International Garden Festival installation, Hahm, Jung, and Lee explored the use of parametrically designed curves and counter-curves, a process that required precise coordination between human intervention and machine automation.

Inspired by the traditional *Métis* sash of Canada, *Augmented Grounds* creates a chromatic and playful topographic experience. The term “playful,” derived from the Latin *ludus*, refers to “official or ritual games” (Rey, 2022: 1151) or “distracting activities pursued for enjoyment” (Souriau, 2010: 960), evoking feelings of joy, pride, and recreational pleasure. However, beyond its entertaining qualities, the installation embodies, in the words of its designers, “the miscegenation of cultural pride and innovation” (Hahm, 2020).

In *Augmented Grounds*, the *Métis* sash - traditionally crafted through the art of finger weaving - has been reimagined as colorful ropes, twisted and layered into intricate patterns that harmonize with the topography of the surrounding gardens. These ropes are meticulously arranged across the terrain, creating a flow of curved lines, bubbles, and geometric contours that follow the existing landforms. They also reflect various layers of the cultural history of Canada’s Indigenous peoples. Within this unique landscape installation, visitors are invited to move, walk, crawl, dance, run across the mounds and pools, jump along the ropes, turn, sit, or recline on the coiled seating of this giant, interactive instrument, which comes alive in resonance with the surrounding forest.

The designers of *Augmented Grounds* explore a singular collaboration between humans and computers, employing an avant-garde methodology to generate intricate forms achievable exclusively through computational tools. This approach, commonly referred to as parametricism, establishes itself as the successor to modernism in architectural innovation. Parametricism transcends postmodernism and deconstructivism, movements often considered transitional and insufficient in addressing the increasing complexity of contemporary society (Schumacher, 2009: 15).

Modernism, which emerged in architecture in the early 20th century, marked a radical departure from past traditions, championing principles such as rationalization, standardization, and functionalism. Postmodernism, which arose in the 1970s, was a reaction against modernism, primarily from an aesthetic standpoint, critiquing its excessive simplicity and lack of nuance (Loyer, 1981: 380). Deconstructivism represented another form of dissent, transgressing modernist architectural archetypes to recombine them "according to their formal genealogy" (Wigley, 1993). Finally, parametricism, a product of the digital revolution, enables the creation of flexible forms, where altering one parameter triggers progressive transformations across the entire architectural design (Woodbury, 2010: 226). This paradigm prioritizes fluid, adaptable forms generated through parametric algorithms rather than fixed, standardized models (Al-Azzawi & Al-Majidi, 2020). A wide range of design software tools has been developed to support this approach, often leading to aesthetic uniformity due to their shared manipulation techniques.

For *Augmented Grounds*, the installation's forms were parametrically designed using mathematical algorithms such as *Metaball* and *Boids* (Fig. 6-1, 6-2). *Metaballs*, which can be described as convolution surfaces, are spherical shapes notable for their ability to cluster and merge fluidly. *Boids*, derived from the term "bird-oid", simulates the collective movements of a flock of birds. Both algorithms are ideally suited to creating curved, fluid aesthetics, favoring continuous variations that align with the formalism of parametric design. This formal language also resonates with the dynamics of bodily movement during playful activities, evoking the rhythmic gymnastics of a flexible, sinuous human body in motion within a play space. The playful experience embodied in *Augmented Grounds* engages the body in a state of dynamic balance and constant rebalancing, enabling choreographic expressions through both deliberate and spontaneous gestures.

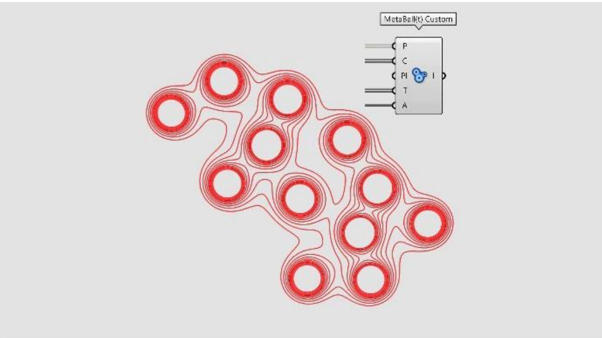


Figure 6-1: Simulation of a bird flock's flight using the *Boids* algorithm**.** (Parametric House, 2024)

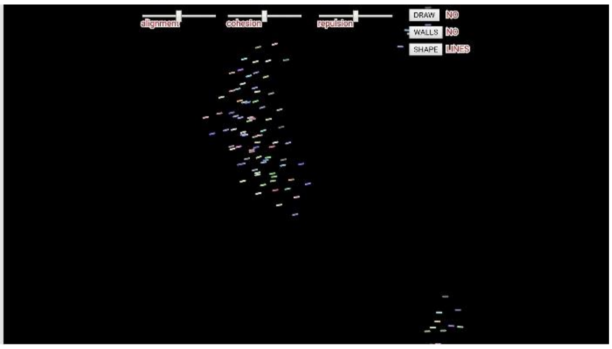


Figure 6-2: A parametrically adjustable *Metaball* component. (Ananthram, 2020)

3.3. Head-mounted displays In Service of Parametric Architecture

On a conceptual level, the *Augmented Grounds* work was designed using parametric modeling software such as *Grasshopper*, an extension module of the *Rhinoceros 3D* computer-aided design software (Fig. 7-1, 7-2). *Grasshopper* allows iterative adjustments of parameters while visualizing their effects on the modeled form. The virtual models generated through this parametric approach to architecture were then projected using a holographic program named *Fologram*, which connects them to Microsoft's augmented reality headset, the *HoloLens* (Fig. 7-3). This interface, instantly connected to a computer, includes one or two small screens positioned in front of the user's eyes, creating a panoramic virtual environment while remaining grounded in the real world. It is equipped with a battery for mobility and a motion detector that simulates movements and enhances the optical thickness of real-world appearances.

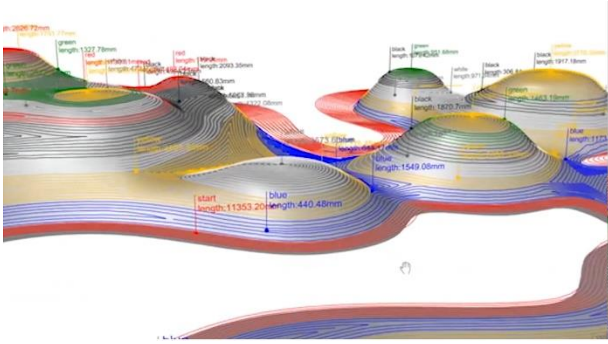
The first perception provided by this device is a pre-programmed grid serving as a holographic guide to facilitate the assembly of the installation throughout its realization. While these holograms are instructional, they also challenge corporeality and natural human sensory perceptions by providing an interactive, multimodal immersion. Numerous anthropological and sociological studies emphasize the profound impact of the rise of computing - particularly augmented reality - on spatial perception, human behavior, and worldviews, fostering a life increasingly mediated “on screen” (Turkle, 1995).

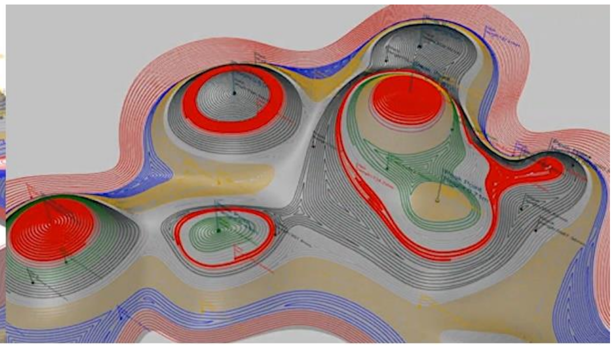
Due to health constraints, the realization of *Augmented Grounds* was carried out remotely, simultaneously, and through close collaboration. Festival volunteers, serving as builders, wore head-mounted displays that projected holograms made of light in arbitrary locations. These holograms, integrated as semi-transparent, customizable images into the physical environment, allowed users to visualize occlusion phenomena between real and virtual elements. Acting as a medium, the holograms enhanced the builders’ perception, improved their sensory-motor and cognitive activities, and enriched the collaborative fabrication experience between humans and machines.

Fully engaged in the construction of the project, the builders of *Augmented Grounds*, equipped with their headsets, were guided by virtual and adjustable images to perform the complex and meticulous assembly of the ropes. The advantage of this interface lies in its precise guidance regarding the placement and assembly of the ropes. The device displays virtual models on a stereoscopic screen, making them appear in real space, particularly at the exact spots where the ropes will be positioned (Fig. 8). Meanwhile, Hahm, Jung, and Lee monitored the fabrication process remotely using a digital replica of the site based on cloud computing technology (Fig. 9). This allowed them to control the process and instantly transmit necessary instructions to the construction site via remote servers, regardless of their location or time.

In craftsmanship, even the simplest gestures of the artisan draw upon their mind to fuel creativity. Through experience, passion, and patience invested in their work, artisans learn to anticipate sensations and adjust their movements based on an intuition shaped by practice (Sennett, 2010: 286). This intuition, combined with passion and experience, is at the heart of the creative act, including in the field of landscaping. It remains essential even in the age of machines and automation. From this perspective, *Augmented Grounds*, created by Hahm, Jung, and Lee, represents a unique symbiosis between the human gestures of the builders - considered as creative artisans - and the computational precision of machines. The intricate forms emerging from this installation cannot be entirely created by either digital automation or manual labor alone; they are the result of a curious and harmonious collaboration between human skill and technological power.

In an article titled *Augmenting Human Designers and Builders: Augmentation Discussed*, Soomeen Hahm highlights two critical aspects of this human-machine coexistence, which allow greater tolerance in the fabrication process. First, there is the unpredictability inherent in manual craftsmanship, stemming from the artisans’ intuitive decisions when confronting unexpected errors during the assembly and tracking of holographic models (Hahm, 2021: 139). Second, there is the computer’s ability to react immediately and adapt to changes in parametric models. This leads to the creation of what Hahm calls “calculated unpredictability” (Hahm, 2021: 117). As noted by Mattia Santi, this conceptual approach facilitates intuitive and rapid communication between designers and builders, simplifies the fabrication process, reduces construction costs and time, and encourages the adoption of flexible parametric geometries that can adapt to unforeseen modifications (Santi, 2021). Ultimately, the success of *Augmented Grounds* was underscored when it was revisited and reinterpreted with a certain mannerism at the 2021 Seoul Biennale of Architecture and Urbanism, whose theme was *Crossroads*.





Top left, Figure 7-1 and Top right, Figure 7-2: 3D simulation created using the *Grasshopper* parametric modeling software.

Figure 7-3: Image of the *HoloLens* augmented reality headset**.** (Tillinac, 2017)

Figure 8: Images illustrating the in-situ fabrication process of *Augmented Grounds*.

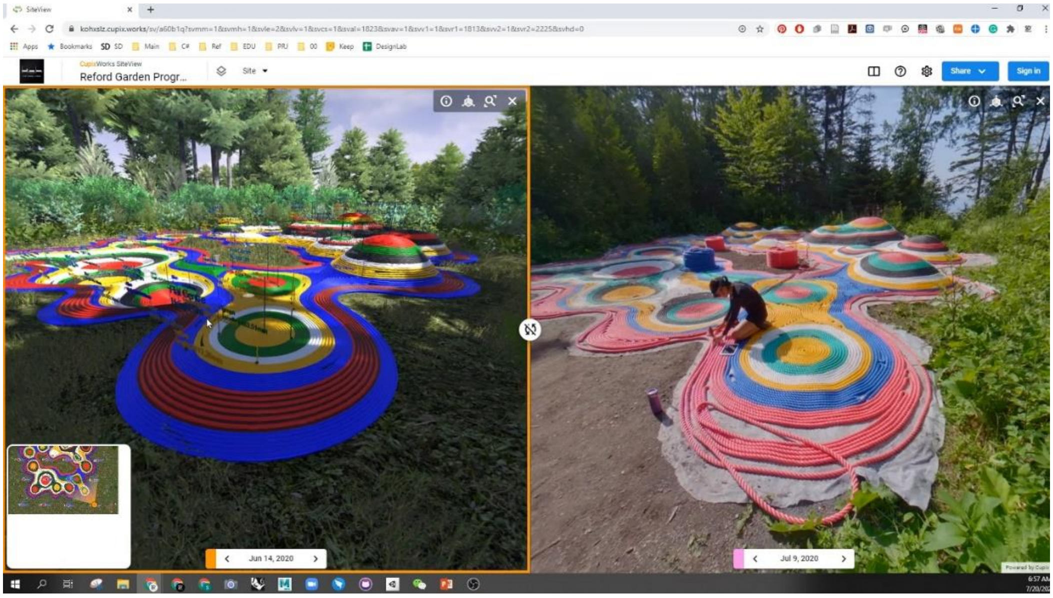


Figure 9: Image showing the use of cloud computing technology.

4. Conclusion

This study explored the integration of a unique interface technology within a renowned festive landscape experience at the *Métis* Gardens in Canada. The *Augmented Grounds* installation reimagines the cultural heritage of the *Métis* Nation of North America by merging augmented reality technologies with traditional craftsmanship and cutting-edge parametric fabrication. The work of Hahm, Jung, and Lee is characterized by a supple, curvilinear formalism, adaptable through gradual modifications, and inscribed in the dynamic gestures of the body during playful activities.

During the fabrication process, the builders' actions and movements were reflected in real-time within the virtual environment through a program and holograms pre-designed by Hahm, Jung, and Lee, who remotely supervised the construction. This groundbreaking approach paves the way for alternative methods, divergent ideas, and novel perspectives on manufacturing, challenging the notion of the interface as merely a headset and integrated screen while transcending the traditional boundaries of architectural artefacts. We emphasize that the fabrication technique itself is a source of fascination in this project and is likely to be further refined in the near future, potentially creating a library of construction technologies that leverage augmented reality headsets in artistic and architectural projects.

These findings invite reflection on the broader implications for recreational spaces and architecture as both a lived experience and an applied discipline. What might be the impact of the widespread adoption of portable, disposable, and affordable augmented reality headsets on architectural fabrication processes? How could such technologies reshape the parametric design movement and the aesthetics it promotes? What new avenues might architectural research pursue with this form of interfacing? Lastly, what forms of reconciliation - or tension-might emerge between handcrafted and artificial fabrication through today's headset-wearing creators?

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Ethics approval

Not applicable.

Conflict of interest

The author(s) declare that there is no competing interest.

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