

Nature: Metaphysics + Metaphor (N:M+M): Exploring Persistence, Feedback, and Visualisation in Mixed Reality Performance Arts.

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ABSTRACT

Nature: Metaphysics + Metaphor (N:M+M) is an art experience and exhibition that explores the intersection of Nature, Art, Man, and Technology. This immersive experience aims to bridge physical and digital, tangible and intangible, and ephemeral and persistent in mixed reality arts through new interaction and visualization methods. The performance was presented in front of an audience of 50 people, during which the artists constructed a physical-digital artwork that became part of a subsequent exhibition. This paper describes the rationale, creative approach, and technical contribution behind this work while reflecting on audience feedback and future directions.

CCS CONCEPTS

• **Applied computing** → **Performing arts; Media arts; • Human-centered computing** → **Mixed / augmented reality.**

KEYWORDS

Mixed Reality, Performance Art, Persistence, Tangibility

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1 INTRODUCTION

N:M+M is a series of performances and immersive experiences that explore the duality between Man/technology and Nature. This paper focuses on the first occurrence of this series, conducted on December 2, 2023. N:M+M unfolds into two stages, starting with a live performance where two performers engage in the collaborative creation of a physical-digital artwork. The performance is followed by an exhibition inviting viewers to engage with the resulting artwork. As a collaboration between three artists of different backgrounds, N:M+M incorporates multiple media, from ephemeral on-site installation to digital content in mixed reality (MR).

The performance was conducted in front of an audience of 50 people. On a deep and narrow stage, two performers embody the duality between Nature and Man/technology, Physical and Digital, Tangible and Intangible. One performer, wearing an MR headset and a custom-made haptic controller, engages in a shamanic dance, drawing a digital tunnel from the front to the back of the stage. The second performer undertakes a slow, meditative walk through the digital tunnel, reaching the ephemeral installation at the front of the stage. A semi-transparent curtain, serving as a canvas separating the audience from the stage, overlays a real-time 2D projection of the digital artwork onto the stage. The resulting physical-digital artwork took centre stage in a 2-week long exhibition. Visitors became active participants, experiencing the artwork through different techniques, from 2D projection to complete immersion with an MR headset. By blending physical and digital, tangible and intangible, ephemeral and permanent, this work pushes the technological and artistic boundaries of MR, exploring the persistence and tangibility of digital performance art and examining the co-existence of immersive experience with physical installations.



Figure 1: N:M+M is a two-part immersive experience that symbolically reveals the 'fields of force' and 'flows of materials', invisible to us but intrinsic to Nature, and through such a revelation, to raise awareness, appreciation and reconnection with Nature. The opening performance sees the artists combining digital with physical, building a 3D digital artwork projected on a semi-transparent screen separating the audience from the stage. The stage becomes part of an installation showcasing the final mixed physical-digital artwork in mixed reality through a headset or an iPad app.

2 BACKGROUND AND RELATED WORK

In *Sculpture in the Expanded Field* [Krauss 1979], Krauss discusses the liberation of sculpture from traditional constraints of materials, shapes, and spaces in contemporary art. N:M+M builds upon this idea by combining painting, sculpture, and digital technology to create a new form of art that transcends physical boundaries at the intersection between physical and digital, tangible and intangible, ephemeral and permanent. This work is also inspired by artworks that describe nature and technology coexistence, such as *Bioluminescent Forest* [dezeen 2015], *A Forest where Gods Live* [team-Lab 2024], and *X* [Hattler 2012], which use projection mapping in natural environments to create immersive experiences.

The relationship between the audience, artist, body movement, and artwork creation is also redefined through new media. Picasso's glass painting [Film [n. d.]] turns the art creation process into a performance, with the glass acting as a canvas incorporating the artwork into the physical world. Extended reality (XR) enables new forms of creation beyond time and space [Adobe 2018]. It has been widely applied to performing arts [Kennedy and Atkinson 2018]. Virtual Reality (VR) has been applied to live performance [Bhargava 2022; Zhilyaeva 2019], while performances such as "Accelerating Dimension" [Tan 2022], "0AR" [AΦE Company 2018], "TouchAR" [Lewis et al. 2022], and Gorillaz' AR music video [Silva 2022] blend digital and physical. XR enables live performances to exist in both the physical and digital worlds [Triebeus et al. 2022], outside of the traditional stage [James et al. 2021], while

allowing the performer's physical actions to extend to the digital content [Santini 2024]. N:M+M takes inspiration from these works to develop a new performance type of performance that integrates multiple visualization modalities. These modalities are synchronized, allowing the performers and audience to alternate perspectives between the performance and subsequent exploration.

3 MOTIVATION AND DESCRIPTION

N:M+M is a collaboration between three artists of different backgrounds, A1 focuses on oil painting and has significant martial arts practice, A2 develops mixed media artworks and ephemeral land art. A3 specializes in MR arts and design. As eco-artists, they draw inspiration from Andy Goldsworthy, using natural materials and ephemeral techniques to create site-specific art that leaves no permanent mark on the environment. MR opens up new possibilities in eco-art. While having demands in terms of power, it only leaves a digital trace between the spaces of material-ephemeral and tangible-intangible. It further contributes to minimizing the impact of the intervention on the space, allowing for more sustainable artistic practice while leaving a permanent digital trace.

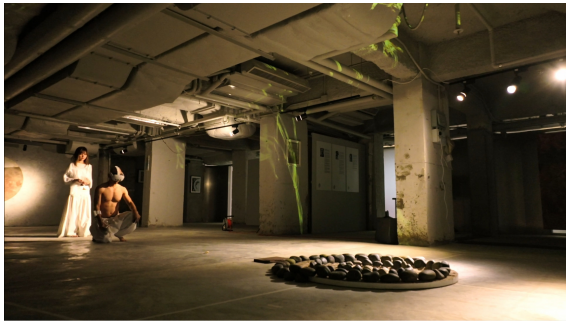
The project explores the intersection of Man/technology and Nature, asking whether technology can reconnect us with the natural world. It aims to metaphorically make visible the 'fields of force' and 'flows of materials' intrinsic to Nature [Ingold 2010], known as "qi," "animus," or "kami" in diverse cultures. By using MR to symbolically "reveal" these forces and flows, the performance



(a) Start of the performance. A1 starts drawing close to the screen (0'10")



(b) A1 draws the tunnel across the stage; A2 slowly walks towards the screen (2'00").



(c) A1 and A2 cross paths (3'00")



(d) A2 traverses the digital tunnel built by A1 (4'00").



(e) A2 interacts with the ephemeral installation (5'30").



(f) Final view of the performance (6'30").

Figure 2: Key moments of the performance.

aspires to raise awareness, leading to appreciation and ultimately, reconnection with Nature.

During the performance, A1, symbolizing "Man", wears an MR headset, "Technology", while A2 represents "Nature", with an ephemeral onsite installation of stones aligned along Earth's meridians. The installation configuration forms a nexus, akin to magic circles or Stonehenge, as focal points of Nature's energies. These spiralling installations, built by A2, are inspired by evolution and love, reflecting the mathematically precise and visually pleasing patterns found in Nature, here, the sand circles formed by mating pufferfishes.

The performance incorporates elements of meditation and spiritual practices. A1, having practised TaiChi Calligraphy, which synthesizes the meditative/martial aspects of TaiChi with Chinese calligraphy, begins the performance with TaiChi meditation, which aligns the practitioner's qi with Nature's for artistic co-creation. In

the performance, A1 aligns himself with A2 and the soundtrack, around A2's installation as a metaphorical/physical nexus of Nature's qi. Man, represented by the audience, aligns with both. A1 creates an MR artwork that "reveals" the forces and flows of Nature through a "shamanistic dance" informed by martial arts and Chinese calligraphy. These flows build a tunnel through which A2 performs a slow, meditative walk along a meridian line that connects the states of Nature and Man. Along the way, she picks up pebbles, symbolizing the four corners of Earth and everything within. At the end of her sojourn, she gifts these pebbles to Man. The silent simplicity of her motion is contrasted with the frantic movements of A1's 'dance', as the opposing forces that coexist and cooperate in our ecology. The performers' attire is simple and rustic, drawing inspiration from the brahmins of India and the priestesses of ancient Greece and Rome, roles of those who commune with the

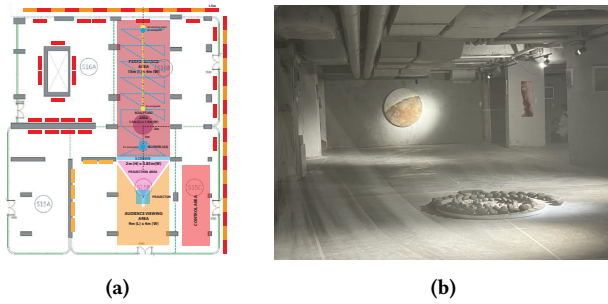


Figure 3: Floor plan of the performance and pathways of A1 and A2 (a). Performance space featuring the ephemeral artwork behind the semi-transparent curtain (b). A1 draws the digital artwork across the entire performance space, building a tunnel through which A2 performs her meditative walk.

gods, and, by extension, Nature. These contrasts, of stillness and movement, sound and silence, of male and female, are all embodiments/enactments of the interactions between Yin and Yang, which generates qi. The MR ‘metaphysically’ tracks these interactions and visualises them as lines of energy. As the saying goes, ‘out of sight, out of mind’, we bring back to mind these forgotten or ignored interactions of Man and Nature by using technology to ‘visualise’, again, ‘the fields of force’ and ‘flows of materials’. The performance ultimately seeks to achieve a balance between Man/technology and Nature, encouraging a more harmonious relationship.

4 PRODUCTION

Before this project, A1 and A2 had limited experience with 3D graphics and no prior exposure to MR. The project’s production thus aims to reinforce the physical presence of digital elements to reflect their practice.

4.1 Floor Plan

The performance and subsequent exhibition took place in a large exhibition space in Hong Kong. As a former underground parking lot, it features a raw concrete interior with structural pillars forming a long central corridor (25 m x 4 m) surrounded by small alcoves (see Figure 3a). The central space was used for the performance, leading to a stage longer than wide in which A1 and A2 respectively move away from and come to the audience. A semi-transparent screen separated the audience from the stage.

4.2 Audio and Lighting

The performers’ movements are enacted with the accompaniment of a third element, an original soundtrack composed by A1 and A2. It features a mix of ambient guitar and ocean waves, heavily inspired by the music of Brian Eno and the timbral quality and music of the Chinese zither (guqin), “an instrument of nature and of spiritual reverie” [Spitzer 2021]. The two performers play the roles of Man/technology and Nature with the soundtrack the third actor, forming an artistic interpretation of “One gives birth to Two, The Two gives birth to Three, The Three gives birth to all universal things” in Taoism [Tzu 2020]. The adagio tempo of the piece guides

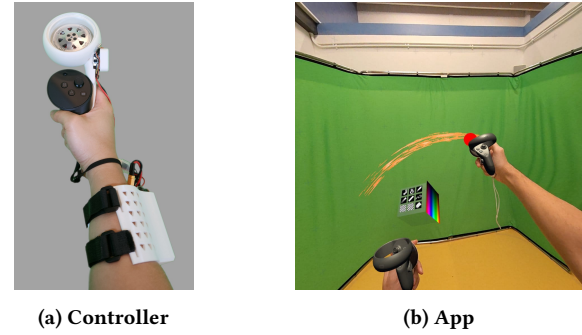


Figure 4: Setup developed for the performance. (a) Custom-made controller for haptic feedback in MR drawing. The gyroscopic wheel responds to users’ motion and acceleration. (b) MR view of the application.

the actions of A1 and A2. Combined with the unusual dimensions of the performance space, it contrasts the movement of A1, drawing an expansive (60 m²) digital artwork, with A2’s slow straight walk over the 7 minutes of the performance.

The lighting design was informed by the artists’ expectations and the performance’s technical constraints. The screen’s semi-transparent material obscures the audience’s view of the stage while reflecting all lights. On the other hand, the MR headset tracking is less efficient under dim lighting. Therefore, to maximise visibility and reliability, bright directional lights were used on the right side of the stage, pointed towards the back. This created hard shadows on the left, reinforcing the duality between A1’s frantic motions and A2’s meditative walk.

4.3 Haptic Feedback

A1 initially expressed concerns about the lack of tactile feedback in MR compared to traditional canvas. To address this, the team developed a haptic feedback device (Figure 4a) to provide friction, tensility, and sound. The device uses a single-axis gyroscope driven by a brushless motor. An inertial measurement unit (IMU) drives appropriate resistance to users’ motion through the gyroscopic wheel. While providing immediate tensility, it incidentally offers friction and sound through the vibrations and accelerations of the motor and wheel. The fixed-wheel gyroscope provides feedback only in the hand’s frontal plane, similar to sword-wielding, which resonated with A1’s martial arts background. This feedback was crucial for A1 to perform the large, slow movements required to cover the 60 m² stage in sync with the music’s tempo.

4.4 Performance visualisation

MR performances have typically been conducted with small audiences, relying on individual devices [James et al. 2021], or in CAVE-like environments [Kyan et al. 2015; Santini 2024; Tan 2022], and often asynchronously [AΦE Company 2018]. Although individual devices reinforce immersion, they take away from the collective communal experience and do not scale well to larger audiences [Shatilov et al. 2023]. Meanwhile, CAVE-like environments constrain digital content to the outer edges of the scene rather

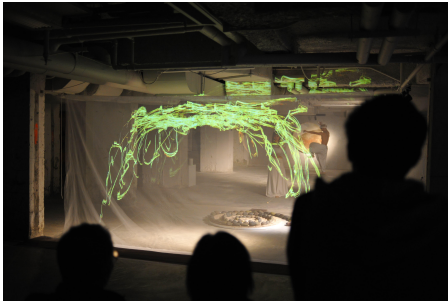


Figure 5: Parallax error from the point of view of one of the leftmost members of the audience. The projected content partially covers the performers for a short duration during the performance. With A2 moving forward, the large empty space in the middle of the tunnel will allow even the most off-centre audience to get a clear view of the scene.

than integrating it with the performance. The project thus adopts an intermediary approach. Only A1 wears the MR headset during the performance, onto which we run a custom-made 3D drawing application (see Section 5). The application is connected to a laptop that projects a real-time 2D projection of the scene drawn by A1 onto the screen at the forefront of the stage, allowing the audience to see the performance's physical and digital elements in real time.

MR as an artistic medium presents its own set of unique characteristics and constraints, demanding artists work with, around, and beyond these material (and immaterial) limitations to realize their vision.

First, with the performance stage being deeper (15m) than wide (4m), members of the audience located on the sides experienced significant parallax error (see Figure 5). The "tunnel" visual device was chosen to mitigate this effect. By drawing a tunnel guiding A2 in their meditative walk, A1 builds the digital artwork at the screen's sides, leaving the centre area for the audience to see the performance. A tunnel symbolizes transition and connection. A1 uses Technology to build a tunnel, encouraging the audience (Man) to transition into states of renewed communion with Nature. Furthermore, the tunnel functions as a secondary stage, framing the audience's attention on A2's journey and the physical installation. After the performance, the audience could walk through the tunnel using iPads or the MR headset. The tunnel's ethereal, cathedral-like aspect enhances the immersive experience of MR art.

The 2D projection of the tunnel onto a translucent screen is another key visual element. The screen's mist-like appearance creates an "in-between" state, simultaneously separating and connecting performers and the audience. This material-immaterial quality draws parallels to cultural mythologies, from Hong Meng in Taoism, where mist represents 'the genesis of the world,' to contemporary popular culture references like the Stargate portal, which separates yet connects different worlds. At the start of the performance, A1 draws the first strokes straight onto the screen. The direct correlation between the controller motion and the projection reinforces the audience's immersion, linking A1's motion to the digital content creation.

By presenting a summarized 2D projection of the digital work, the screen places the audience in a liminal space: simultaneously separated and connected, hidden yet revealed. As A1 moves away from the screen, the digital content evolution becomes more abstract, disconnected from A1's motion due to the parallax. It transitions from a direct signifier of A1's actions to more generally contributing to the audience's immersion by framing the stage and mitigating projection artefacts. The digital tunnel and its projection ultimately present metaphors and experiences that reveal the complex duality between Man and Nature, between separation and connection, material and immaterial, permanent and ephemeral.

4.5 Exhibition Presentation

The performance was presented at the opening of a two-week exhibition. To improve its materiality and persistence, the performance and resulting artwork were documented in several ways. The performance space became the exhibition space for the physical-digital artwork that could be experienced in three formats: a 2D life-sized projection on the screen and in MR using a Meta Quest 3 headset or an iPad application. The projection documented the performance, while the MR headset and the iPad presented the digital artwork in situ over the performance space. These formats allowed the audience to immerse themselves in a blended physical-digital environment by bringing materiality and persistence to the digital artwork. During the exhibition, the audience preferred the Meta Quest 3 headset due to its immersiveness, while the iPad application allowed multiple people to view the artwork simultaneously. The 2D projection provided context for the artwork before visitors explored it using the MR headset.

5 IMPLEMENTATION & CHALLENGES

Implementing a blended physical-digital performance and exhibition at a scale led to implementation decisions that we summarize for people willing to conduct similar events:

5.1 Hardware

The project used Meta Quest devices, starting with Meta Quest 2 in early 2023, quickly moving to the Meta Quest Pro to address the issues of performance and resolution. However, the Meta Quest Pro struggles with tracking the headset and controllers' position in low-light environments. The Meta Quest 3, released in late 2023, resolved these issues with infrared tracking.

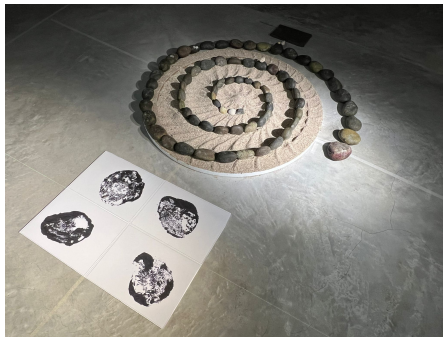
5.2 MR and Meta Quest 3

Our experience originated from experiments with OpenBrush¹ and RealityMixer², which allowed us to superimpose the image of the player onto the digital content through a virtual green screen. However, the iPad's body tracking used in RealityMixer frequently failed beyond a 5m distance in low-light environments. Besides, a bug in OpenBrush displayed the user's point of view in RealityMixer instead of a third-person perspective³. Upon investigation, this bug appeared first in the update that enabled video see-through. As such, A1 would have to operate without seeing the physical environment

¹<https://openbrush.app/>

²<https://github.com/fabio914/RealityMixer>

³<https://github.com/icosa-foundation/open-brush/issues/407>



(a) MR Marker



(b) iPad's ARKit visualisation



(c) Meta Quest 3 situated visualisation.



(d) Point of View in Meta Quest 3 headset.

Figure 6: Visualisation of the MR artwork during the exhibition.

for RealityMixer to work as intended. This was not desirable for safety reasons.

Therefore, we redeveloped the entire software system using Unity. This allowed us to create a networked application running on the Meta Quest 3, a laptop, and an iPad, reusing the brush shaders from OpenBrush, and synchronized through Unity NetCode⁴. All points of view are synchronized, allowing for a communal visualisation experience between A1, A2, and the audience. Figure 4b displays the artist's MR view of the app.

5.3 Meta Quest's Boundary

Meta headsets feature a boundary that sets the limits of the usable space. If the user crosses the boundary, the application pauses, and the headset switches to video see-through to avoid accidents. Although this feature is significant in VR, where the user cannot see the physical world, our application did not require it as it ran in video see-through for the entire performance. The maximum boundary size was also smaller than the performance space. Turning off the boundary in the settings is possible, but the floor height drifts over time. Reactivating the boundary resets the floor height and needs to be performed before every rehearsal and performance. Turning off the boundary also removes the option to record video in MR, forcing us to split the space into several smaller areas to document the artist's point of view.

⁴<https://docs-multiplayer.unity3d.com/netcode/current/installation/index.html>

5.4 Aligning the 2D projection with the physical stage

To align the physical and digital elements, we developed a three-step calibration process. First, the performer marks specific physical locations in the digital scene projected onto the screen. The projection's pose and field of view are then manually adjusted to align the digital marks with their physical counterparts from the perspective of an observer of average (1m70) height behind the video projector. Finally, the alignment is refined through a few test strokes. This process needed to be repeated every time the projector, screen, or drawing origin in the MR headset was moved, as even minor angular variations could lead to significant discrepancies on-screen.

5.5 Synchronizing Multiple Points of View

The digital artwork was visualized through three devices: a Meta Quest 3, a 2D projection onto the semi-transparent screen, and an iPad MR application. Each device operates in its own coordinate system, requiring alignment, both in real-time during the performance and asynchronously during the exhibition. While the 2D projection is manually aligned (Section 4.4), the iPad uses ARKit with a static image marker on the floor (Figure 6a). The Meta Quest 3, however, lacks convenient initialization and synchronization techniques. To address this, we employ two subsystems: a Spatial Anchor specific

to Meta's headsets⁵, to attach the artwork in the physical space, and a 2-point initialization mechanism to align the Spatial Anchor with the iPad marker. This involved A1 defining several points on the floor to set the spatial anchor's origin, orientation and scale onto the floor plane, allowing for coordinate system alignment. Turning off the headset's boundary seemed to affect the Spatial Anchor's relocation. The 2-point initialization thus allowed recovery on the MR headset in case of tracking loss.

6 AUDIENCE FEEDBACK

The performance attracted over 50 visitors, and the exhibition over 100. Around half had an arts background, while the other half were onlookers. Most had little to no prior experience with MR. We collected feedback from 20 participants following the visualisation of the MR artefact.

The N:M+M experience, encompassing the performance and subsequent guided tour of the MR artefact, the physical installation's aesthetic, the space's lighting, and the ambient soundtrack, instilled a sense of spiritual sanctuary conducive to meditation and reflection. Audience members reported feeling a renewed desire to re-examine their relationships with Nature.

The perspective shift between the 2D projection and the 3D immersive artwork was met with surprise. Once past the initial moments of tracking A1's motion, the digital artwork mostly framed the physical performance. The audience could see it growing in an abstract manner, but the lack of depth caused by the 2D projection affected their perception. Therefore, most participants did not expect the artwork to sprawl across the entire stage. When wearing the headset, the audience moved from immersion to presence, emphasizing the situatedness of the artwork anchored in the environment, a contrasting experience with the flat, distanced projection on the screen. Many participants would walk through the tunnel back and forth numerous times to explore its curvatures and cadences. This shift in point of view from a spectator to a participant was similar to how one would approach a piece of installation art or even architecture, complimented by the immersiveness of the experience [Pallasmaa 2012].

The tangibility, or lack thereof, of the artwork was a source of intrigue and confusion for many. They would instinctively reach out to touch the 'brushstrokes', only to be surprised by the lack of tactile response. The artists also observed this well-documented phenomenon during the rehearsals, where the headset user would sometimes point at digital elements, forgetting that others could not see them. The bareness of the environment and the headset's improved embodiment seemed to reinforce the presence of the digital content, accentuating this effect.

7 CONCLUSION

N:M+M interrogates our relationship as Man to Nature through the usage of Technology. In terms of Technology, the experience explores persistence and tangibility in performance and digital

arts, from providing actual tangibility to the artist while drawing in MR through active feedback to durably anchoring the artwork into the performance's physical space. This performance

⁵<https://www.meta.com/help/quest/articles/in-vr-experiences/oculus-features/what-are-spatial-anchors/> is the first of a series of works focusing on the themes of space (closed/open, indoors/outdoors, artificial/natural), persistence (permanent/ephemeral), audience perspective (fixed/mobile, planar/circular), and performance settings (planned/spontaneous). While the physical artworks are intrinsically ephemeral, the performances leave a permanent digital trace in their space. This project brings new possibilities for digital and performing arts to exist alongside traditional physical artworks, both within and beyond conventional exhibition spaces.

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