Spheri v1

A body tracking artefact to interact with spherical perspective drawings made on-the-fly

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ABSTRACT

This article presents Spheri, the latest version of the artefact formerly known as "I'm Watching ~~You~~/Me" (IMWYM). Spheri explores the use of Hybrid Immersive Models (HIMs) for artistic applications of immersive environments, created from handmade spherical perspective drawings. The development is framed within the ongoing investigation of Handmade Immersive Art (HIA). The article discusses the artistic and technical implications of utilizing body tracking for navigating a VR environment and analyses user experiences, and their engagement with immersive environments. Spheri is the first web-based and independently coded version of the artefact, and it represents a significant improvement with new features such as an illustrator-centred navigation system, smoother navigation, and enhanced stability. The article contributes to the field of handmade created immersive environments, and it highlights the potential implications for artists, designers, illustrators, and educators.

CCS CONCEPTS

• **Applied computing** → Arts and humanities; Media arts; • **Computing methodologies** → Machine learning; • **Hardware** → Communication hardware, interfaces and storage; Tactile and hand-based interfaces; • **Human-centered computing** → Human computer interaction (HCI); Interaction devices.

KEYWORDS

Spherical Perspectives, Digital Media Art, Hybrid Immersive Art, Virtual Reality, Interactive Installation

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1 INTRODUCTION

Immersive environments have expanded the way we interact with virtual spaces [8], [11]. These environments can be divided into two kinds: "large-scale spaces of illusion that fully integrate the human body (e.g., rooms with 360° frescoes, panoramas, CAVEs, etc.) and apparatuses that are positioned immediately in front of the eyes (e.g., peepshows, stereoscopes, stereoscopic television, Sensorama, or HMDs) [8, p. 349].

In either case, these artefacts have found an increasing use of digital technologies during the last few years, a technology that has provided users with an augmented sense of presence and engagement [9]. Nevertheless, we can find new possibilities with a unique aesthetic appeal in the transition from traditional artistic representations to immersive virtual reality experiences, and it is within this context where the art-practice-based research Handmade Immersive Art (HIA) [17] takes its place.

HIA proposes the utilization of Hybrid Immersive Models (HIMs) [15] to interact and to create immersive environments out of handmade spherical perspective drawings. These drawings are artworks meticulously constructed following the principles of spherical perspectives such as vanishing points and geodesics [2].

Despite their initial appearance of distortion, the same as flattened panoramic photographs, these drawings can be used to cover physical and/or digital spheres. If they are created properly by following the principles of spherical perspectives, and viewed within a digital sphere through a camera placed at the centre of such sphere; then these handmade images will provide viewers with a seamless and undistorted virtual environment.

Converting of photographic or rendered flat panoramas into immersive VR environments has been extensively explored within the field of Computer Science, with numerous software applications available for this purpose. However, Spheri focuses on the real-time conversion, enabling artists, designers, and illustrators to create and witness the transformation from flat perspectives to their VR modality in front of an audience [18], [19].

The artefact-software Spheri is an evolution of I'm Watching ~~You~~/Me (IMWYM). IMWYM was programmed as a TouchDesigner [25] dependent application. Spheri v1 is the first independent version, developed as a web-based application coded using JavaScript, CSS, and HTML. Spheri incorporates the latest features of IMWYM, such as body tracking through the use of the machine learning library Mediapipe by Google [7], and new functions including an illustrator-centred system of navigation, a stabilised and smoother navigation, and an improved system of navigation.

The goals of the article are:

- To explore the artistic and technical implications of utilizing body tracking for navigating a VR environment.
- To analyse the data provided by previous IMWYM versions, such as user experiences and their engagement with immersive environments.
- To dive into the challenges encountered during art exhibitions using IMWYM.

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- To introduce Spheri and its improvements, establishing new milestones for its future development.

The article is structured as follows:

- Motivation and background
- Previous versions of the artefact
- IMWYM 3
- Live tests
- Technical and artistic evaluation of IMWYM
- Transition to Spheri
- Future steps
- Conclusions

2 MOTIVATION AND BACKGROUND: THE HIA RESEARCH

Spheri's development is framed within an ongoing investigation in the field of digital arts called Handmade Immersive Art (HIA). The HIA research seeks to understand the influence of using Hybrid Immersive Models (HIMs) for the creation of digital art, meaning the correlation, impact, and cross-influences between handmade drawing (as a model of thought and reasoning), spherical perspectives (as a representation system), and digital arts (as their main application).

HIMs originated within architectural and engineering drawing, and have found applications in several fields such as engineering, product design, fashion design, e-commerce, cultural heritage, teaching, and architecture [6], [13], [22], [23], [24]. HIA extends the applications to digital arts, it connects to research questions about the model of reasoning and thought, and it proposes a creativity more humanised and less automated.

Some research questions driving the HIA research are: what are the implications of using handmade VR drawings for the creation of virtual realities? Can artists "see and express" differently using and learning spherical perspectives? What is the impact of understanding spherical perspective's principles in artists' creativity? What is a realistic range of applications? How versatile and feasible is to propose a model of thought and expression through a step-by-step drawn reasoning, instead of a final software/product/tool?

In a rough roadmap, the HIA research should define:

- Methodological definitions and a theoretical conceptualisation of HIM within the field of digital arts (aspect focused and developed in [17]).
- Artistic applications (this paper's focus), user studies and expert discussions.

Narrowed down, the specific goals are divided into four parts: a compilation of handmade spherical perspective systems (Part A), the development of mobile and desktop applications for interacting and creating these drawings (Part B), applications within art exhibitions and live performances (Part C), and finally ways of transmitting and cross sharing this knowledge (Part D). Spheri's development is enclosed within Part B of the research, while its application within [IN]Musicality is in Part C.

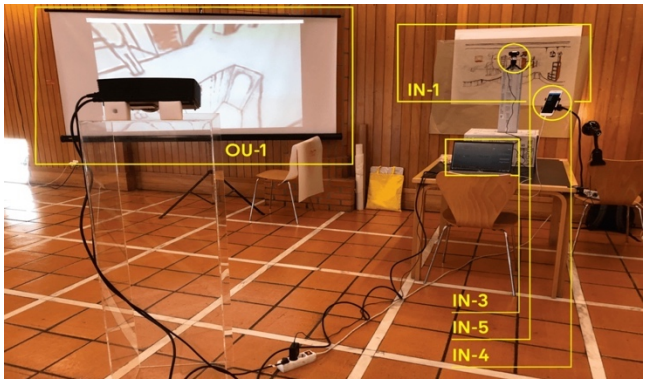

Figure 1: I'm Watching ~~You~~/Me 1st edition.

Figure 2: Live drawing performance using IMWYM 1 and operation of the camera through a mobile phone.

3 RECAP OF THE PREVIOUS VERSIONS OF THE ARTEFACT

The following paragraphs synthesize the three previous versions of the artefact, to better understand the context of development and the importance of the new implementations.

3.1 IMWYM 1

This first version (Figure 1) was presented in October 2021. The installation introduced a pure technical advancement, consisting of a basic workflow created within TouchDesigner in a performative setting with a simultaneous interactive live feed of the spherical drawing's VR visualization [19], [20].

The live visualisation of the VR content was commanded using an external mobile phone (Figure 2, left). The spherical canvas could be fed either from an external camera pointing to a physical drawing, from the dedicated software for spherical drawing "Eq A Sketch 360" [1], or from an already existing file (Figure 3).

3.2 IMWYM 2

IMWYM 2 was showcased in July 2022 during [IN]Musicality, an exhibition part of the shared event *[IN]Tangibilidades Digitais*, held from 12 to 15 July 2022 at the Espírito Santo Convent of Loulé, Portugal [16], [18].

The artefact retained all the same functionalities as in the 1st version, although it introduced several and crucial features for a concrete implementation within the field of digital arts, such as: optimisation of the components and layout (Figure 4), a stronger

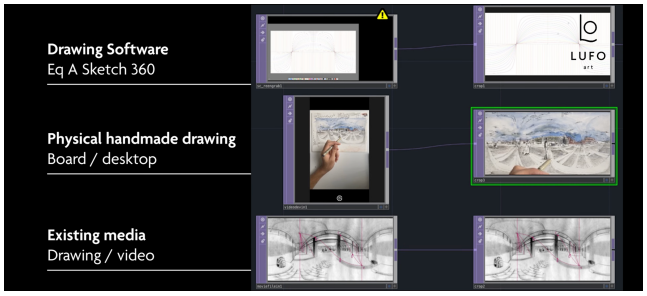

Figure 3: The different inputs for the artefact.

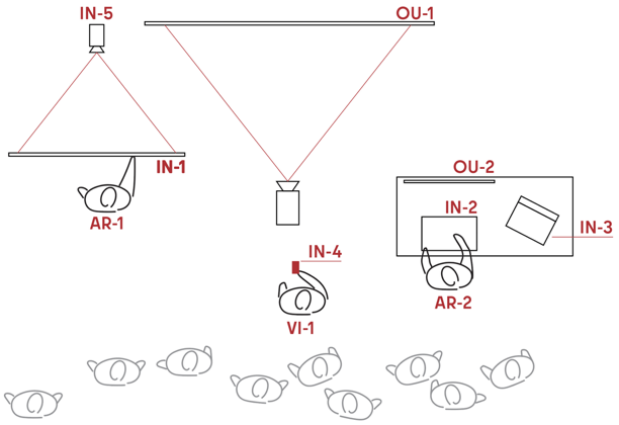

Figure 4: Full scheme of IWMYM 2.

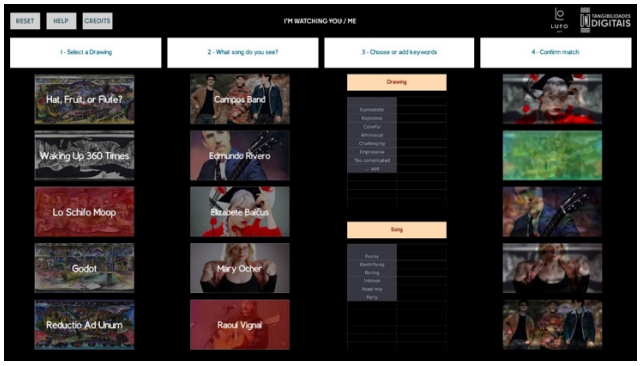

Figure 5: Front-end interface.

concept and a narrative (see 2.3), a graphical interface for an enhanced interaction (Figure 5), and a more seamless and stable user experience after fixing navigation gaps and releasing the phone from being constantly plugged (Figure 6). The artefact was also used for teaching purposes during a drawing workshop held at the same event (Figure 7).

3.3 [IN]Musicality

IMWYM 2 included [IN]Musicality, a concept featuring five spherical drawings from the same collection. The drawings were created

Figure 6: Wireless and improved navigation.

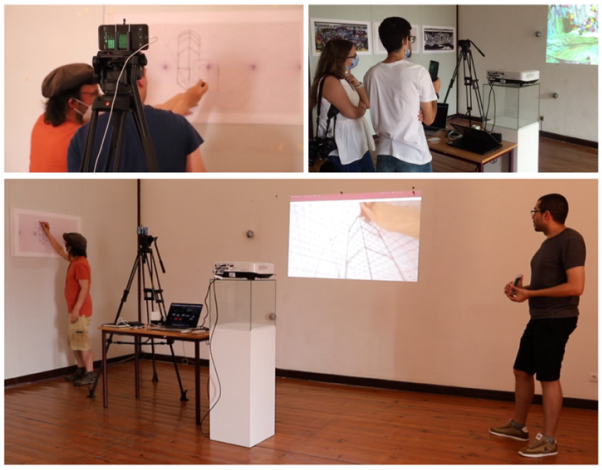

Figure 7: IMWYM 2 was also used with teaching purposes.

while listening to five different music ensembles, four of them live concerts. The compositions condensed the author's experience, inspired by: a) Kandinsky's synaesthetic experiences [5], b) the performance of the different artists and c) the challenge of live drawing an equirectangular perspective. Each artwork reflects a different musical atmosphere, by Elizabete Balčus, Raoul Vignal, Mary Ocher, Campos Band and Edmundo Rivero, conveying plasticity, fluidity, childishness, rigid and soft structures, etc.

[IN]Musicality explored the expression of music through the drawings and investigated how visitors perceived the musicality within them. The concept aimed to understand how artists express music through graphical signs, how visitors interpret the musicality of immersive perspectives, and the accuracy (if any) of transmitting musical sensations using handmade immersive environments.

The interaction with the artefact expected an experience where users should complete a quiz - with no "right" answers - selecting: (follow columns on Figure 5), a drawing (1st column), a song (2nd column), keywords for each drawing and song (3rd column), and the confirmation of each matched pair (4th column). This edition of the artefact included a function for gathering anonymously the interaction data, with the purpose of elaborating statistics afterwards.

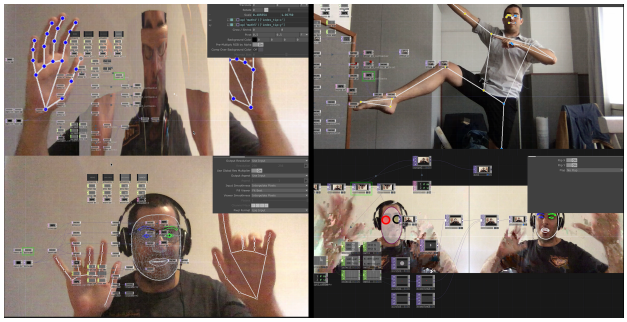

Figure 8: Tests using MediaPipe and TouchDesigner.

3.4 An intricated UX

After the presentation in Portugal several details of the artefact were discussed and settled within a full list of criticalities and future expected developments [18].

One of the biggest issues detected was the overly complex user experience: the concept involved an intricate workflow of interaction, using both the mobile phone and the computer. On one hand, the user had to use the mobile phone for orienting the camera of the drawing's VR view. On the other hand, they also had to use the computer to choose a drawing, a song, keywords, and a match.

This workflow was not clear enough: some users will neither touch the mobile phone nor the computer, fearing to "break something". This fear persisted even after they were introduced to the artefact and the concept, which makes very clear that the interaction was not intuitive for most visitors. Some other visitors understood well both the concept and the interaction, matching all pairs, and completing the quiz. Unfortunately, the exhibition had very few visitors and the data collected was not sufficient to obtain accurate results.

This "broken UX" was particularly enlightening for the future developments of the artefact: it opened the idea (implemented in the 3rd version of the artefact) of using a contactless alternative for navigating the VR environments through body tracking.

4 IMWYM 3

The third version of IMWYM drops the use of the mobile phone, and instead it uses motion capture for operating the VR camera and selecting the drawings. This is accomplished through body tracking by the machine learning library MediaPipe [7].

The algorithm of MediaPipe uses any regular computer webcam to gather image data, it performs an analysis detecting objects and body landmarks, and it returns position data for each landmark. MediaPipe offers several functions, including Face, Mesh Face, Pose, Hand, Object, etc. (Figure 8).

The tests for IMWYM 3 with MediaPipe started in late-July 2022, shortly after the presentation in Portugal. The body tracking functions opened up a world of possibilities and new ways of interacting using hand gestures. In fact, the following gestures and functions were added:

- **Automatic startup:** the software switches from the welcome screen to the home screen starting the experience autonomously as soon as a visitor is detected in the camera's field of view.
- **Right hand to VR camera:** the right-hand wrist landmark controls the orientation of the VR camera. The centre of the screen is taken as the origin of a Cartesian plane with x-y axes. A hand shift in the screen's x-axis rotates the virtual camera around its z-axis. A hand shift in the screen's y-axis rotates the virtual camera around its x-y plane.
- **Left hand to pointer:** the left-hand wrist's landmark controls the mouse's location. A small distance between the tips of the index and thumb fingers of the left-hand triggers a click. These two functions use the Button and Controller functions from the pynput.mouse library.
- **Zoom:** the field of view is adjusted proportionally to the distance between the tips of the index finger and thumb of the right hand.

Another important new feature of IMWYM 3 is the incorporation of the cubical map format. The open cube, or sky box, has been used since the mid 80's, gaining an important place among CGI rendering options for its many performance benefits [4], [10], [26]. Until IMWYM 2 it was only possible to use the equirectangular format as image input, both if the input was a live drawing or an existing artwork. Formats such as the cubical map and the azimuthal-equidistant were tested but not included. The 3rd version of the artefact concretized the possibility of using a cubical map, in both live and storage access modalities. This extension brought new possibilities for the testing of the artefact (see 5.1) and [21].

5 LIVE TESTS

The new body gestures aimed to simplify and make the operation of the artefact more natural. This way, visitors would be able to interact without the fear of breaking something, following their instincts for discovery, and reading less instructions. Thanks to the body tracking functions the interaction with the computer and the mobile phone were entirely dropped, although it was necessary to test the new functions in live settings with an open crowd to see and evaluate their reaction and the real impact.

5.1 Drawing workshop

The first live test of the artefact was during a workshop for drawing in cubical perspective [3], [21], in a classroom prepared with multiple cameras and projectors.

The artefact was set up for teaching purposes, with the input camera pointing to a paper fixed on a desk. The flexibility of the setup allowed a fluid interaction between the flat cubical perspective drawing and the VR content. The body tracking functions helped display the VR results and focus details on-the-fly as they were being created (Figure 9). A full description of this workshop can be found in [23].

5.2 [IN]Musicality at the CLB Space

The second and the bigger live test of IMWYM 3 was during the exhibition Ubiquitous Music + [IN]Musicality, held between the 17th and the 18th of November 2022 at the CLB Space of Berlin, Germany (Figure 10).

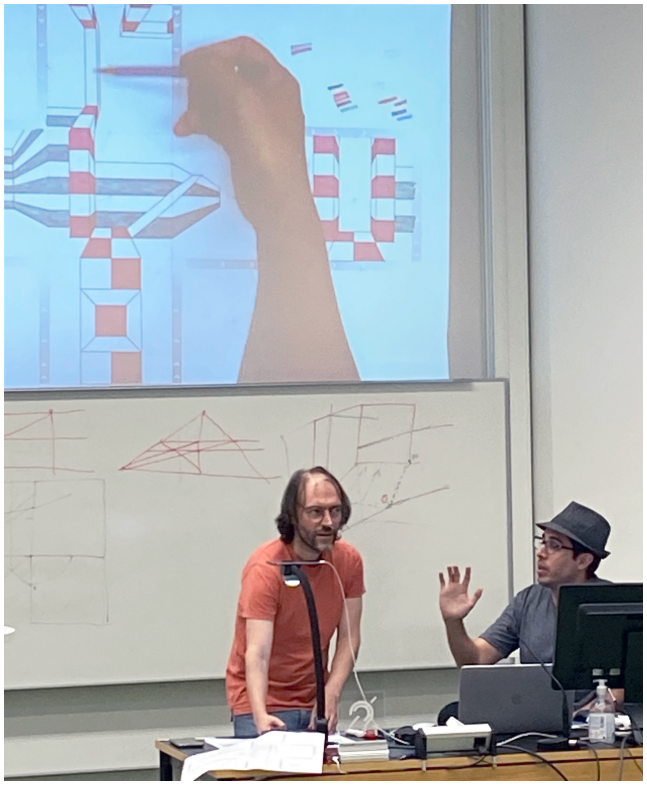

Figure 9: Use of IMWYM during a drawing workshop.

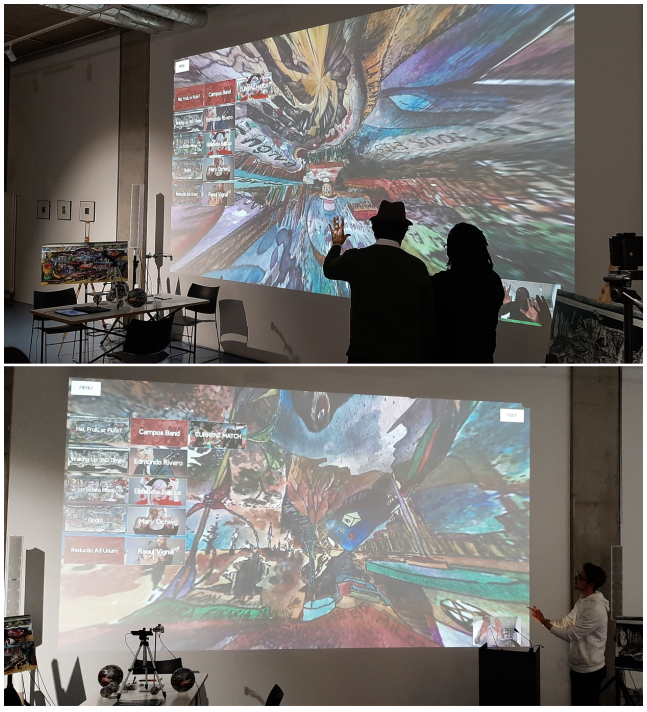

Figure 10: . Users experimenting with body tracking.

The [IN]Musicality experience was simplified for this exhibition, aiming to improve users' experience: the keywords' selection was cut off and the buttons were rearranged in the screen. The presentation in Berlin had around 50 visitors, which gave a larger amount of data, plus very valuable feedback about the user experience with information about the difficulties and gifts of the concept and motion capture.

For example, some visitors mentioned the complications of "clicking by pinching in the air". Some others expressed "it would have been easier to click while touching something, as you do when you use the mouse". IMWYM shall not go back to the use of a classical physical device (that is where it comes from!), yet this feedback was a great input to rethink the interactions as something different.

Another problem with the pointer was visual. Due to time limitations, it was not possible to change the pointer design to make it more visible on the large projection, which contributed to users "losing track of the pointer" during the interaction.

On a more positive side, some visitors expressed their amazement for being able to move both the pointer and the VR camera just by waving their hands in front of the camera and wearing nothing at all such as controllers or special gloves. Almost all visitors highlighted the hand-mouse and hand-camera interactions as the most impressive features of the artefact.

5.3 [IN]Musicality + drawing workshop at ArtsIT

IMWYM 3 was also presented with [IN]Musicality during an exhibition and drawing workshop held the 21st and 22nd of November 2022 at the Hotel Eva Senses, Faro, Portugal [18], [21] (Figure 11).

The general reception was very good and this time, due to the nature of the congress, the artefact was evaluated by a more specialised audience composed by researchers with artistic and technical background in the fields of Computer Sciences, UX/UI and Digital Media Arts.

The feedback from this audience raised questions such as why the command of the pointer is made with the left hand while we normally use the right hand for such a task. They also commented about certain navigation issues, and it was also discussed how to stabilise the navigation (see 6.2).

6 TECHNICAL AND ARTISTIC EVALUATION OF IMWYM

One of the goals of the HIA research is to evaluate the use and significance of this artefact focused on handmade spherical perspectives within the field of digital media arts. Hence, it becomes equally important to evaluate the technical and the artistic impact of the artefact. This is a brief evaluation of the three versions, considering: the artistic/conceptual definition, the artistic/technical advancements, and the artistic/performative experience.

IMWYM 1 introduced **purely a technical advancement through a live drawing performance.** Neither the drawing made during the presentation, nor the technical advancement were supported by a specific **conceptual experience**. However, this version presented an important feature for the development of both

Figure 11: Specialised audience testing IMWYM.

drawing performances and artistic concepts using spherical perspectives: **the live and interactive VR feedback from a spherical perspective input**.

IMWYM 2 did not introduce big **technical advancements**, but it tested [IN]Musicality as a **conceptual artistic experience**. Furthermore, during [IN]Musicality it was used the live and interactive VR feedback for **teaching purposes** during a drawing workshop. Although the path and the ways of interaction were not clear enough, nor was the quantity of participants sufficient, this first presentation of [IN]Musicality gave very valuable return to solve the intricated UX/UI and interaction of the conceptual experience.

IMWYM 3 introduced both **technical advancements** (including body tracking features) and a new test of the **conceptual experience**, although this time [IN]Musicality was tested with a larger audience. During the presentation, there were visitors who easily understood the operation of the artefact, successfully completed the quiz, and with that provided numerical data for analysis. Nevertheless, there were other visitors who got lost in what to do, how to do it, and in using which gesture for which command. Furthermore, IMWYM 3 was also used for teaching purposes in two occasions, providing a powerful tool for live showing the correspondence between the flat drawing and the VR visualisation. In all cases of interaction, visitors spent more time just contemplating the artworks and/or interacting the VR camera without completing the [IN]Musicality quiz. **This implies that the technical strength of the motion capture features, and the contemplation of the artworks as individual pieces, were stronger aspects of the artefact if compared with the [IN]Musicality concept.** Indeed, during the exhibition in Berlin most visitors got engaged moving the VR camera waving their hands in front of the computer and contemplating the drawing they found in screen, but very few used all commands for choosing a different illustration, song, or completing the quiz.

Hence, IWMYM introduced **technical, performative, and conceptual artistic advancements**, with a stronger emphasis in the technical and performative applications. This puts some important questions for the further steps of the research such as:

- Should the conceptual artistic experience be as stronger as the technical and performative advancements, for the artefact to be valuable within the field of digital media arts?
- How to make the conceptual artistic experience as valuable as the technical and performative advancements?
- Which other concepts might fit better the artefact?
- Is the current emphasis on the technical and performative sides a limitation or a characterisation?
- If yes, is it a characteristic of the artefact (meant just to be a technical and performative device), a characteristic of the concept (meant to be complex and not massive), or a limitation caused by the inexperience of the artist to define a simpler concept?
- How to measure the success of an artistic concept?

Whatever the new applications will be, it seems very likely and necessary to keep simplifying both the concept and the interaction to reach a larger audience and give an innovative conceptual experience through the technical and performative strength of the artefact.

7 TRANSITION TO SPHERI

Spheri preserves all the previous functionalities gathered from IMWYM, plus some important improvements which include:

- The first independently coded web-based version, more accessible and flexible for open implementation.
- An illustrator-centred system of navigation that follows the movement of who is actually drawing.
- A stabilised and smoother navigation, it uses the average value to ease the navigation and determine the orientation of the camera.
- An improved system of navigation for selecting drawings, using hand gestures.

7.1 Independent code

A significant enhancement in this latest iteration is that Spheri is the first standalone web-based platform version of the artefact. This transition marks a significant milestone as it liberates the platform from its prior reliance on TouchDesigner. The change brings forth several advantages, including the removal of restrictions on video output resolution, the elimination of compatibility issues across different devices, and improved accessibility.

Spheri can be accessed at https://spheri.art. The code has been developed using JavaScript, incorporating Three.js for the geometry and lights, and MediaPipe for the body tracking functions. The code has been cleaned in comparison to the one used within TouchDesigner, and it has been successfully tested in computers with Windows and MacOS, within the most common browsers and devices. The changelog is available for consultation at https://spheri.art/changelog.txt.

7.2 The new navigation system

IMWYM required two persons for the interaction: one would operate the VR camera while the other was drawing (Figure 7, Figure 9). Instead, Spheri joins the two features in one same person, centring the view in the hand of who is drawing. Consequently, one must

be either touching the drawing or doing it, so to navigate the VR camera (Figure 12, Figure 13).

Thanks to this function, the body tracking feature (pointed out as one of the strongest characteristics of the artefact), is now used to "force" the person to touch the drawing and thus find a correlation between the flat and the VR view by a direct experience.

7.3 Stabilised navigation

Per default, MediaPipe returns position coordinates within a certain range of confidence that can be setup within the code. However, the returned values are still very unstable, which generated oscillations and shakings either in the VR view or in the pointer's position.

Spheri includes a new feature to facilitate navigation. The function stores the latest 15 position values provided by MediaPipe within an array. Thus, it returns average values that ease and smooth the navigation, determining the camera's position with more stability. This stabilisation function - result of the discussion during the presentation at ArtsIT - results very valuable for the artefact, as it makes the navigation smoother and stabler, hence more user friendly.

7.4 Input selection

Spheri eliminates mouse command through the left hand's movements. Instead, it uses a function that switches among inputs using a simple swipe hand gesture that triggers the action indistinctively the used hand.

The function follows the landmark 8 (Figure 14), and it switches backwards/forwards if a certain distance is covered by that landmark within a certain time. This means that if users move their hand quick, the input will switch, while if they move the hand slowly (like when they are exploring the virtual environment), the input will not change (Figure 15).

7.5 Open tests

The first version of Spheri will be publicly released by 01/01/2024. This version will be presented within the digital artistic community through live performances, collaborative drawing installations, workshop lessons, exhibitions, and congresses. These presentations should provide the data for testing:

- the new features introduced by Spheri v1,
- the current strengths of the artefact,
- the latest experiences made with cubical and equirectangular perspectives,
- the potentiality for **exploring and visualising** spherical perspectives,
- the strength of the artefact for learning about spherical perspectives and for teaching purposes,
- the goals of the HIA research,
- the results and feedback from previous editions.

During these presentations, visitors will either interact with pre-existing media or with an on-the-fly made drawing created in a translucid canvas. The canvas is captured through a camera placed below/behind and provides to the software both the drawing and the position of the hand (Figure 16).

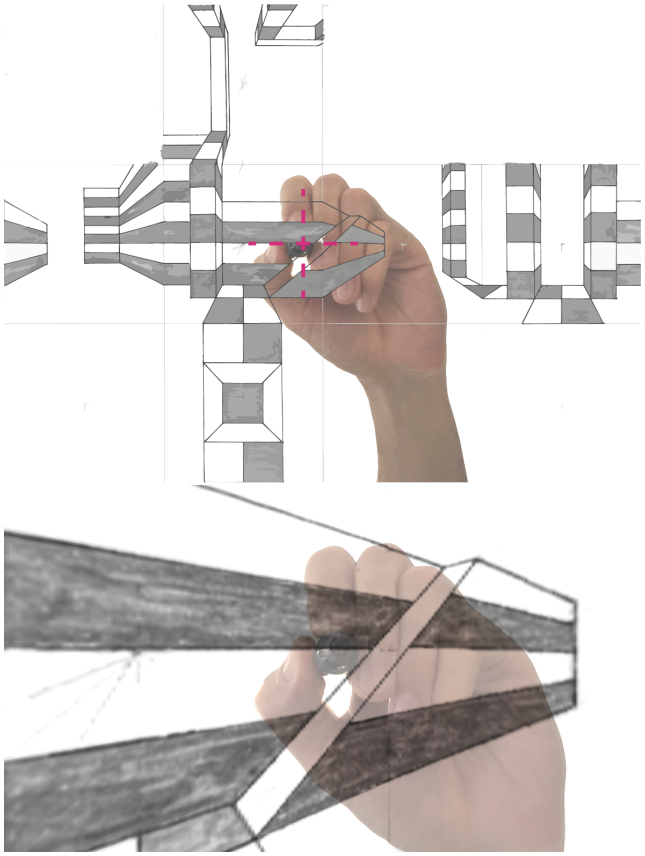

Figure 12: The navigation system of Spheri follows the drafter's hand: view on the cubemap (up) and in VR (down).

8 FUTURE IMPROVEMENTS

Although there are still many functions and improvements to implement within Spheri, these are some features expected to be deployed within the near future:

- **Auto-calibrating tracking system:** this should simplify the setup of the artefact, avoiding the fine and fragile calibration currently needed. Furthermore, the function could allow Spheri to be used dynamically from a mobile phone without any tripod or stabilisation system.
- **Snapshot to VR environment:** a function to take a screenshot and use it for creating the VR environment. This comes very handy when the user has not access to a transparent canvas.
- **Customised input:** add the possibility for users to load their own input, either in equirectangular or in cubical perspective. The program will then show the VR environment accordingly to this input.
- **Implementation of the azimuthal-equidistant perspective as input:** this could be very beneficial to keep expanding the available options among the full bestiary of spherical perspectives.
- **Wireless mobile phone/computer synchronisation:** a function to allow the use of the phone as a remote input.

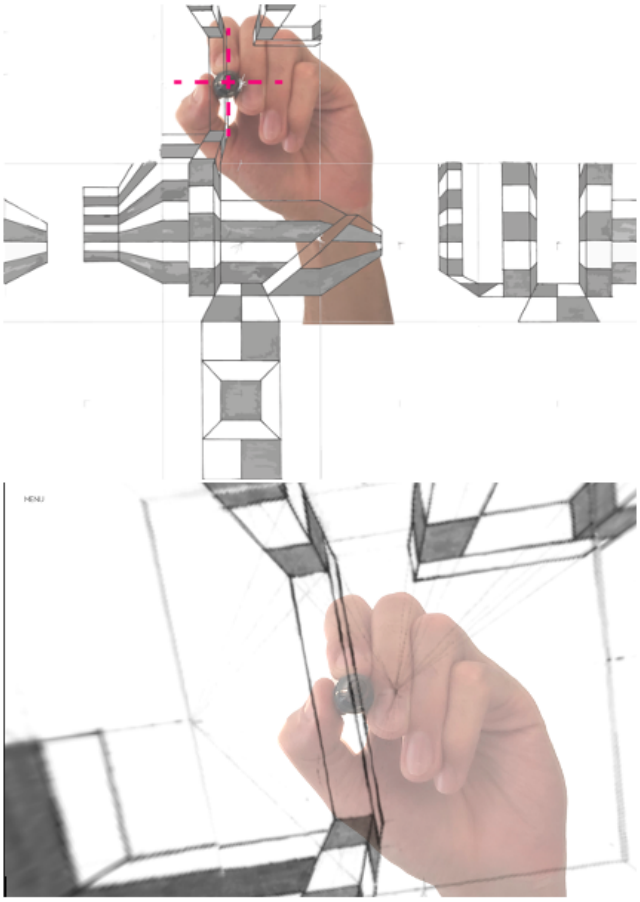

Figure 13: Drawing in the upper part of the cubical map (up) and VR view (down).

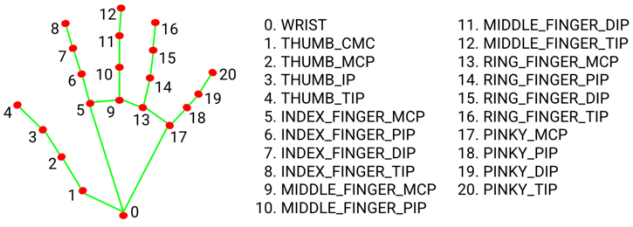

Figure 14: Hand landmarks detected by MediaPipe.

- **Galleries:** either pre-set or user based.

9 CONCLUSIONS

Spheri represents a significant advancement in the development of an artefact/software/installation for interacting with spherical perspectives, building an extended experience upon the previous versions of IMWYM and incorporating new features to enhance the user experience. By focusing on handmade spherical perspective drawings and addressing the artistic, technical, and conceptual aspects, Spheri goes up to the boundaries of digital art to expand

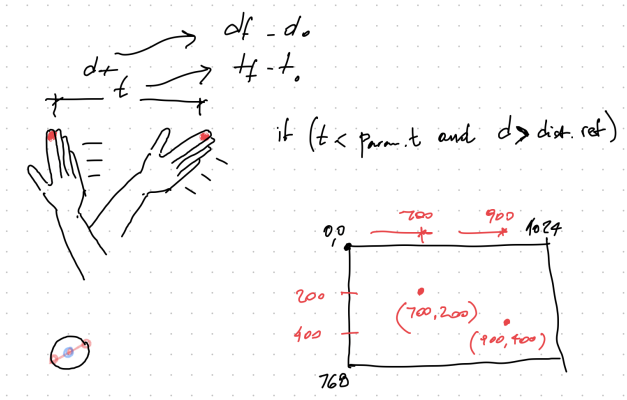

Figure 15: Gesture to switch among inputs.

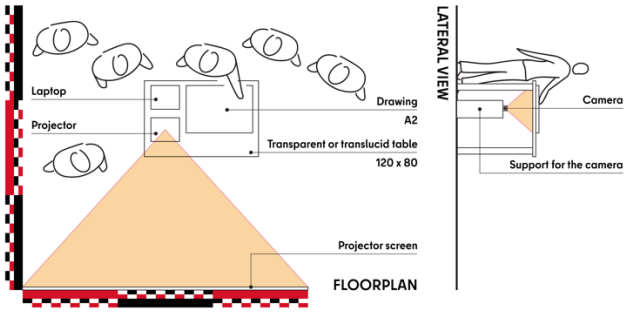

Figure 16: Installation scheme.

the possibilities for artistic expression. The artefact follows the goals of the research Handmade Immersive Art (HIA), aiming to contribute to the ongoing discourse on digital culture, software's role in contemporary society [12, p. 9], and the artist's integral awareness [14].

Spheri's development and the live tests of IMWYM have demonstrated the technical and performative strengths of the artefact, while also highlighted the need to simplify the interaction and conceptual experience for reaching a broader audience. The artefact opens up new avenues for exploring creativity and the collaborative art making using body tracking and immersive virtual environments from handmade drawings.

As a result, Spheri paves the way for further advancements in Handmade Immersive Art and digital media arts, offering unique and engaging experiences that bridge the gap between traditional artistic representations and cutting-edge digital technologies.

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