[IN]Musicality: A Collection of VR Drawings and Music as an Artistic Application of Hybrid Immersive Models

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Abstract. A recent work called I'm Watching ~~You~~/Me (IMWYM) introduced a technical apparatus for live VR visualization of 360 drawings made on-the-fly. The exhibition [IN]Musicality uses and improves on the techniques presented in this first prototype but focusing on their artistic application. In fact, [IN]Musicality explores the artistic side of Hybrid Immersive Models through the interaction with spherical perspectives drawn to live music.

The article enumerates the issues from the first version of the artefact, presents possible ways to solve them, describes the solutions adopted for [IN]Musicality, and establishes milestones for the future roadmap of developments.

Keywords: Spherical Perspectives · Digital Media Art · Hybrid Immersive Models · Virtual Reality · Interactive Installation

1 Introduction

I'm Watching ~~You~~/Me (IMWYM) is an artefact for interacting and visualizing immersive environments created from handmade spherical perspective drawings [1]. The spherical perspective drawings are flat artworks methodically built, element by element, following the rules and using the elements of spherical perspectives such as vanishing points and the construction of geodesics. A thorough definition and characterisation of spherical perspective can be read at [2]. One particularity of these drawings is that they look "distorted", right as one can recognise that a flattened full panoramic photography is. However, we can use them to cover a digital sphere and, if the camera is placed within the very centre of the sphere and the drawing is correctly made, then the visitor will be looking at a virtual environment without noticing neither any discontinuity nor any distortion on the image.

The workflow from the flat drawing (or picture) to the VR environment is well-known and covered within the field of Computer Sciences, with a large variety of software that can easily make the conversion. The artefact IMWYM uses these known processes and tools but focuses on the real-time conversion, in such a way that an artist, a designer or

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a drawing professor can create the flat perspective in front of an audience and see the results in VR modality at the same time.

This article presents the second version of the artefact (IMWYM 2), recently tested in July 2022 with the exhibition [IN]Musicality. This new version adds several and important features, such as a graphical interface for a smoother interaction.

1.1 Motivation and Background: [IN]Musicality Within the Research About Hybrid Immersive Models

The developments of IMWYM aim to extend an ongoing investigation about Hybrid Immersive Models (or HIMs) to the field of digital arts. The term Hybrid Immersive Model comes from the field of architectural and engineering drawing where the research started. A full definition about why the use of every term is given in [3].

Some of the fields in which HIMs have found applications are engineering, product design, fashion design, design, e-commerce, cultural heritage, teaching, and architecture [4–6]. The current ambition is to extend the investigation to the field of digital arts as well. Underpinning this migration is the versatility of the research, which does not propose a product *per se* but a model of thought and expression through drawn reasoning [3]. In this regard, focusing on the relationship and the influence of handmade drawing and the use of spherical perspectives for the creation of digital art, a HIM studies the link between:

1. A spherical perspective drawing,
2. A VR panorama,
3. A drawing on a physical closed surface (i.e., an anamorphosis onto a sphere or a polyhedron, e.g., a cube) (Fig. 1)

Fig. 1. A Hybrid Immersive Model

Although every medium has a different geometry, there is a correlation between their visual data: the virtual environment and the physical object are created from the same flat original drawing. The base drawing must be constructed methodically using the equirectangular [7], the azimuthal-equidistant [2] or the cubical perspective [8]. This means that the perspective is not automatically generated by any algorithm, instead, is the illustrator who might think in the connection between the flat illustration and the VR result, and construct the perspective through logical relationships and deductions. Then, visitors and creators can compare and analyse the immersive image (the sphere from

within), the physical anamorphosis (the sphere from outside), and the flat drawing (the spherical perspective). This way, they have a direct way of understanding the distortion of spherical perspectives and the correspondences between each of them.

Although the research started outside the field of digital arts, the hybrid immersive models belong to both the physical and the digital worlds. In fact, one potentiality of drawing a physical spherical perspective is the possibility of creating a full-immersive environment from them, and this is mainly possible thanks to the use of digital technology. Indeed, with the digital technology is not only possible to create, visualise, and interact with virtual environments in a handy way without the bulky installations of the old panoramas [9, 10], but it is also possible to manipulate the spherical maps for the creation of the physical objects. Hence, there is mutual feedback between both worlds, where the current research investigates how a HIM is thought, nurtured, and positioned from and among the concepts of digital art. In other words, we are not dealing with the digitisation of an existing analogue process, but with a model that:

- is native to both the physical and digital fields,
- promotes thinking and graphic reflection in extended terms regarding traditional drawing techniques,
- promotes research through the artistic practice,
- seeks to define itself in the terms of the disciplinary field of art,
- produces pieces of visual art.

1.2 Goals

The first prototype of the artefact IMWYM was introduced in October 2021 [1] as a technical advancement with the novelty of a performative setting with concurrent interactive live feed of the spherical drawing's VR visualization [11]. After that presentation, an article showed and discussed the general reception and interaction with the artefact, from which it was elaborated a brief list with future developments [11].

In continuation to that work, the first goal of this article is to present the full list with the improvements and modifications considered for [IN]Musicality. The list gathers the experience of live testing the first prototype, the research made since then, current research goals, published articles, new studies in digital media art, and methodological requirements for art-practice-based research. This list aims to set up a log of reference about the elections taken and not taken for developing the artefact.

The second goal is to give an extensive and detailed description of the second prototype. This will be the base for commenting and developing the second live testing, and for future developments.

2 The First Edition of I'm Watching ~~You~~/Me

This version of the artefact has five inputs and one output (Fig. 2): a drawing board (IN-1), a computer running the software *Eq A Sketch 360*[1] (IN-2), drawings in equirectangular format (IN-3), a mobile phone (IN-4), a camera (IN-5), and a projector screen (OU-1).

The artist chooses either one or several inputs between IN-1, 2, 3. Meaning, that it is possible to draw interactively with other artists or visitors. To such an end, the artefact composes a unified texture by adding a new layer for every input, to then send the result to the sphere (see [11] for more details).

While the artist draws, the visitor interacts with the mobile phone (IN-4), sending OSC data to the computer. Hence, the software updates the output (OU-1) on-the-fly, showing the section of the drawing corresponding to the camera's orientation within the visual sphere (Fig. 3). The detailed functioning and components of the first version can be consulted on [11].

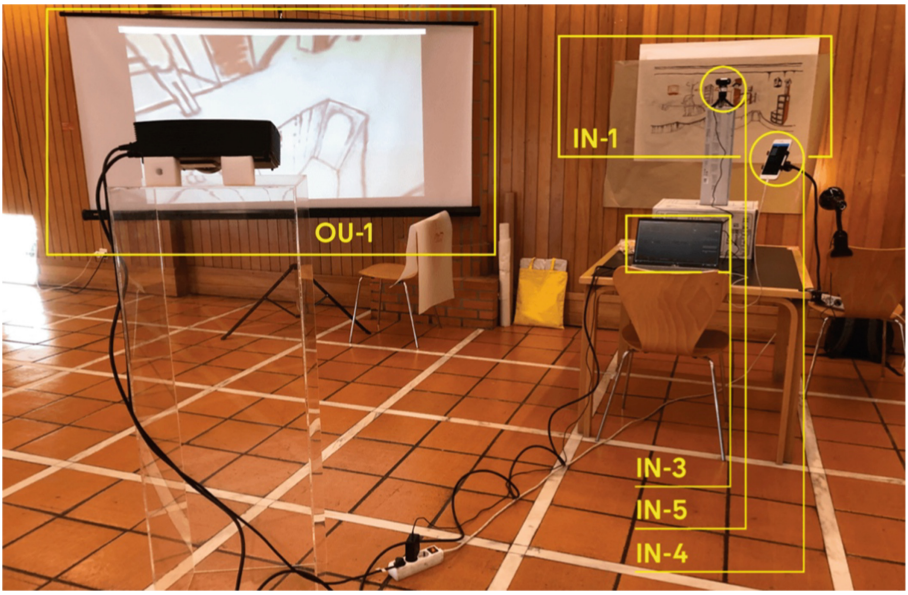

Fig. 2. I'm Watching You/Me. 1st edition

The first prototype of the artefact was introduced during the congress ARTECH 2021, held 13–15 October in Aveiro, Portugal, within the exhibition "Contingency" [1]. This first version had a key innovation with regard to the state of the art of immersive drawings visualization [11]: the on-the-fly VR visualization of live spherical drawing

[1] The software *Eq A Sketch 360* is a raster-based drawing program that helps the user to learn about equirectangular perspective while drawing. The software uses the translational symmetry of equirectangular perspective to create a snap-to tool that allows the user to draw with precision an equirectangular line by choosing two arbitrary points or a special apex point [12].

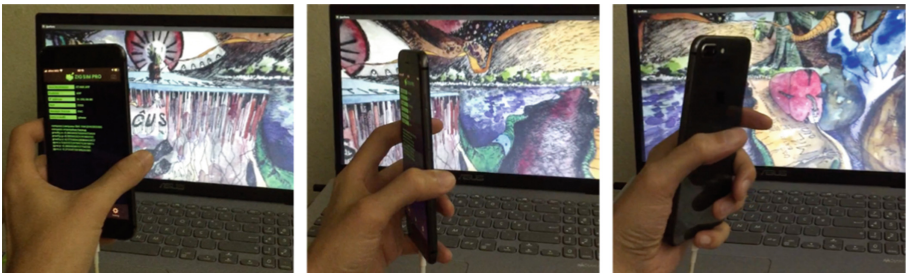

Fig. 3. Interaction with the artefact: the user sends OSC data using the mobile phone (IN-4), the software selects the values of Compass and Horizon sensors, and updates the virtual camera's orientation on-the-fly

inputs. During the exhibition, there were artworks made either by the authors of the artefact (during a live performance), or some previously composed drawings (made either by the author of the artefact in collaboration with A. B. Araújo, or by external collaborators[2]).

2.1 Issues of I'm Watching ~~You~~/Me 1st Edition

The Appendix A (see 6, after References) presents a list with issues of artefact's first version and their possible solutions. This material was used to define a second version, [IN]Musicality, that improves the first prototype and focuses the artefact on an artistic application (see 3). The issues are divided in three sets: narrative/development, interaction/evolution, and experience/fruition. These axes relate to the methodology a/r/cography [13], adopted for the development of the second version. The list considers:

- The **live testing of the artefact**, which helped to highlight many functional, aesthetic, interaction, and conceptual issues. For this, I considered both my own critique and analysis, and the visitors' feedback.
- The **new research** conducted since the release of the first version, and especially the investigations made within the courses of the Digital Media Art PhD Program DMAD[3], academical year 2021–22. Among those courses I explored important topics not previously considered, such as methodologies for art-based and art-practice-based research [13–21]. After that, I narrowed some methodological definitions for the current research.
- **The reviewers notes** regarding two articles about the artefact [1, 11].
- An **updated state of the art**.

[2] The collaborations were from professors and students from the course TAC (Technology, Architecture and Communication), Faculty of Architecture, National University of La Plata, Argentina. Professors: Tania Zuccari and Analía Jara. Students: Jimena Junco, Julian Alcalde, Marcelo Vias Alcacer, Agustina Castellini, Maria Pilar Ramos, Nadia Luengo, Catalina Vilas, Katherine Rosas Tantalean, Juan Pablo Simonini, Jimena Sierra, Martin Roque, Rocío Filoni, Pedro Troyano, Rodrigo Antonini, Celina Giustozzi.

[3] See dmad.ciac.pt and www.ualg.pt/en/curso/1714 for more information about the program.

3 I'm Watching ~~You~~/Me 2nd Edition

The second version of the artefact introduces many of the solutions developed in the Appendix A, focusing on those issues with high and medium-high priority. The prototype was introduced as "[IN]Musicality", an exposition part of the shared exhibition *[IN]Tangibilidades Digitais*, held between 12 and 15 July 2022 at the Espírito Santo Convent of Loulé, Portugal, during the 9th Doctoral Retreat on Digital Media Art 2022. The next paragraphs extend the details of the adopted solutions, considering both generic definitions for presenting the artefact at any place and specific definitions matching the real possibilities at *[IN]Tangibilidades Digitais*'s venue.

3.1 Concept

Critical Issue 1: Missing Concept. [IN] Musicality is a first attempt at centring the artefact within an artistic focus. It explores how to express music using hybrid immersive drawings, and how visitors perceive the musicality of and within those drawings. In other words, [IN]Musicality proposes an investigation about how music affects the graphic creation.

Reflecting about the relation between music and drawing, specifically about his strong visual experiences during the representation of operas, Kandinsky writes: "I felt that I had all my colours in front of me. Disorderly and almost absurd lines were forming in front of me" [22]. Thanks to his synaesthetic ability, Kandinsky perceived the power of music and painting at the same time. For him, the relationship between colours and sounds was not only supposed but actually existed, and it captivated him to such an extent that it became one of his artistic pillars [22].

Within my own experience, I can see the musical atmosphere in which my artworks were created: it is the same music but with a different structure, accordingly either to the aesthetic results of the flat perspective or to the VR navigation. For example, the artwork

Fig. 4. Elizabete, Hat, Fruit or Flute. Scan the QR to see the VR environment © Lufo Art, 2017

"Elizabete: Hat, Fruit or Flute" (Fig. 4) shows more plasticity, fluidity and colours, while the inner shapes connect many points around the visual sphere that one can follow within the virtual environment. This is a graphic representation of Elizabete Balčus' music: her compositions have certain elements and passages connected within different songs, like different acts of a same symphony.

Instead, "Waking Up 360 Times" (Fig. 5) is black and white, uses shapes with a more defined outline, and guides the visual experience towards certain specific points of view. In turn, Raoul Vignal's music has softer variations than Elizabete's ups and downs, as if all the songs were based on the same harmony, something that I perceive as a black and white composition. Raoul's music has subtle and delicate structures, that forward the listener to certain horizons, as the perfect soundtrack for a road trip.

Fig. 5. Waking Up 360 Times. Scan the QR to see the VR environment © Lufo Art, 2017

Under my vision as an artist, the historical moment of Walter Benjamin (my own historical moment), the "here and now" and the "aura of the artwork" are printed and clearly visible on those artworks, even if I was not aware of those element's existence during the drawing session. Nowadays I can hear again the music of Elizabete Balčus and Raoul Vignal while I navigate the VR environment. However, can the visitor see what I see? If the visitor would be asked to describe the music that they hear while watching to those VR drawings, what would you they say that the music is like?

From here, the concept of the Musicality of Drawing, or [IN]Musicality, researches about the reflective actions of:

- How does the artist express music using graphical signs and immersive perspectives?
- How do visitors read the musicality of a hybrid immersive perspective?
- How do we see music?
- What music is created in the mind of a viewer?
- What is the degree of accuracy for transmitting from the artist to the viewer, a certain sensation caused by music using a hybrid immersive model?

[IN]Musicality uses the artefact to reflect on those questions, focusing on the visitor's experience while interacting with a *dedicated* set of Hybrid Immersive Models (no longer a random selection as in the first version). In short, the goal of [IN]Musicality is to understand how visitors relate those HIM with a musical track.

3.2 Narrative: *[IN]Tangibilidades Digitais*

Critical Issue 2: Missing Narrative. [IN] Musicality was hosted within *[IN]Tangibilidades Digitais*, a narrative composed for an exhibition shared with a collective of nine artists. The story invites the participants to come across matters inherent to working with digital art through the exploration of the tangible/intangible binomial: near/remote, palpable/impalpable, probable/imaginary, in/out. The game of digital intangibilities challenges the "things only exist as soon as they are perceived" (*Esse rerum est percipi)* [23] and proposes to perceive what is not perceived (Fig. 6).

Fig. 6. Concept, narrative and artists' collective of *[IN]Tangibilidades Digitais*

3.3 Front-End Interface

Critical Issues 3 and 4: Missing Interface/Dependence on Artist's Presence. Contemplating the new concept and narrative, the requirements for the interface cover:

- Giving access to drawings (both existing and created on-the-fly) and to songs,
- Interacting with a gallery of VR drawings while listening to the music and pairing a certain drawing with a certain song (Fig. 7).
- Conducting an anonymous survey of the interaction and options made by the user.

The interface was created using visual programming with Touchdesigner plus some functions coded with Python. It gave a first autonomous interactive experience between

the visitor and the artefact, in which visitors matched one drawing with one song according to what they considered to be the best match. This sort of "quiz mode" (actually, there are no "right" or "wrong" answers) defined a pre-set path to experience the artefact, solving a problem pointed out to the first version of the artefact. Indeed, during the interviews conducted to the visitors after the interaction with the first version, one recurrent point was that users would not have a reference about what was the artefact for, what does it do, how to operate it, etc. [11].

Another key point was the necessity of gathering data from the public's interactions. This data is collected anonymously using local databases and saving which drawing was associated with which song, how many interactions there were, and what was the users' best match. This data can structure a study of the sociological reading of the experience, and the understanding of the concept.

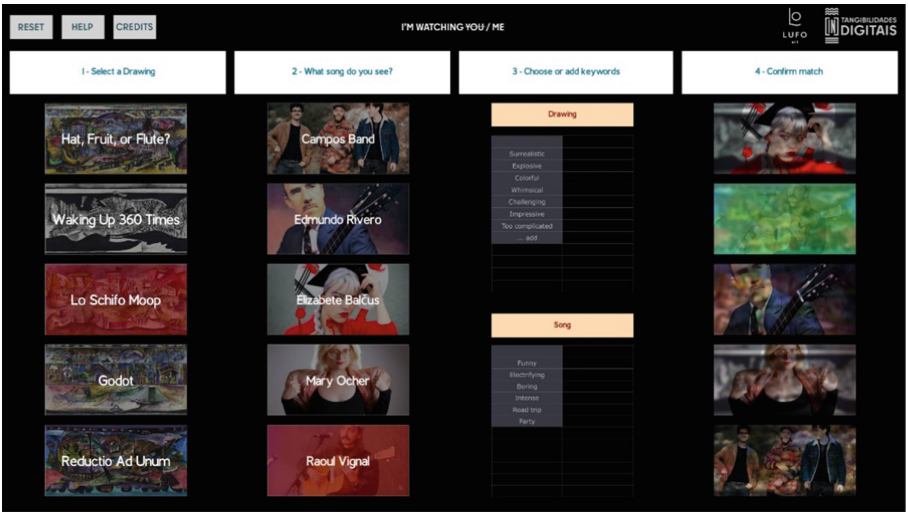

Fig. 7. Main screen

3.4 Printed Material + Digital Logbook

Critical Issue 4: Dependence on the Artist's Presence. Graphic material was produced and printed with the purpose of disseminating the functioning of the artefact, so to give the user the possibility of learning more about it before the visit[4]. Among this material we find:

- Flyers and posters with the Narrative of the shared exhibition and the concept of each individual installation (Fig. 6). The used formats were individual sheets (A4), posters (A2) and fold-out room sheets (A1).

[4] This material was produced and gathered for the collective curatorship *[IN]Tangibildades Digitais* (course "Curadoria partilhada"), for the digital logbook or DDB (course "Digital Media Art Project"), and finally also as for individual purposes.

- Material distributed in place and written both in English and in Portuguese.
- A dedicated entry within the Research Centre's website (dmad.ciac.pt).
- Three videos, one about I'm Watching ~~You~~/Me[5], the second about [IN]Musicality[6], and the third one for the after exhibition and the future of the artefact[7].

3.5 Components

[IN]Musicality has the following components (Fig. 8):

- IN-1: a physical drawing (a paper on a transparent structure, with a rear camera)
- IN-2: a digital drawing (made either with a drawing pad or a table, or with a drawing software, such as *Eq A Sketch 360* (See footnote 1).
- IN-3: pre-existing drawings in equirectangular format (in this case, five drawings from the same collection)
- IN-4: a mobile phone with orientation sensors
- IN-5: a high-resolution camera
- OU-1: a projector screen
- OU-2: an external monitor

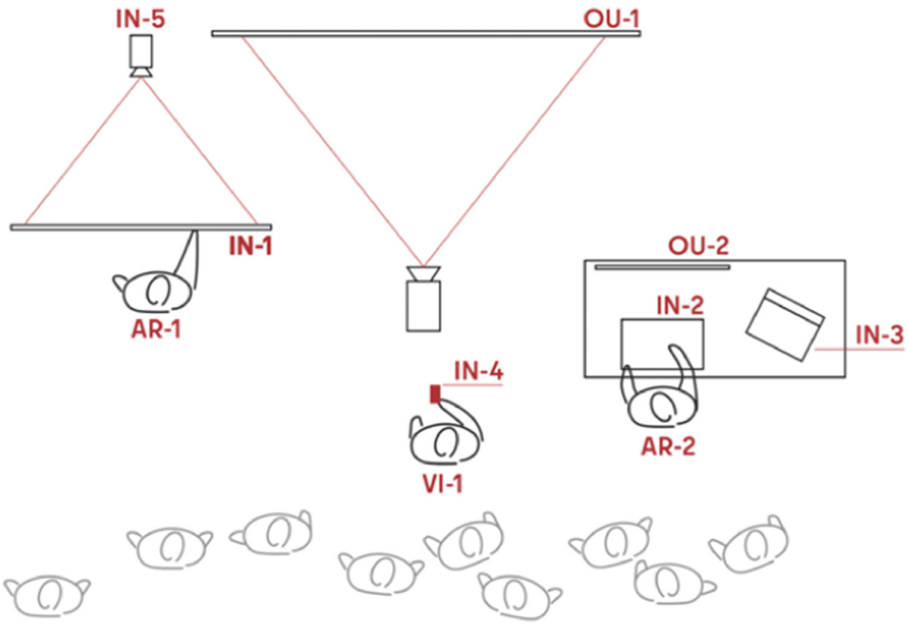

Fig. 8. Ideal scheme

[5] https://youtu.be/9JCo-Q1LJFo.
[6] https://youtu.be/OQj4jpx4UGc.
[7] https://youtu.be/LBp9-_gTFCM.

3.6 Functioning and Interaction

The general setup of the artefact has three screens: the main monitor (used for IN-2 and IN-3), a projector screen (OU-1), and an external monitor (OU-2). A welcome screen appears in the three screens (Fig. 9, up left), and from then there are two modalities for interacting: visualization and drawing.

Visualization Modality. The interaction happens on the main monitor: the visitor clicks on the welcome screen and the main screen (Fig. 7) pops up, the projector switches to the VR navigation of the chosen drawing (Fig. 10, Fig. 11). The monitor (OU-2) remains on the welcome screen (it will switch within the drawing modality).

Second, the visitor chooses a drawing from the gallery and interacts with the mobile phone. The movement of the device sends data to the software through compass and gravity sensors. Every new orientation of the phone updates the camera, discovering a new part of the drawing.

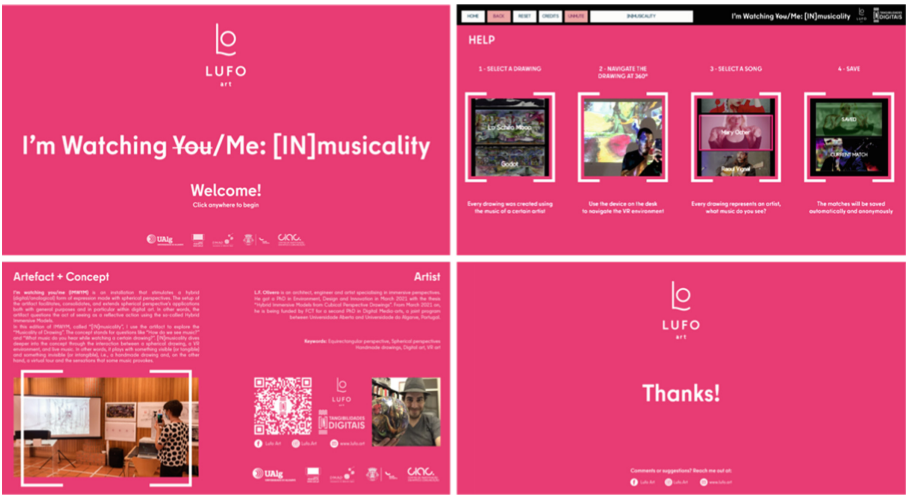

Fig. 9. Screens: splash (up, left), help (up, right), credits (bottom, left), thanks (bottom, right)

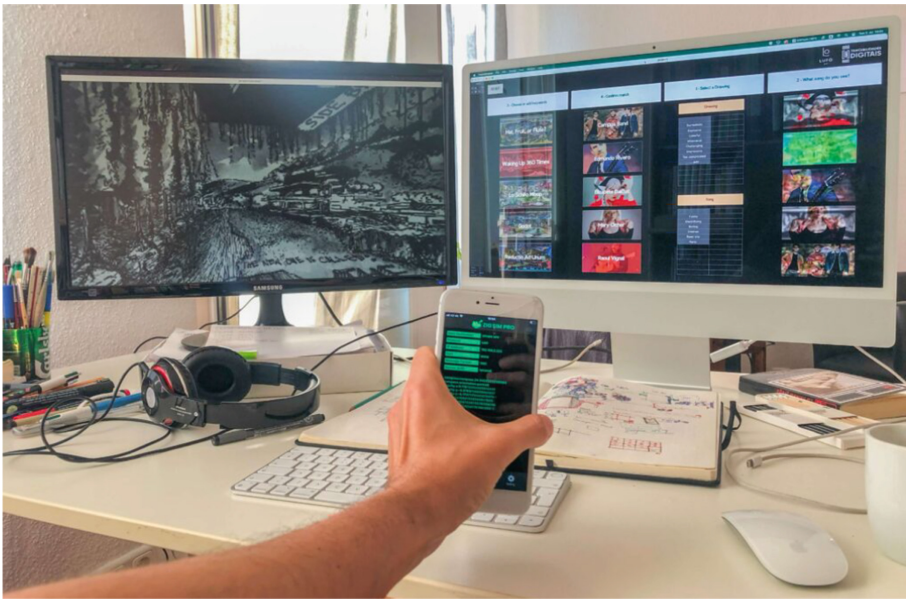

Fig. 10. VR Navigation Screen (left) and Main Screen (right)

Fig. 11. Navigation screen projected on the wall

Third, the visitor chooses a song from the 5 available tracks, each of them representing the musicians to which the drawings were drawn to. The visitors interact with the artefact playing with different pairs of drawings and songs and selecting representative keywords for each drawing and song. There are some pre-set keywords available (e.g., Surrealistic, Explosive, Colorful, Whimsical, Challenging, Impressive, Too complicated, Funny, Electrifying, Boring, Intense, Road trip, Pop, Party, Oldies), although it is also possible to add new ones that will remain in screen for the next visitor.

Fourth, the visitor confirms the match between a certain drawing with a certain song. Then, the software saves the pair and the keywords in an external file and put the selected drawing and song as inactive. After that, the user starts a new cycle with another drawing and artist. When the user confirms all the available pairs, the program shows the closing screen (Fig. 9, bottom, right) and runs a reset function for the next visitor.

Within the main screen, visitors can also access to: a help screen (Fig. 9, up right) that explains the functioning of the artefact with short videos; the credit screen (Fig. 9, bottom left) with a brief explanation of the concept and a mini biography of the artist, and the drawing/visualization function (used for the drawing modality).

Drawing Modality. The artist uses the function drawing/visualization to switch from pre-loaded drawings to the live drawing modality. In the drawing modality, the external monitor shows an *Eq A Sketch 360* canvas, and the projector screen shows the VR navigation of the content created by the artist with a FOV previously set (e.g., at 60°).

The artist can choose one medium between IN-1, 2 or 3 based on a personal preference. Through the main screen it is possible to select use up to two parallel inputs, meaning that the drawing can be composed interactively along with another artist or visitor. If the artist chooses the drawing board, the camera (IN-5) captures the drawing on-the-fly (Fig. 13 bottom and up left). If the artist chooses *Eq A Sketch* 360, the artist draws on the external screen. Then, the software converts, mixes the inputs (adding pixels) and streams the result back on the projector screen (Fig. 13 up right, Fig. 10, Fig. 11). The artist has visual feedback in VR modality on the projector screen, and in equirectangular mode through the external monitor when using *Eq A Sketch 360*.

3.7 Spatial Setup

Figure 8 presents an ideal scheme for the artefact, which helps to solve **issues 10** (calibration of the camera), **11** (Drawing software and external monitor were not live tested), **12** (Setup between the boarding board, the artist and the camera) **and 13** (Setup between the physical drawing and the projector screen). Due to logistical reasons, this scheme was not entirely followed during the exhibition at *[IN]Tangibilidades Digitais*. Furthermore, some components were not on scope for this exhibition (such as the glass table).

On the other hand, Fig. 12 presents schemes specifically focused on the exhibition at the Convent of Santo Espíritu, Loulé, Portugal. These sketches show preliminary studies for getting the better distribution considering the issues on Appendix A, the integration with other exhibitions, and the assigned spot within the Convent.

Figure 13 shows the real distribution during the exhibition in Portugal, with two differences regarding the ideal scheme of Fig. 8: first, the use of a drawing board attached to the wall instead of a transparent support and a retro camera, and second, the use of just one output screen (OU-1) and two inputs (IN-1, and IN-3. IN-2 was not in scope).

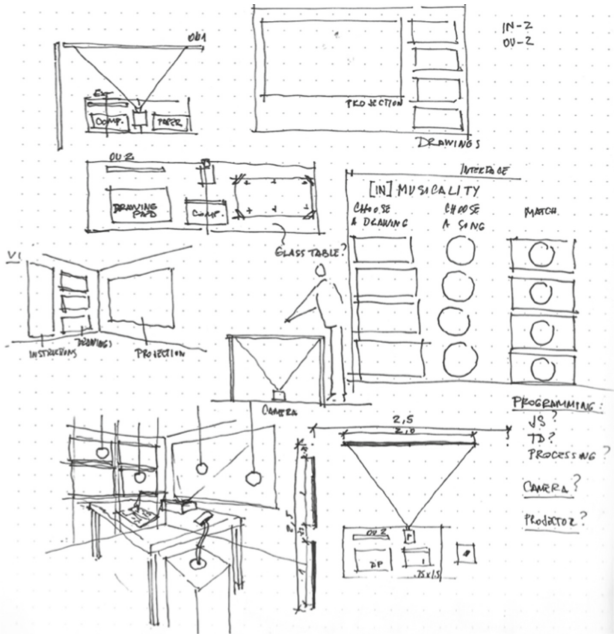

Fig. 12. Studies for the best setup considering the given space at the convent.

Fig. 13. Final setup during the exhibition at Loulé

4 Conclusions

[IN]Musicality was not just part of a shared exhibition, but the corollary of a full academic year of work. With the new modifications, the artefact accomplishes a dual goal: first, it gets more related and focused as an application within the field digital arts, and second, it solves several critical issues considering the list of problems and improvements. The data gathered by the artefact might be used to understand how visitors relate music and immersive drawings. However, the real data collected during *[IN]Tangibilidades Digitais* is not enough for having trustable results yet, so it will be necessary further editions to enlarge the samples and get more representative results.

The artefact has still many issues to solve and new inputs to incorporate: one of the criticisms was about the use of the phone which does not invite visitors to interact, contrary to what I was expecting. Furthermore, the suggestion was to use body tracking, so to not have any intermediate device and, effectively, by the time that this article is being written, a third version of the artefact is being tested without phtone. This last version incorporates the ML library Mediapipe: when a person is detected the program switches from the welcome screen to the main screen automatically, and then the visitors use their hands for pan, zoom, and select the drawings and the songs.

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Appendix A – Table of Issues and Solutions

A.1 Narrative/Development

Issue	Criticality and draft solution
1 - Missing concept. IMWYM 1 focused on a technical advancement. There was neither a clear artistic concept nor a defined narrative. As the goals of the research changed, the new edition focuses on the artistic application. Consequently, both concept and narrative were critical improvements for integrating IMWYM with the new goals.	**Critical issues.** IMWYM 2 would not have any sense without the definition of a concept and a narrative. **Solution.** Elaboration of a concept and a narrative for redirecting and integrating the artefact to/with artistic purposes, and for highlighting the particularities of its components. For example, the artefact has a strong focus on the interaction with 360 content, which might open a wide range of possibilities for exploring VR content using gamification.
2 - Missing narrative. IMWYM 1 was included within the shared exhibition "Contingency" [24], yet neither limited nor oriented towards any specific direction by it. This lack of narrative was both with the general exhibition, and within the prototype.	

A.2 Interaction/Evolution

Issue	Criticality and draft solution
3 – Lack of a front-end interface. An interface was critically necessary for a more efficient and simplified operation. For example, one characteristic of the artefact was the possibility of switching or adding inputs, and then interacting with them. Yet, visitors would not know how to do it since the available screen was showing pure visual code, something not inviting to interact with.	**Critical issue.** The interface is the connection between the content and the interaction. As so, it is very important for a simplified operation and for gathering visitors' feedback. Then, the data is the base for understating the phenomenological reading of the interaction with the artefact. Furthermore, the artist's guidance is required without the interface (issue 5). **Solution.** Elaboration of a front-end interface that enables a fluent interaction with the content, gather data from it, and show a menu for visitors to get help and read information.
4 - Dependence on the artist's presence. Due to issue 3 and missing additional graphic material (flyers, posters), the interaction was very hard to understand, which required the authors' presence for operating the artefact and explaining its functioning.	**Critical issue.** The artefact should stand by itself, with a minimum of explanations. **Solution.** Addition of supplementary material explaining the artefact distributed either digitally with an external device and/or with printed material

(*continued*)

(*continued*)

Issue	Criticality and draft solution
5 - Fixed FOV. Currently, the field of view can be set in *Touchdesigner* but remains constant at runtime. It might be useful to add a function for setting it dynamically so as to zoom in and out while looking at details.	**Low priority.** This issue is not connected with the main functioning but with an advanced fruition and visualisation feature. **Solution.** Add a button/function on the interface to change the FOV dynamically.

A.3 Experience/Fruition

Issue	Criticality and draft solution
6 – Software incompatibility. The first problem arose migrating from Mac to Windows. Using *Touchdesigner* on both OS, one might have expected a better integration. Yet, I needed to rework some key components. The second incompatibility was with the external camera (IN-5) since the one provided was dated.	**Medium priority.** Compatibility issues are a big problem if we are using a local computer. **Solution.** Have access to the local facilities with more anticipation to test extensively the artefact. Otherwise, it can be solved using the original laptop with which the artefact was built. In any case, it would be more opportune to have a web-based solution to avoid any OS' limitations.
7 - Navigation glitch. Compass and Gravity sensors determined the camera's position. A glitch occurs during the navigation: there is a jump of the view under certain rotations.	**Low priority.** The navigation is less trustable, but still functioning. **Solution.** Use of Quaternion-based calculations instead of Euler angles.
8 - Zig Sim app. The app needed to be maximized and onscreen to send the OSC data. Plus, the wireless connectivity was also an issue due to OS' restrictions. Consequently, the artefact used a wired connection both to keep the phone's battery loaded, and to simplify the net connection.	**Medium-high priority.** The problem avoids a smoother interaction with the content. **Solution.** A mobile application able to send OSC data running on the background. The creation of a dedicated application might be useful for other purposes (e.g., using the phone within a VR headset).
9 – Limited inputs' projection. The presented version was limited to the equirectangular projection.	**Medium priority.** It is important to integrate better the theory of the research. **Solution.** Add cubical and azimuthal-equidistant perspectives as inputs.
10 - Calibration of the camera (IN-5). The calibration of the camera was very fragile, which forced a recalibration very often.	**Medium-high priority.** The live capturing should not rely on a physical calibration, but on a dynamic calibration based on the analysis of the image. **Solution.** Use of markers on the paper or board and live image-processing tools.

(*continued*)

(*continued*)

Issue	Criticality and draft solution
11 - IN-2 and OU-2 were not live tested. Due to spatial and equipment constraints in the room.	**Low-medium priority.** The functioning of both components was verified during the programming stage. However, IN-2 might result difficult to whom is not familiarised with the device and spherical drawing. Hence, much likely IN-2 might be only on the interest of dedicated artists or teachers. OU-2 is needed for separating IN-3 and the interface. **Solution.** Larger space and equipment availability.
12 - Setup IN-1 (physical drawing)/AR-1 (artist)/IN-5 (camera). This configuration generated a rather obvious problem: being the physical drawing hanged on the wall, the artist casted shadows while drawing and the visual captured by the camera was partially blocked.	**Low priority.** The problem is more aesthetical since does not block the functioning nor avoids the normal interaction with the artefact. **Solution.** Consider a setup for drawing onto a glass (or something transparent), and a camera capturing the drawing from the rear side.
13 - Setup IN-1 (physical drawing)/OU-1. During the first presentation, IN-1 and OU-1 were almost parallel and within the same line. Therefore, it was very complicated for the artist to watch the VR results and having instant visual feedback.	**Low priority.** The issue is only for the artist using the artefact and not for regular visitors. **Solution.** Build a flexible setup considering the installation with and without the live drawing performance and pay attention to the perspective that both artist and visitors have.

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