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A Virtual Reality Application for Fostering Interest in Art

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Abstract

There is concern within the cultural community about the decreasing number of people, especially young people, visiting museums and cultural institutions. To fight this trend, new ways of accessing art are needed. We believe that technologies like Virtual Reality can greatly foster the relationship between users and works of art. In this paper we present an elaborated Virtual Reality experience, ImmersArt, whose aim is to take users literally inside a work of art and the creative universe of its creator. The motivational impact of this tool was empirically analyzed and compared with other formats for experiencing art such as illustrated books and audiovisual presentations. The study suggests that young people are more motivated to study artwork when using virtual reality.

Introduction

Art is a defining characteristic of societies, both throughout history and all over the world. Being part of a society involves knowing and understanding its cultural heritage, including a good knowledge of the works of art that society has produced. Fostering interest in art is necessary for a culture to define its identity and take it into the future.

With the advent of the digital revolution, traditional ways of accessing art, such as museums and galleries, seem destined to explore new resources to attract people and to increase their interest in art. Several recent reports lament the decrease in the number of visitors to these institutions, especially in the case of young people: they do not seem quite interested in the "old" ways of accessing art [1]. This is consistent with other behaviors of today's youth, who generally tend to obtain all their information from online digital sources, not from physical ones such as newspapers or books [2]. This growing trend towards the use of digital technologies includes Virtual Reality (VR), a technology that offers an alternative to approach pictorial artworks using immersion while preserving the diegesis that the work of art itself expresses. The hope is that VR can play an important role in making art and cultural heritage more appealing and educational for young people.

To this end, we have designed and developed an immersive and interactive VR tool, called ImmersArt. This tool allows users to get "physically" into two well-known paintings: *The Persistence of Memory* by Salvador Dalí and *The Garden of Earthly Delights* by Hieronymous Bosch. Users are virtually transported inside these paintings, in which objects come to life around them through animations, whose aim is to highlight and reinforce the main characteristics of the painting. Digital recreation of paintings is a challenge, as every detail and meaning must be respected and expressed within the virtual experience.

Technology and Access to Art

Nowadays, many digitally-based strategies are being developed to make our cultural heritage more appealing. Three groups of emerging technologies are mostly used: Augmented Reality (AR), VR, and

Web3D. An interesting survey was conducted by Bekele et al. [3], who relate VR, AR, and Mixed Reality (MR) with cultural heritage. In their manuscript, they discuss the technological needs to support cultural heritage through these technologies. One successful example of this use of technology is the work of Gonizzi et al. [4]. Their application is focused on making the Egyptian funerary objects, exhibited at the Sforza Castle (Milan), accessible to a wider audience through the use of VR technology.

In addition, technologies like VR have demonstrated a positive impact on motivation, as shown in Virvou et al. [5]. And this increase in the motivation of the users can be effectively utilized to promote learning and interest in arts.

This is also the idea behind projects like “The Night Cafe: A VR Tribute to Vincent Van Gogh” (<http://www.borrowedlightvr.com/the-night-cafe>), available for Oculus Rift and HTC Vive, in which viewers can visualize the painting from the inside. This project showed the great potential of immersion when accessing art, but there is still a long way to go, both from the point of view of technology and from the point of view of conceptualization: what about using a VR experience as a gate to the artist’s creative universe. That is one of the contributions of our project ImmerArt.

As other authors have remarked [6], it is not an easy task to conceptualize and develop this type of immersive experience. Performance requirements, realism and fidelity to the artwork, movements without cybersickness and a high sense of presence are challenges to overcome. In the next section, we describe the approach we have taken.

Application Design and Development

ImmersArt is an interactive and immersive VR experience that takes users inside different paintings and into the creative universes of their creators. Through a VR device, users are carried into the virtual artistic work, becoming a part of the world enacted in the painting. We have reconstructed selected paintings using 3D scenarios, whose objects come to life through animation. We allow users to move within this virtual world and interact with the objects that make up each painting.

Part of this process includes the transformation of a bidimensional representation, the one originally conceived by the artist, into a 3D stereoscopic world. This presents an important challenge: as the point of view of the viewer changes with a 360 degrees freedom of movement, getting to be the center of the visualization space, the viewer is going to have access to perspectives not originally conceived by the artist. Therefore, developers have to “fill the gap”, adding the parts of the painting not included in the original work, but that will be visible for a VR user.

In our first investigations, we have developed two different virtual worlds for users to choose, based on two famous works of art: (I) The Persistence of Memory (1931), a painting by Eugenio Salvador Dalí; (II) The Garden of Earthly Delights (1515), a painting by Hieronymous Bosch (see Fig. 1).



Figure 1. Images of the virtual paintings using the ImmersArt tool. Left, recreation of the painting *The Persistence of Memory* (<https://www.moma.org/collection/works/79018>). Right, recreation of the hellscape panel of *The Garden of Earthly Delights* (https://commons.wikimedia.org/wiki/File:The_Garden_of_earthly_delights.jpg)

Application Design

The first part of the development process for our tool involved the artistic study of the selected paintings and their creators. Due to its strong cultural component, the virtually recreated painting has to be an accurate “duplicate” of the real piece. Every detail of the painting must be modeled in 3D, and the animations of the virtual objects must never change the composition and structure of the original work of art (see Fig. 1). We use Maya software for the modeling process of each object in the paintings. Also, we perform the texturing with Mudbox (<https://www.autodesk.com/products/mudbox>) and Substance (www.substance3d.com) software.

In addition to recreating the artwork, ImmersArt also creates a virtual context that helps users to understand the intrinsic meaning of the painting. This includes the personal environment and a graphical representation of the biography and the creative universe of each painter, always beyond the visual limits of the original painting (see Fig. 2).

As a first step in the design process, the artists and art historians in our team did a thorough analysis of the paintings, their structure, visual disposition, elements, and symbols. They also researched the biography of the painters and their main artistic characteristics, to be able to reflect them in our tool through different recognizable virtual models. All this information was collected in part through several meetings at important art galleries in Madrid, being our aim to create a new work of art, based on the original painting, able to capture users’ attention and to make them feel the atmosphere and spirit of the original, while also exposing them to interesting biographical and informational elements.

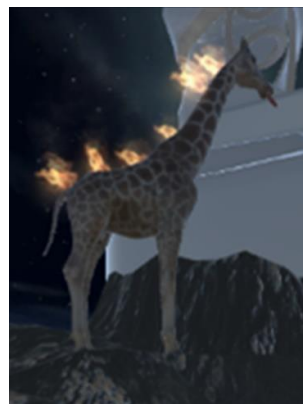
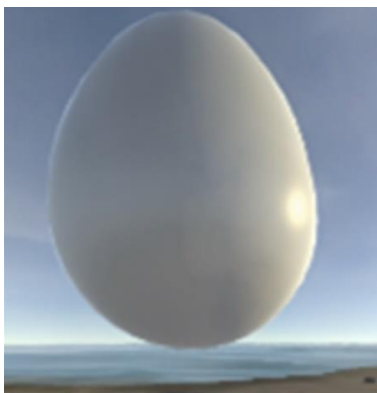


Figure 2: Images of some of the virtually recreated details of Salvador Dalí's painting "The Persistence of Memory" and the painter's biographical highlights. At the top, close-ups of the recreation of the artwork. In the lower part, objects extracted from the author's biography and other of his paintings.

In the case of the virtual environment based on *The Persistence of Memory* by Salvador Dalí, users can freely navigate through the virtual recreation of the bay of Port Lligat, the bay and mountains shown in the background, a favorite location depicted in a number of Dalí's works. This representation is topographically consistent with real-world maps of the bay and includes other images and objects associated with the artist, rendering them on the virtual beach: the tomb of Dalí's deceased brother or the piano where the painter's father taught him music, for example. Every object found on the beach, every image evoked, was extracted from Dalí's visuals collected by Enric Bou in his book on Dalí's work "Daliccionario"[7].

Through these biographical elements, users not only get to know the painting itself, but they also have the chance to increase their knowledge and appreciation of the painter. Along with illustrative elements from Dalí's other works, like a giraffe in flames and a giant egg emerging from the sea, we have also included anecdotal examples and curiosities, illustrating Dalí's personality. For instance, we have added a half-open drawer in the table that holds the clock, not present in the original painting. This drawer is not visible for the users unless they go around the table. Inside this drawer, you can see clothes and a piece of excrement with two long Dalí-like whiskers. Simultaneously,

a child's laughter is played. As told by the painter himself in his diary, when he was a child he liked to poo in the drawers where his clothes were stored and then close them [8].

VR Display

The process of designing and modeling each of the paintings is a complex task. The 3D representation generated with Maya must be realistic, respecting the indications of the painter.

We display the recreated virtual world on an HMD (Head Mounted Display), an Oculus Rift CV1 (<https://www.oculus.com>), in this case. This allows for the viewing of the virtual world with stereoscopy while interacting with it through hand controllers. In addition, we added tactile interaction with some parts of the picture through kinesthetic haptic devices (see Fig. 3). With a Novint Falcon haptic device (<https://hapticshouse.com>), users can experience kinesthetic textures of sand and of a distorted human face breathing while lying on the beach and, above all, they can feel the deformability of the soft clocks, an essential feature in Dalí's work. These kinesthetic characteristics allow for a multimodal interpretation of the work, not available in the original painting. This is a novel technical inclusion that can help to capture people's attention.



Figure 3: The haptic device used at ImmersArt to provide virtual touch to the user: the Novint Falcon.

The force feedback for each object is calculated through haptic techniques that allow for the characterization of the virtual insertion of the pointer in each virtual object.

With the aim of providing a multimodal experience in VR, immersive sound effects are also included. The sound of the sea or the hands of a clock, in the case of Dalí's painting, transport the user to the coast. The sound of demons talking, crows and fire are heard in hell in the case of Hieronymus Bosch's work. In addition, we have composed two pieces of music to inspire the painting in a multimodal way, one for each work of art.

The number and diversity of elements in each one of the paintings was a challenge - the realistic rendering of each of them jeopardized the performance of the software. The number of polygons affects performance inversely, and a high number of animated objects limits the use of static lighting, consequently reducing the number of frames per second. This led to a very careful selection of the elements to be animated, as the animation of all the relevant objects and beings would have involved a too high computational load for a VR application (this type of real-time application needs to have a frame rate of 90 frames per second, as a minimum, to meet the requirements of the Oculus device.). To achieve this frame rate, we tried to limit the design of the scenes to less than 75k polygons and reuse materials to reduce the drawcalls to less than 40. As a clear example of this, we had to delimit

the interaction of Dali's sea with the rest of the scene, not producing any type of shadow and being only a semi-transparent layer. In some cases, we use less heavy and optimized shaders. The physically-based shaders used by the Unity engine we employed (see "Technical Design" below) are resource-intensive, and physically correct animation is not really required in this application.

In the case of The Garden of Earthly Delights, a very important section was selected as the center of most of the animations finally included: the big head holding the dance of the fire – this head is a self-portrait of the painter, and a central element in this work of art. In the elaboration of both artworks, we used some efficiency techniques for rendering such as limiting level of detail, occlusion culling techniques, bump mapping materials, and light-map backing, and by doing so we have notably reduced the number of drawing calls. The use of these techniques is essential to obtain a fluid and realistic navigation in VR, decreasing the latency in the movement and, consequently, reducing the sensation of cybersickness for the user.

Another challenge was to move from a 2D painting to a 3D navigation system with VR. We had to project the vertical disposition of the objects and characters in the painting into a 3D landscape within the virtual world. A thorough study to determine the final location of each element in the new coordinate space was conducted, especially complex in the case of The Garden of Earthly Delights.

The research carried out to achieve the highest level of realism as an educational tool, together with the necessary requirements for VR, has allowed us to have a fluid and complete system in which users can appreciate all the main aspects of the two works of art.

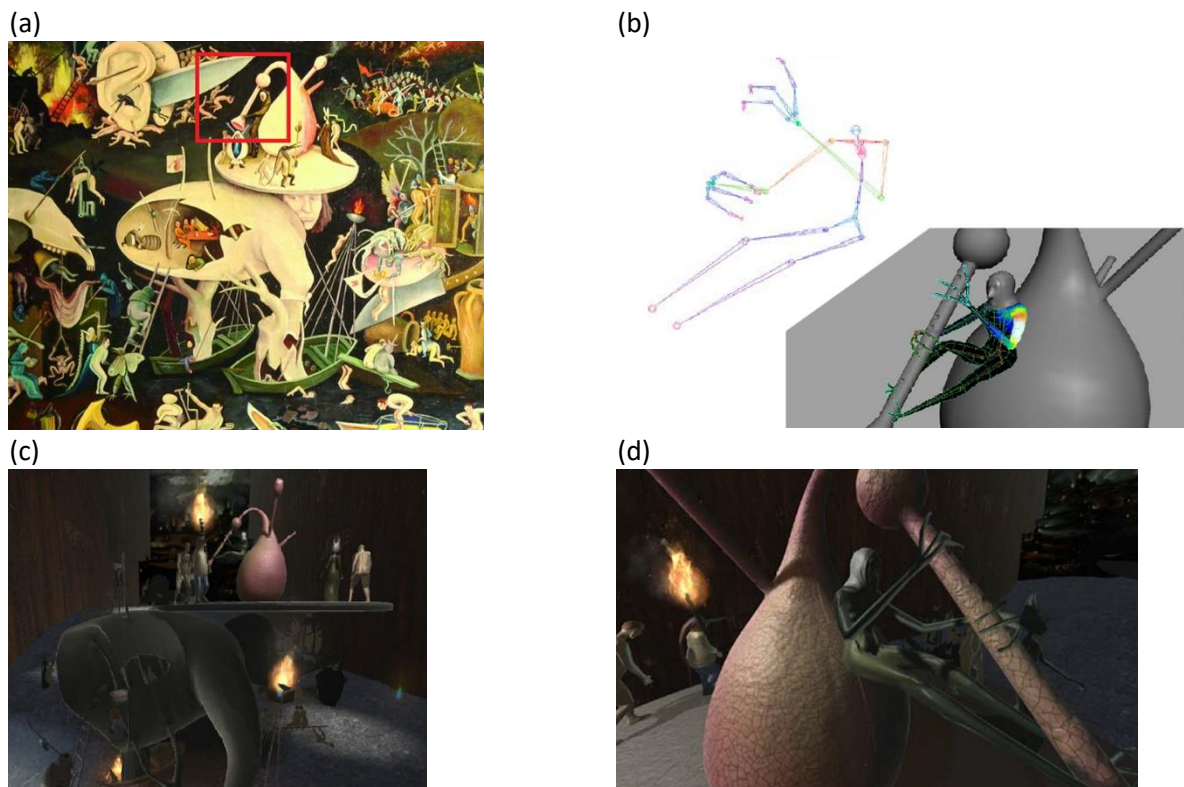


Figure 4: The figure shows the process of building this virtual scenes: (a) the piece of art origin of the sketches, (b) the modeling/rigging phase, (c) shading, lighting, and (d) the result (with animation, FX, CFX and optimizations).

Technical Design

Our ImmersArt tool employs a number of graphics technologies. We used the Unity 2019.3.0f3 game engine (www.unity.com) for the development of the VR experience and Maya 2019 (www.autodesk.com/maya) for modeling and animation of virtual objects. We used the Chai3D simulation framework (www.chai3d.org) to code for the haptic device, also. Users can choose between two options to interact with the artworks:

- They can use a gamepad to navigate and interact with the system [9]. To this end, an Xbox One controller (<https://www.xbox.com/en-US/accessories>) is used (the Oculus controllers could also be used). This allows the user to navigate freely in the virtual world. By means of the gamepad, users can move to anywhere in the virtual scene. However, as it is not a guided navigation method, users can miss relevant places or information. According to the usual recommendations [10], rotary movements have been avoided, allowing the user to advance or retreat only to where he or she is looking.
- They can also follow a trail of Points of Interest for interaction and navigation [9]. This method is half-guided, allowing users to move to different predefined places in the virtual scene. To make the identification of Points of Interest easier, visual cues have been added through a diegetic interface. That is, visual cues are displayed within elements that are part of the virtual world. When users look towards a specific Point of Interest, a circular indicator shows the remaining time to initiate the movement towards it. Although this navigation method fixes the accessible places on the scenario in advance, users are free to choose what places they want to visit and how long they want to stay in them.

In both navigation methods, the displacement speed is limited to 1.5m/s, following the established recommendations to avoid cybersickness [9].

The core of the software architecture in charge of the movement and interaction in ImmersArt is based on two main classes: Interactor and InteractableItem. The Interactor class gives the player the ability to interact with the interactive elements of the virtual environment.

InteractableItems are those items in the virtual world that can be activated by the Interactors. Two child classes of Interactor have been defined, providing alternative methods of navigation: Gamepad and SightPlayer. The difference is that, with the Gamepad, actions are performed by pressing a button, whereas with SightPlayer, actions are performed after staring for some time at the InteractableItem (in this case, the interactions occur through a raycast sent from each Interactor to a set of InteractableItems). The different types of Interactors are used by MovablePlayer, which is a representation of the user in the virtual scene. Fig. 5 shows a simplification of the class structure developed for this application. This system allows us to easily create new interactive elements, as well as introduce new methods of movement and interaction.

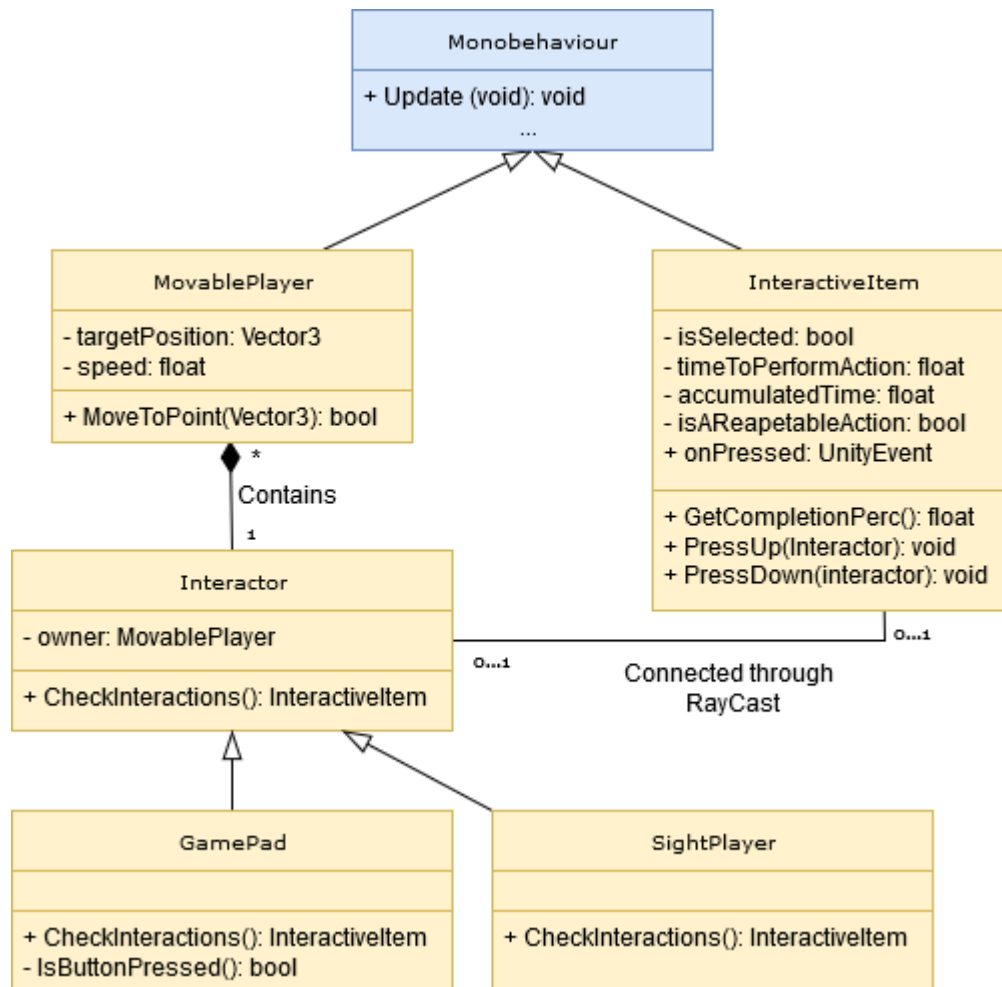


Figure 5. Simplified class diagram of the interaction system developed for this experience. The Monobehaviour class is part of the Unity3D API, and inheritance from it is required in order to be called by the Unity3D internal engine during the rendering of each frame.

Evaluation

We have developed an immersive tool, ImmersArt, which brings art closer to people by bringing people closer to, actually “into”, art. ImmersArt uses VR to recreate pictorial works and to virtually take the user into the artwork and the life of the author. The ImmersArt tool was evaluated through an empirical study in which a sample of young people experienced the same piece of art in different formats: an illustrated book, an interactive audio-visual presentation, and the ImmersArt tool. Our main hypothesis was that VR motivates young people to approach art. So, we aimed to analyze the motivational impact of these different formats on young people when they approach art.

The sample under study consisted of 66 university students from different areas (technology, science, arts and humanities). They were from 18 to 32 years old and the gender distribution was 37 men and 29 women. The sample was divided into three balanced groups maintaining the gender and study area ratio. Then, they were asked to access the artwork in one of the available formats. After the experience, they filled out an ad-hoc online questionnaire anonymously on a Likert scale from 1 to 5. This evaluation instrument allowed

us to check the users' satisfaction with the format they experienced, as well as their motivation towards art (represented by the desire of repeating the experience and the willingness to try new similar experiences with other works of art). All the experiments were executed on the same computer, capable of running the experience at 90 frames per second (with a GTX 1080 ti).

The quantitative results obtained by surveying the sample are shown in Table 1. These results indicate that the ImmersArt VR tool was much more appealing than the other formats. The satisfaction with the experience was higher when using the VR tool than when using an illustrated books or an audiovisual presentation. Likewise, both the desire to repeat the same experience and the desire to repeat the experience with other works of art were also higher when using VR instead of books and presentations. Through an ANalysis Of VAriance (ANOVA test), we verified that the differences found between the groups of subjects who used the different formats were statistically significant. Furthermore, fully 90% of the people who used the VR tool said they would like to use the same tool to view a different piece of art, and even 70% of people who used the other formats also said they would like to use the VR tool to experience other works of art.

	Illustrated books	Audiovisual presentation	ImmersArt VR tool
Satisfaction with the experience *	3.25	3.96	4.25
Desire to repeat the experience *	3.29	3.82	4.40
Desire to repeat the experience with another work of art *	4.12	4.36	4.95

Table 1. Survey results about the usage of different formats to experience works of art

* Statistically significant difference at p -value < 0.005

Conclusion

The ImmersArt tool makes it possible to go inside two pictorial works of recognized value using VR, as well as to have an appealing, introductory glimpse at the biography of the artists and the reasons that led them to the creation of the paintings. The 360 degrees recreation of the painting and the inclusion of biographical details make this software application a new form of interactive technological art. Our evaluation suggests that VR used as a way of experiencing art generates high satisfaction and a strong desire to continue experiencing works of art.

Therefore, it would be interesting to include new experiences with other representative works of art in the application. The already-developed tool will make it easier for the creation of new interactive VR paintings, as the software architecture is ready, even if the art modeling and animation would take a significant time. Specifically, we are planning to recreate the painting "Guernica", authored by Pablo Ruiz Picasso that, due to its historical importance and the great number of details that this painting has, could be deeply explored through VR. In addition, we plan to adapt the experiences presented in this paper for mobile devices to enable VR by means of low-cost HMDs. Although the quality of the experiences could be reduced and some features would be lost, such as the kinesthetic experience of textures, this would allow reaching a larger audience. We believe that people enjoying pieces of art using VR from anywhere through their smartphones will make them more inclined to visit centers of art to enjoy original artworks.

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