Towards a Digital Window

Interpenetrations, Challenges and Potential of Augmented Reality in Architecture

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Abstract

The present work has as its starting point and inspiration in the observation of the habit of staying at the window, mostly performed by older adults, in Lisbon, Portugal. Beginning from this habit, we seek to substantiate, develop, and record speculative and artistic visual experiments that propose a digital reinterpretation of the architectural element window. Such experiments deal with the intertwining of diverse concepts as hybrid architecture, material, digital, virtual, and augmented reality (AR). The experiment, entitled *Projected Windows*, consists of three different installations where we visually simulate, through image capture and projection, various possibilities of visual reinterpretations of the window in the context of the interior of dwellings. The experiment is based on digital imaging. The first two parts of the experiment are non-interactive AR experience, while the third one is a visual interactive AR experience. The project is in the initial phases of development, indicating the potential of correlating concepts, which allow to fundament experiences and visual narratives that can instigate greater advances in terms of interactivity as the work progresses.

Introduction

Adopting the window's theme is a way of discussing architecture based on the analysis of its parts, and through this, aiming, to some degree, to make generalizations about the whole. In this same ambition, we pay attention to the domestic habit of staying at the window, or "*janelar*", observing, and eventually interacting with the landscape and its agents. "*Janelar*" was how the Portuguese writer Eça de Queirós (1845-1900) referred to the act of staying at the window in his novel *O Primo Basílio* (2013), originally published in 1878. This habit, still frequently observed in the city of Lisbon/Portugal (among others), also tells us about dwelling and issues inherent to population ageing, addressed here as general subsidies for us to investigate, speculate, and explore visual interpretations of the window.

Gonçalo Furtado & Inês Moreira (2001) justify the house as the ideal space for investigating architecture in view of the transformations arising from information technology, both for being it a predominant theme in architectural production and because it is the environment where people spend most of their time. In this regard, Patrícia Matias (2016) details the issue, stating that it is precisely the most aged portion of the population that spends the most time in the domestic interior. Perhaps, this fact justifies the occurrence of the habit of staying at the window, as recorded in Figure 1.

FIGURE 1 Lady at the window, Alcântara, Lisbon (author, 2019)

This work is still justified in the perception that architecture and architectural practice have great potential for being explored in association with the digital field, in areas as augmented reality (AR), for example. The project opens up to behaviour analysis and the interface in interactive and intelligent environments (Krueger, 2006). Therefore, it becomes possible to glimpse, as Neil Spiller (2006) suggests, the house as an interface, and to conjecture about a range of design possibilities that can come about from this prism. Antoine Picon (2003, p. 109) points out that cinema has sought to illustrate the possibilities of this approach: "the changes in the perception of ordinary space that should be brought by the development of sophisticated interfaces between the ordinary space and the digital one."

In this context, our general hypothesis is that the visual simulation of digital windows, as an augmented reality (AR) experience, is capable of providing new possibilities for domestic visual interaction. Thus, the article's main goals are to substantiate, develop, and record small speculative experiments that propose a digital reinterpretation of the architectural element window.

Such reinterpretations aspire to simulate and present possibilities of visual interaction with space, in a conceptual way. These experiments are carried out with the intention of instigating future developments, which may constitute alternatives that contribute to the human-machine interaction in the daily domestic experience. These preliminary contributions seek to be beneficial to all, in general; but, especially in the case

of older adults, it could, in the future, enable easy and uncomplicated operational interfaces, which would allow greater digital inclusion, for example.

The methodology is structured in two main stages. The first stage consists of a brief literature review (A), where concepts developed and explored previously by Anne Friedberg (2006), Antoine Picon (2003), Beatriz Colomina (1994), Georges Teyssot (2005), Mark Wigley (1991), and Ronald Azuma (1997) are highlighted. In the second stage, we develop and present the visual experiment (B) *Projected Windows*, divided into three parts: *window.jpg*; *window.gif*; and *window.avi*.

Significant experimental works, with a similar theme, have already been carried out, with their own goals and methods, which show great references for possible future evolutions of the work developed herein. In this sense, it is worth mentioning, Mark van Doorn et al. (2008), Peter Dalsgaard & Kim Halskov (2009), and Xiao-Nan Liu & Min-Zhi Shao (2020), related to the public spaces (a sort of Media Façade, which is a subdivision of urban computing). In Mark van Doorn et al. (2008), we have a narrative (retail context) structure translated into a programming script that generates an interactive display system. Peter Dalsgaard & Kim Halskov (2009) show us the development of an interactive mechanism that allows only the directly observed part of the window shop to become transparent, while the rest remains translucent. Recently, Xiao-Nan Liu & Min-Zhi Shao (2020) created a scene with four different interaction devices and assessed which one arouses the most public attention and interaction. And as a reference for a future evaluation phase, we cite the work of Ferreira et al. (2016), which presents methods and criteria for evaluating the bodily reaction in different simulations in the domestic space.

With the relationship of these apparently diverse subjects, we hope to present a coherent narrative capable of tracing a logical path that supports a particular sort of visual-spatial human-machine interaction. Even though we are aware of the brevity of this text, we believe that its approach, and the way it is structured, can open paths for future phases of work, which can be developed with greater depth.

Towards a conceptual window (a)

In Latin, *Fenestra* points to an opening that promotes lighting and ventilation (Friedberg, 2006, p. 103), while in Portuguese the consolidated word is *Janela* (from the vulgar Latin *Januella*), being the diminutive of the term *Janua*, which designates door (Wikcionário, 2017). In English, the word "window" (originating in the Old Norse), etymologically, leads to the junction of "wind" and "eye", reinforcing the meaning of an opening that allows ventilation of the eyes (Friedberg, 2006, p. 103).

In the book *The Virtual Window: From Alberti to Microsoft*, Anne Friedberg (2006, p. 103) gives us an overview of the first records and early evolutions of the window: "The window began as an opening slit for light and ventilation (a *clostra*) and developed in Roman times as glazing was introduced. Representations of windows appear in wall paintings in Egypt and in reliefs from Assyria."

The evolution of the window occurs due to the most varied reasons, from the improvement of glass production techniques to behavioural changes of social and economic nature. Since before Leon Battista Alberti (1404-1472) compared painting to an open window (in 1435), many analogies have been made about the window; however, Friedberg (2006) does not believe that Alberti refers properly to the capture of the image of what was seen through the window by painting, but rather to the framing power of the window. The author is guided by metaphors that are attributed to the window as the guiding thread of her narrative;

in this universe, it highlights the window as a possible visual metaphor for photography, cinema, television, computer screen, etc. Each with its particularities and limits.

For Friedberg (2006) the visual metaphor resides in the immateriality of language, even when it refers to the material world. In this sense, the virtual window is the element capable of providing a simulacrum understood by virtuality:

The screens of cinema, television, and computers open "virtual windows" that ventilate the static materialities and temporalities of their viewers. A "windowed" multiplicity of perspectives implies new laws of "presence" – not only here and there, but also *then* and *now* – a multiple view – sometimes enhanced, sometimes diminished – out the window. (Friedberg, 2006, pp. 4-5)

To avoid terminological confusion, we must differentiate the terms "digital" and "virtual" in the context of this work. By "digital" we mean the information processed and based on the binary logic, proper to the computer. The concept of virtuality, on the other hand, precedes the development of computers and is linked to the power of representation, which refers to the appearance of something real, potentially real, or believable – a simulacrum –, as do painting, photography, cinema, television and even the computer screen (Friedberg, 2006).

As much as this concept about the virtual is basal for this work, it is also important to bear in mind the digital bias of our approach, where all the information worked in the experimental stage, has its information mediated by digital, since the image capture, post-production, and exhibition. Such visual speculations would not be possible, in the same way, without the participation of computing (although we recognize a very restricted and practically embryonic use of it here). Therefore, when we talk about *Projected Windows*, we are also referring to a virtual window (as proposed by Friedberg, 2006), but conceived and mediated by a digital apparatus (*digital window*).

To understand that the screen (of cinema, television, computer, smartphone, etc.) can be considered an architectural window (Friedberg, 2006) is a key point in our discussion. This metaphor (as presented in *Things to come*, 1936, among others movies, for example) allows us to discuss the issue of materiality since the materiality of the traditional window is different from the materiality of the virtual and digital window.

In a more hurried glance, we could imagine that *Projected Windows* are marked by immateriality; however, as Antoine Picon (2003) maintains, materiality is not an exclusive result of physical matter. Under this perspective, our relations with the physical elements are changed (and mediated) by digital elements, in a hybrid environment, where our experiences are affected, thus generating a new type of materiality:

The notion of enhanced or increased reality does convey the idea of a different materiality made possible by the hybridization of the physical and the digital. This hybridization is not yet fully there, but some features of the displacement of materiality can be already observed. (Picon, 2003, p. 109)

In a way comparable to that exposed by Picon (2003), and considering the underlying particularities of each scope, Friedberg (2006, p. 11) states that "Virtual images have a materiality and a reality but of a different kind, a second-order materiality, minimally immaterial."

From the blurring between material and immaterial, different types of materiality emerge, as stated by Picon (2003) and Friedberg (2006). Extending the question a little further, Georges Teyssot (2005), in his article *Hybrid Architecture: An environment for the prosthetic body*, points to this blurring of limits previously considered to be clear, where dualities such as interior/exterior, public/private, organ/function, etc., become extremely slippery and blurred in contemporary times. Such blurring is also perceived when we focus on real/virtual duality, once augmented reality (AR), virtual reality (VR), and mixed reality (MR) are rapidly expanding concepts, for example.

Le Corbusier, quoted by Beatriz Colomina (1994, p. 332), states that it was first the invention of the locomotive that was responsible for the "interpenetration" of the countryside into the city, and the city into the countryside. Afterward, the architect highlight that new devices deepened this flow, like the telegraph, the telephone, airplanes and finally, television (then a novelty). We understand that the approach pointed out by Le Corbusier, and called as interpenetration, is related to the blurring verified by Teyssot (2005) and Picon (2003), where everyone is deeply affected by the advances in information technology. It is important to establish these relationships, as they impact the emergence or reframing of concepts such as hybrid architecture, AR, and prosthesis.

Faced with the most varied challenges imposed by contemporary society and the unfolding of the digital age, Teyssot (2005) defends the concept of hybrid architecture as a coherent alternative, where digital technologies can allow a new (hybrid) manner of relating space and body, the body and the machine, the body and its materiality.

A hybrid architecture becomes important, not only for being it the sum of different parts, but mainly because it is the potential result of the intertwining (interpenetrations) of different parts (and often antagonistic, such as body/machine, to speak in Teyssot's terms). We understand that this is precisely the type of argument that justifies this work, as stated by Teyssot:

The urgent task architecture ought to assume, therefore, is that of defining and imagining an environment not just for "natural" bodies, but for bodies projected outside themselves, absent and ecstatic, by means of their technologically extended senses. Far from assimilating the tool with the body according to the mechanistic tradition of Cartesian dualism, we must conceive tools and instruments like a second sort of body, incorporated into and extending our corporal powers. (Teyssot, 2005, p. 81)

When Teyssot (2005) states that we must design tools and instruments that incorporate and expand the body's capabilities, he clearly refers to prostheses. In a very brief form, we can say that the concept of prosthesis is naturally architectural, evidenced by the etymology of the word, since "Prosthesis" derives from "Thesis", which, in its Greek origin (*thesis*), had its meaning related to the idea of structure, proposition, position, and something that stands firm against adversity (Wigley, 1991).

Through a more general approach, Le Corbusier understood the house as a prosthesis responsible for shelter and protection against the elements (a complement to the skin), since the windows were comparable to the eyes that, in certain contexts, have gained so much importance in the architect's work, to the point of being

affirmed by Colomina (1994, p. 7): "The house is a device to see the world, a mechanism of viewing."; and, in the words of the architect himself: "All my architecture is conditional upon the windows." (Le Corbusier, as cited in Reichlin, 1988, p. 61). In turn, Marshall McLuhan (1964) points to computer memory as a device (prosthesis) for the expansion and enhancement of human memory.

Teyssot (2005) points out that, according to Marshall McLuhan, like the media, architecture is also an extension of the human body, that is, a prosthesis. Such an argument is still defended by Mark Wigley (1991): "Of course, the mechanical eyes, ears, and skin provided by modern systems of construction/representation have given way to technologies that relocate architecture within an electronic space […]". Certainly, our speculative experiment *Projected Windows* meets this approach, aiming to point a possible repositioning for architecture (based on inhabiting) within a hybrid space, where digital elements can enhance the domestic experience.

According to Ronald Azuma (1997), while virtual reality (VR) is considered a fully immersive experience, the augmented reality (AR) is a variation of it, where we can see the real world, but merged with virtual fragments. Thus, what our visual experiments are offering are some sort of AR experiences which, conceptually, can also be understood as a hybrid space. There is still the concept of mixed reality (MR), which is not explored in this work (as well as VR). MR can be considered a variation of AR, where exists a deeper spatial real-time interaction between digital and physical contents (Milgram & Kishino, 1994).

The concepts and references listed here, even if presented in a summarised form, seek to establish an investigative line capable of supporting and justifying the proposed experiments, understanding them as AR experiences into domestic space.

Projected windows (b)

The experimental proposal has a visual speculative character, intending to provoke reflections about the human-machine interaction through architectonic spatiality, mediated by the digital reinterpretation of the window. For its realisation, we use digital image capture devices, image post-production software, and a projection device (SVGA projector).

Even though our starting point is the habit of staying at the window (commonly practiced by the elderly portion of the population, as said before), in our experiments we do not use this group at this moment of development, once we are in the preliminary stages. However, in the future steps this is an important aspect to be faced. And it is worth noting, as of now, that our experiments, even in initial way they may be, are premised on providing easily accessible AR experiences, without the need to use head-mounted displays (HMDs), AR glasses, or similar, that are often uncomfortable, especially for older adults.

The three *Projected Windows* are based on elements from digital culture, namely: the image (in .jpg format); the animated image (in .gif format); and the video (in .avi format). We try to take advantage of the specific features that each digital format has in order to create unique AR installations.

In support of this article, all experiences are presented as figures (inanimate images), though, on the *digital window* website (Nogueira, 2020) it is possible to have a more diversified and realistic view of the experiments, as well as to better understand their insertion in the domestic interior.

Finally, it is worth mentioning that all the images were made based on an existing window, in a housing context, in the city of Lisbon, in 2020. And starting from this real window, its replication and digital manipulation provides us with possibilities that try to replace and metaphorically rethink the window in the house.

FIGURE 2 Scheme and simulation based on the work of Renè Magritte and the local landscape (author, 2020)

window.jpg

The first projected window, the installation *window.jpg*, is based on a static image, in .jpg format (or .jpeg, *Joint Photographic Experts Group*), obtained through the use of a digital camera that (like any digital camera) "contains sensors capable of capture the light emitted or reflected from the objects, and decomposes it into its fundamental components: red (R), green (G) and blue (B)" (Contribuidores da Wikipédia, 2020), that is, the camera transforms into digital binary information, the variations of light and colour found in a given temporality and spatiality.

In this simulation, we take as base a large set of paintings by René Magritte (1898-1967), where the artist turns to the window theme. The artist challenges the framing of the window and seeks to expose permanent friction between the exterior and the interior, merging them, a sort of "augmented virtuality". These premises, in general, justify taking part in this artist's work as a compositional reference. In *window.jpg* (see Figure 2) we try to continue the external landscape, visually "breaking" the wall and evidencing (in a simulated way) a new possibility of framing the window, questioning its limits and changing its perception, with a non-interactive AR experience.

The digital file, projected on the wall, pursues to break the continuity of the surface, shuffling the outside and the inside, in a similar way with Magritte's paintings. Image capture emulates an appropriate framework, capable of maintaining an articulate perspective. Geometric coherence and scale were taken into account during the projection. Nevertheless, the difficulty of calibrating the projection brightness, due to the abundant source of natural light offered by the window, remains a challenge.

It should be noted that, in *window.jpg*, the proposed visual narrative can be viewed/assembled at any time. However, its narrative coherence restricts it to the daytime period (as a visualization that intends to merge the interior and the exterior, to a certain degree of continuity), just when its image projection quality (light on masonry and white painted wood) is more critical. At night the projection reaches its best aspect, but the external context is transformed and prevents the idea of visual continuity.

window.gif

In this second experiment, we explored the .gif (*Graphics Interchange Format*) format, which allows us, in the same image file (bitmap), to explore up to 8 bits per pixel (Contribuidores da Wikipédia, 2020). In this way, it is as if an image could be transformed continuously through changes in its own colour palette. This type of file can behave similarly to an animation, with the succession of different layers of colours, within a certain time interval. However, its parameters are more limited (and lighter) than those aimed at animations in files of video.

FIGURE 3 Scheme and the temporal dimension, in the time of a .gif (author, 2020)

In this sense, Friedberg (2006) points out the chemical process that managed to fix the image of the camera obscura, as the one responsible for introducing time as a dimensional element in visual culture. According to the author, while one photography records a fraction of time, a sequence of photographs can simulate the time passing.

In this simulation, the installation *window.gif* (see Figure 3), we seek to take advantage of the potential provided by the .gif format, to represent a sequence of images, representing a passage of time. Therefore, we capture the same frame 96 times, over the 16 hours of sunshine of the same day in late spring (shots were taken every 10 minutes), to record the transformation of external light, reflected in the colour changes on the images.

Subsequently, these images were grouped next to a window frame and converted into a .gif file, that is, they were transformed into a single image, where the 16 hours were compressed into a .gif lasting 20 seconds that are repeated continuously (the result in .gif can be seen on the project website , but as a way to visualise what is proposed and discussed, we set up the panel contained in Figure 3).

This non-interactive AR experience also proposes a temporal and spatial complement, as it projects a daytime view originally not available on an inner wall without a window, at night. These simple manipulations can show how elementary experiments (like the present one) have the power to alter, to some degree, the space-time perception and the internal environment ambiance.

window.avi

The third and last projected window, *window.avi* installation (see Figure 4), we intend to reproduce the existing window in real-time, and for that purpose, two cameras are required. The first one behaves like an eye prosthesis (together with the projector, via wireless connection), left in an active mode, the device simultaneously reproduces what it "sees". The second digital camera takes on the prosthetic function of memory, as it is in charge of registering the experiment, where we can even observe both the existing and the reproduced window, simultaneously (such visual speculation finds precedents, to some extent, in video installations by Nam June Paik, Bruce Nauman, among others mentioned by Friedberg, 2006).

In this approach, at the moment of simultaneity, the temporal relationship breaks with the cinematic logic of the montage; though, it generates other unusual spatial possibilities, such as creating a sort of perpendicular reflex "mirror", or the possibility of seeing the body interact with the projected image itself, and, in some positions, with its shadow (as can be seen in our short film *window.avi*, also available on the aforementioned website).

In this visual interaction, the challenge was to reproduce the window to duplicate its visuality, which starts from the indoors towards the outdoors; however, potentially, other "windows" could be developed, with other interiors, or other exteriors, or still, with other intentions and goals.

This visual interactive AR experience, more emphatically than the previous ones, illustrates part of the possibilities of interaction that can be established inside the dwelling. For Friedberg (2006, p. 150) "The screen functions as an architectonic element, opening the materiality of built space to virtual apertures in an 'architecture of spectatorship'".

This sort of interaction can reach greater complexity than visuality (explored here), and potentially involve other dimensions of information that can be read as digital information (sounds, gestures, etc.). In this context, an interface system capable of adequately relating to the domestic interior and allowing interactions between the body, space, and cyberspace can be envisioned (and projected).
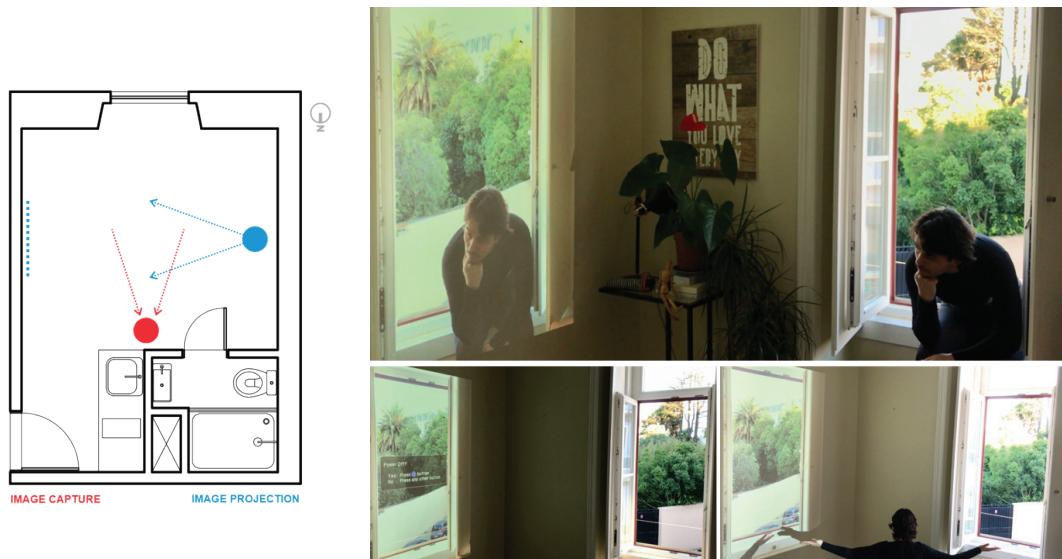

IMAGE CAPTURE   IMAGE PROJECTION

FIGURE 4 Scheme and the digital allowing new domestic visual experiences (author, 2020)

Conclusions

In this article we, briefly, articulate diverse subjects, proposing a conceptual background for a digital reinterpretation of the architectural element window. Assuming a specific domestic habit of the most aged part of the population as inspiration to try explore borders between real and virtual, having as object the window, as a historical, metaphorical, physical and digital agent. The goals of supporting, developing, and recording speculative visual experiments that pursue to propose a digital reinterpretation of the window were achieved with the development of augmented reality (AR) installations. The methodology applied proved to be adequate, and in the continuity of the research, it will explore other frameworks, in order to go further through programming toward achieving a more interactive approach, specially creating and testing more inclusive solutions, especially for older adults. Nevertheless, works with this scope, more conceptual, artistic and experimental, are important to help us visualize and conjecture about new creative possibilities, identify critical points, and develop a thematic affinity.

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