

# Lines from the Past

## *Non-photorealistic immersive virtual environments for the historical interpretation of unbuilt architectural drawings*

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*The trajectory of virtual reality for architecture is towards photo-realism. While this may be effective for some contexts, we propose that abstraction is more appropriate for the purposes of a historian interpreting drawings of unbuilt works of architecture. The case study we are using to explore this proposition is the Palazzo Littorio competition set in 1934 Rome. We present two prototype immersive virtual reality (iVR) applications developed in Unity for Oculus Rift: the first uses an etching aesthetic to produce a quasi-realistic site context and an interface that enables the comparative evaluation of competition entries from key viewing positions; the second application takes an even more abstract approach, where the aim is to immerse the historian within a 3D drawing, along with other historical material (drawings, photos, paintings, narrations of texts) and uses spatialized sound to evoke the ambience of the period.*

**Keywords:** *Virtual Reality, Non-Photorealism, Architectural History*

### INTRODUCTION

The development of low cost, high performing head mounted displays (HMD) coupled with widely available authoring software such as Unity, has led to a renewal of interest in immersive virtual reality (iVR) within the CAAD community. These include a re-evaluation of workflows in the design studio (Dokonal et al, 2016) and for architectural exhibitions (Kreutzberg 2016). Our interest in iVR is in relation to architectural history, in particular the translation of architectural drawings of unbuilt architecture. Unlike historic reconstruction where there is an empha-

sis on faithful representation based on photographs or 3D scans of the building, historic drawings are projections (both literally and figuratively) of the imagination of the designer. As Robin Evans explored in depth, the age of projective drawing by hand required translations from orthographic and perspective projection to a mental image of what it would be like to occupy and move through the project (Evans 1995).

The advent of 3D modelling has enabled the virtual construction of unbuilt architecture for some time. The focus of our research is on non-

photorealistic approaches that aim to extend understanding through abstract, generally multi-sensory approaches. For example *Virtual Terragni* used virtual re-construction for analysis, rather than visualization. Eschewing any attempt at photo-realism, the translation from historical drawings to three dimensions explores what Saggio refers to as the hierarchical structures that emerge from an "operation of analytical disassembly and reassembly" (Saggio, 2000). Such a 'digital forensics' methodology is also to the fore in research that reveals the constructional logic embedded within an unbuilt work of Auguste Perret (Webb and Brown 2011). The research of Sirbu is based on an alternate approach with the idea that remediating a drawing to digital form, provides the possibility for translation "into a navigable virtual space that is close as possible to the original artefact (the drawing)" (Sirbu 2003). Through a case study of a project by Henri Labrouste, Sirbu documents a process where the lines' colour, texture and lighting of the historic drawings are used as the basis for the digital modelling and animation. In a similar vein, the research into 'digital etching' by Voordouw adapts 17th century techniques to develop a novel approach to 3D modelling, based on the idea that "historic modes of representation can engage a deeper cultural context" (Voordouw 2014).

The above precedent forms the background to our research into the potential of iVR to extend historical methodology for the interpretation of unbuilt works of architecture. Our research with iVR is informed by the theory of affordance. Initially developed in psychology by James J. Gibson (1986), the concept of affordance has been re-defined and used in a range of domains. From a literature review, the simple definition by Stuckey in relation to the design of virtual environments is the most appropriate for our research - " ... we use the concept of affordance to refer to the latent possibilities for action presented by an artefact, tool or environment." (Stuckey 2009).

For the architectural historian, what does immersion in a virtual environment afford, that is not readily available via non-immersive technology? One obvi-

ous starting point is in terms of engagement: rather than manipulating a model on screen with a clear distinction between the observer and 3D model; there is potential to explore from a position of visual and aural immersion; and the capacity to experience volumes, spatial sequences and relationships between architecture and external context. As one set of considerations, we can posit the affordance of iVR enables alternate visual, aural and kinaesthetic experiences of the drawing. Leading on from the implications of immersion is a second set of affordances related to embodied interaction. Authoring content for iVR enables a range of interactions that include: head tracking; haptic interfaces; temporal shifts; teleporting; and not least the interactive augmentation of the 3D model with analytical volumes, images, and narrations from key texts. Our research explores these two sets of affordances based on the technical capacity of Oculus Rift HMD and Unity VR content authoring software.

### **Scope**

As the means to explore the above agenda for translating drawings to immersive experiences, we are undertaking a case study using the 1934 Rome Palazzo Littorio competition. The competition attracted leading Italian architects from an important period in architectural history, when Italian rationalism was developing alongside the legacy of 19th century historicism. The best known project from the competition is that of the team led by Giuseppe Terragni, whose 'Scheme A' presented a curvilinear façade suspended from a truss structure to give the appearance of a 80 metre surface appearing to float in space. Receiving comparatively minimal attention, Terragni's 'Scheme B' shifted the theme of suspension to the cantilever, proposing a monumental block projecting along a similar distance. These two projects have recently been exhibited as photorealistic renders of 3D models based on the drawings (Casa Dell'Architettura 2015). While we appreciate the accuracy of these models, once drawings are actualized and superimposed within contemporary site photographs, para-

doxically they become more resistant to critical interpretation. Our position is that unrealized projects have and will continue to provide a pivotal role for architectural theory and history. But the power of the unbuilt to extend architectural thinking and provide historical insight, resides in the capacity for the drawings to be interpreted. Our aim is to avoid verisimilitude, to explore a mode where productive suspension of the virtuality of the drawing within iVR may enable the historian to accrue new insight.

This article is a collaboration between a design researcher who uses drawing as an openended process of feedback and negotiation, an architectural historian who engages with drawings of the unbuilt in a mode of critical interpretation, and a technical team who are exploring the affordance of VR technology to extend research methodology. In the following sections we articulate the role of drawing for critical design practice, and how drawings in combination with other historical sources enable critical interpretation by the historian. From this we project how the multi modal affordance of the technology can augment 'desktop' methods of historical research. We then document two approaches to an IVE application. The first has a focus on the external context to enable a comparative evaluation of Terragni's two schemes plus competition entries by Liberia, Moretti and Palantini. The graphic approach involved modelling the immediate context, adding textures using an etching filter, in combination with a skybox that provides a background panorama. The second approach is more abstract, enabling the occupation of the Terragni drawings, overlaid with volumetric analysis of the geometry, supplemented by atmospheric sound and artworks that evoke the period in which the projects were conceived. Through discussion of trials with our with an expert in Italian history from the period, we reflect on the iVE interface design and the efficacy of the two non-photorealistic approaches. In conclusion we outline the next stage of the research, which will involve developing and evaluating the interface in response to the specific requirements of a range of unbuilt works.

## **DRAWING AND HISTORICAL INTERPRETATION OF THE UNBUILT**

### ***The role of drawing for critical practice***

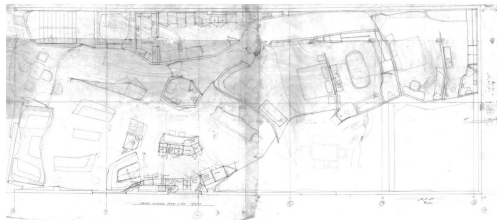
Before embarking on the design of the prototype, discussion on the role of drawing for critical practice is required. Drawing has traditionally played a key role in the practice of design; it has been, and still is, the primary way in which built space, that is yet to come into existence, can be immersively explored. In analogue drawing this has come with the advantage that the immersion is incomplete. Through vagaries of pencil and paper, the built space predicted in the drawings can't be fully described, it remains incomplete, sketchy and reliant on the mind of the drawer - the drawer is prompted to imagine space within or between the lines. Another factor is the spatiality of drawing. Analogue drawing is its own spatial world, one where the materiality of marks in the drawing, their qualities of weight, delicacy or even the speed in which they were made, is evocative of atmospheric conditions, hovering between the drawing world and the world of the yet to be built. This makes drawing an immersive world with a complex spatiality. In drawing, this tends to operate in two ways concurrently: drawing is descriptive, of built space, and evocative of things beyond easy description.

The twin conditions of drawing are vital to its role as a tool for thinking and immersion in the world of the yet to be built. Representations of three dimensional space, in ways which can be read by a cultivated viewer as projected built space, are augmented by drawing's inherent capacity to prompt imagined occupation, in a sensory, emotional, or even affective way. This is carried through drawing's qualities as an inherently open medium, through its gestures, marks and materiality. The marks in a pencil drawing hover between delineating the composition of a plan, or a pictorial scene, and alluding to atmospheric conditions: mass might be evoked through heavy shading or dense enclosure implied through erasures of a darkly drawn mass of graphite; lightness might be conveyed through a febrile, delicate line, or move-

ment in space implied by arcing diagrammatic tracings. Qualities of light, time, and density of occupation can also be evoked. The shifting qualities of light can be implied through careful shading, a sense of occupation through subtle outlines of people, trees - or temporality through the inclusion of ephemera, such as cars, aeroplanes, or even clouds and weather.

This drawing world is built up through its descriptive and evocative marks, marks that are known, but also marks that are less known. Much of the sensory, temporal and emotional information is subtly conveyed through marks in the drawing that have this dual role, marks that are partly semiotic and partly non-semiotic - the 'brushstroke, pencil line, smudge, and erasure' and the 'recalcitrant, "meaningless" smears and blotches' (Elkins 1995). These qualities allow for sensory and emotional projection into a representational system that can be read, by a cultivated viewer, as built space, and at the same time imaginatively occupied. This paired capacity hinges on drawing's qualities of open-ness, the ability to evoke, imply and invite a multi-sensorial occupation. Through this, an analogue drawing provides much more than a digitally created, rendered and supposedly complete scene.

Drawing is more than an instrumental way of predicting space it is a way to capture intangible qualities of that space and engage with a cultivated viewer, such as an historian. It is from the critical practice of drawing, that we draw inspiration for conceiving approaches to VR for the interpretation of unbuilt works of architecture. The aim being to imaginatively occupy the drawings and other historic artefacts, using the affordance of the technology to explore alternate modes of historic inquiry.



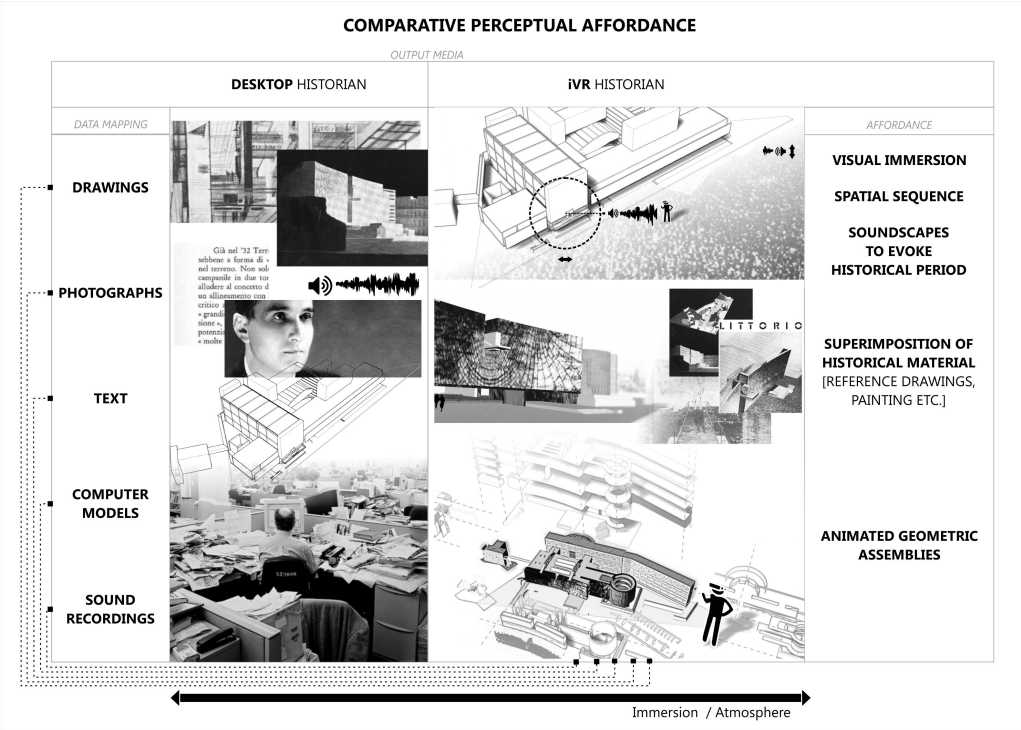
### ***Augmenting historical inquiry***

Our objective is to develop prototype applications that explore the potential of augmenting historical inquiry through the adoption of iVR. The 'desktop' historian typically works with historic drawings (printed or onscreen) and other reference material relevant to critical interpretation of the project. These include historic photographs, other works that provide insight such as paintings associated with period, text documents and in some cases sound recording. In a sense the desktop historian makes virtual connections between these disparate sources by studying the visual material, reading historical accounts and listening to soundtracks. The office of a typical researcher is packed with reference material, multiple books open and with various images in peripheral view, as they critically interpret the theoretical and historical significance of the drawings in question. As indicated in Figure 3, our proposal for augmenting this methodology is through the affordance of the technology. In particular the capacity to engage the kinaesthetic and aural senses alongside the visual. Stuckey et al (2009) have used the concept of affordance in their research on virtual environments. Their reference is to Gibson's original concept of affordance as the latency presented by an artefact, tool or environment for action. Using this broad definition, they present a distinction between what they term constructed and native affordances. Their approach looks at the latent possibility of a mimetic world in terms of the 'native' affordance of environment, the multitude of mimetic objects and experiences provided. 'Constructed' or non-mimetic affordances systematically violate the constraints of the natural affordances, to introduce such interface elements such as the overlaying of information and images. For our purposes, native affordances involve the inhabitation of an abstract mimetic world of the 3D drawing placed in a quasi-real physical context. Complimenting the abstract experience of the 'built' form would be set of constructed affordances such as the superimposition of volumetric analysis or the capacity to teleport to key viewing positions.

Figure 1  
Simon Twose: Plan  
drawing for 'White  
House', Wellington  
2005



Figure 2  
The affordance of  
iVR for historical  
research into  
unbuilt architecture



Our concept of the 'iVR historian' is that of immersion in an abstract world, where he/she can navigate through drawings transformed into 3D experiences, exploring spatial relationships and sequences. Potentially, immersion and the engagement of kinaesthetic senses can trigger new insight on the significance of the work and the intent of the designer. An underutilized affordance of virtual reality for historical research is spatialized sound. As has been well established in videogame design, interactive soundscapes based on spatialized sound samples is central to evoking atmosphere. For the purposes of historical interpretation this could include ambient sound from the period in relation to streetscapes, supplemented by sounds within volumes that suggest activities, and footstep sounds can be associated with

different room volumes to reinforce spatial interpretation. Such affordances are in effect 'native', in terms of a mimetic occupation of the drawings and the evocation of the historical period.

A second set of constructed affordances can augment this quasi 'natural' occupation of the 3D drawing. The work of Galli and Mühlhoff (2000) provides precedent for supplementing the drawing with exploded isometric drawings that identify geometric relationships. The capacity to switch from a perspectival 'experience' of the drawings to more analytical 'birds eye' views of the underlying geometry and spatial relationships, facilitates mixed modes of engagement with the drawings. Other constructed affordances involves the superimposition of historical material through an image library that would contain

the original drawings, photographs from the period and other works associated with the unbuilt work. Reading a large amount of text within a virtual environment is physically fatiguing. We could however provide access to narrations of texts such as the architect's description of the project or key critiques by theorists and historians. In the next section we describe two iVR prototype applications we have developed structured around the distinction between natural and constructed affordance.

## TWO iVR APPLICATIONS

### ***iVR App 01: Designs in context.***

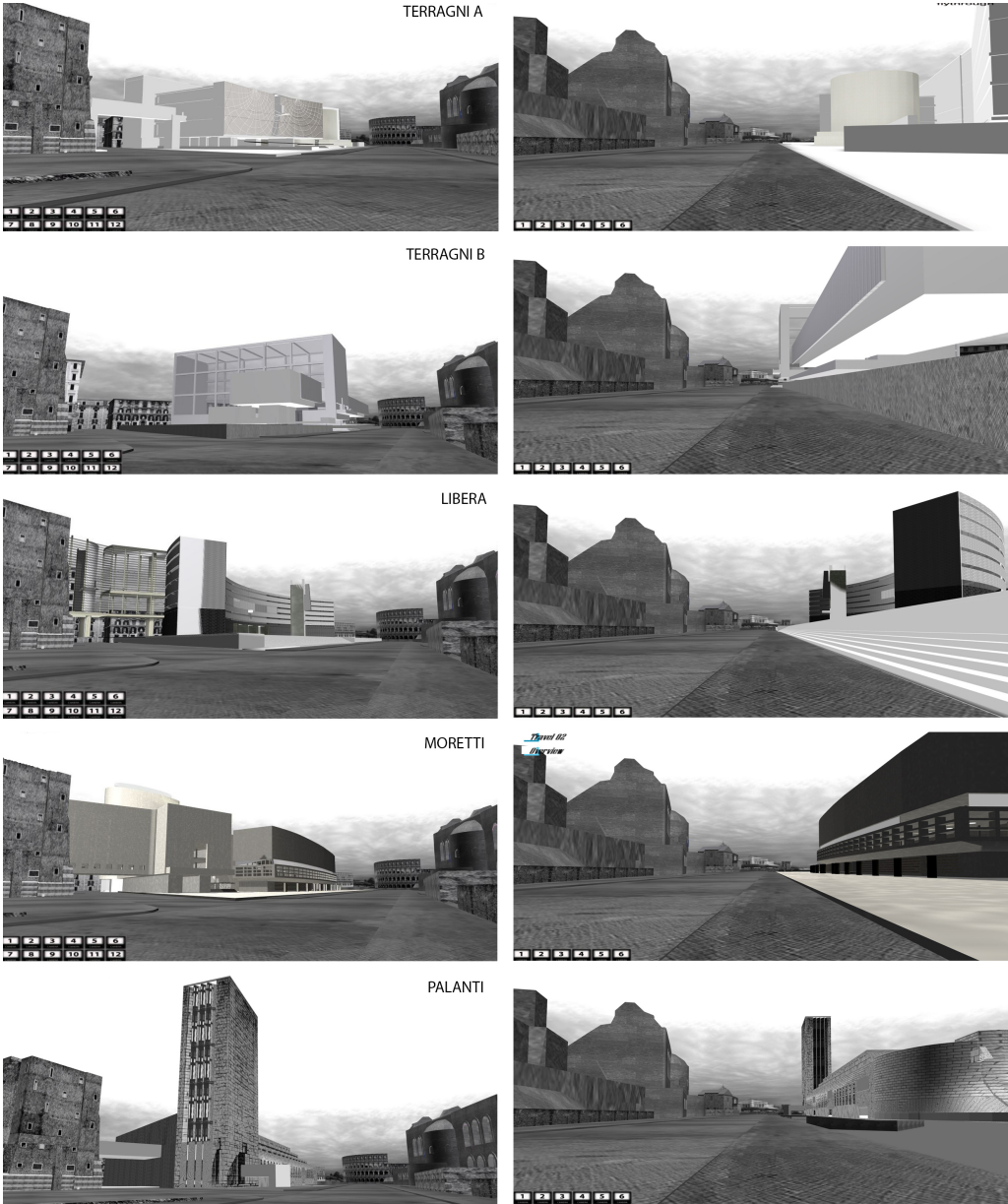
iVE App 01: Designs in context. The purpose of this first application was to evaluate the competition entries in context, with the emphasis on providing multiple ways to navigate and compare different designs. The site encompasses key monumental building including the Coliseum, Basilica of Maxentius and numerous excavations of Roman ruins. Our approach involved the accurate volumetric modelling of the immediate context with images parsed through an etching shader to provide an abstraction of the building detail. The background was provided via a 'sky-box' where a panorama image taken on site provided a sense of the overall context. Six of the competition entries were selected (chosen by our historian collaborator) and these were modelled with a level of detail approximating the original competition drawings. Twelve key viewing angles were selected around the competition site and a simple interface enabled teleporting within the VR scene to these positions. The six competition models can be swapped in and out through the Xbox controller, enabling comparison of the designs from key viewing positions as illustrated in Figure 3. As well as using the 12 viewing positions to quickly navigate around the scene, the user can also navigate freely and record screengrabs of points of interest. These screengrabs and camera positions are added to a linked database and can be accessed through a 'saved views' menu. Selecting an image within the panel teleports the user to the viewing position from which the image was taken. The

image browser enables another form of navigation and a way of identifying points of interest that can be shared with another researchers. They also provide a set of reference images to be used outside of the iVR environment.

### ***iVR App 02 : Atmospheric occupation***

The purpose of the second prototype application is provide an interface that enables the historian to examine the unbuilt project in multiple modes: firstly a non-photorealistic 3D model that is accurate in scale but is graphically realized to align with the original drawings; to provide a second mode of analytical graphics that reveals the underlying geometric relationships; and a third mode where historical materials (photographs, associated drawings and painting, and narrated transcripts of key writing) can be browsed and overlaid within the VR scene. Given these multiple modes, we have chosen to implement the prototype using an Xbox controller as at present this interface allows the widest range of controls. Figure 4 shows the mapping of functionality to Xbox controls and illustrates some of the features. The application can be run in desktop mode to enable the scene to be set up and to familiarize the user with the Xbox controls. Once in VR mode the user can move freely on the XY plane, adjusting the speed as suits the task. The textures for the 3D drawings can be adjusted by using alpha channel and noise parameters and a number of layers that be overlaid. Inspired by the Terragni drawings we have developed a crowd simulation that uses the Unity terrain engine, substituting the 'grass' sprites with individual figures that randomly populate the scene. We have also implemented a 'map view', that reveals pre-set animation paths that allows the user to be taken through a spatial sequence of the projects. There is also a volumetric mode that shifts the camera to orthographic projection and superimposes analytical drawings of the geometry. The image viewer panel opens up a browser that enables access to a database of images relevant to the historical context that can be selected and placed within the scene.

Figure 3  
IVR Historian  
Appplication 1:  
Enables  
comparitive  
analysis of unbuilt  
proposals in a  
quasi-real context



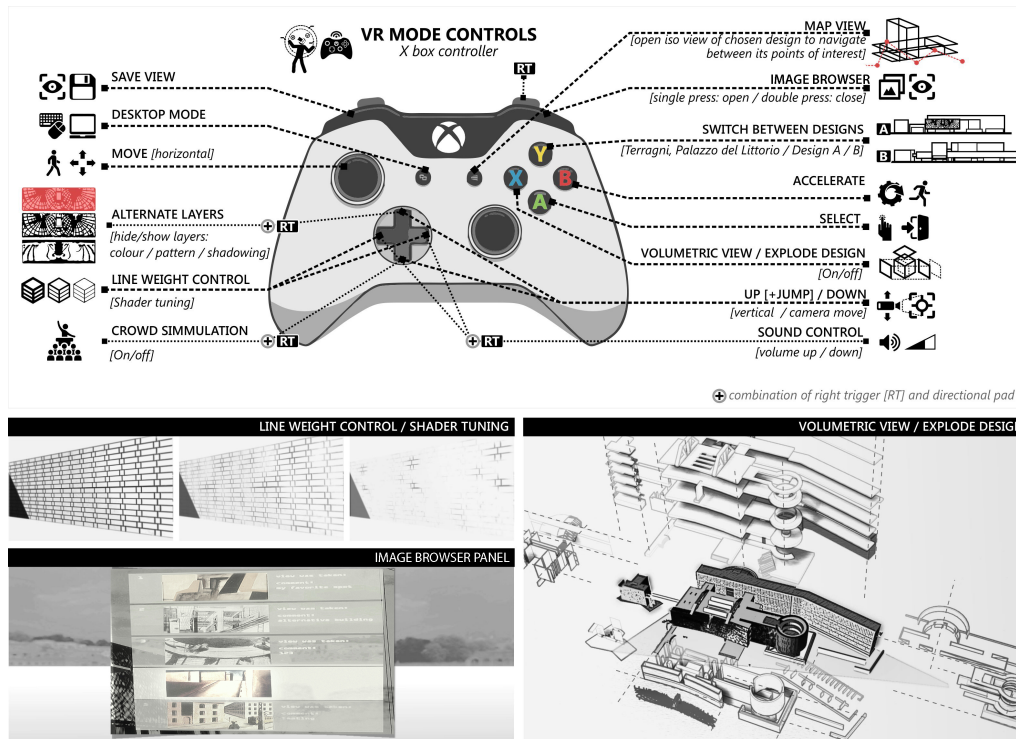


Figure 4  
iVR Historian  
application 2 :  
overview of Xbox  
interface controls

## DISCUSSION

The two prototypes have been developed by the technical team in a three way conversation between the historian and design researcher, who are located in different institutions. Prior to their full implementation much of the discussion was based on exchanging screen grabs and videos of the early mockups. Through these exchanges, while more clarity was established in terms of the potential, generally the response to the images and videos was less enthusiastic. The transformation in reception to the prototypes dramatically improved when the team assembled in the lab and the non-technical collaborators could experience the prototype through the oculus rift. Particularly for the historian, who had minimal experience of iVR, the immersion in both prototypes

received much more positive feedback. The following are initial reflections on what insight was gained in relation to the two Terragni schemes.

For Terragni's Littorio projects A and B an immersive environment afforded re-examination of previous interpretations. Here we might point to three main issues. First, site: on the newly created Via dei Fori Imperiali, with its light carpet of tarmac newly laid across the ruins of imperial Rome to link Colosseum and Piazza Venezia, immersion afforded free movement along it and around the building such that the interaction of the building with views to and from the Colosseum could be tested, along with the apse of the Basilica of Maxentius across the road. This was the primary objective of iVR historian prototype 1, where the use of the etching approach to the site



Figure 5  
iVR App 2 :  
prototype in use  
with simultaneous  
screen projection of  
VR scene ; the user  
is in the act of  
selecting reference  
images from a  
browser.



modelling worked well in terms of enabling dimensionally accurate comparison, but without the jarring impact of photo-realism. Immersion enabled the testing of the proposition that both of the Terragni projects are crucially animated by the curved masses of the Basilica ruin: project A, with its great curved façade, by assimilation and project B, with its rigid masses, by contrast. The ancient predominantly arcuated structures nearby are met sympathetically by the inverted arches in the façade of project A. Second, gravity: immersion afforded the ability to sense the immense weight of the great porphyry screen 80 metres long suspended above the street and the enormous hovering mass of project B, which is one of the largest cantilevers of its day. The capacity to teleport between key viewing points to enable quick and accurate comparison between schemes was very effective, particularly for a comparative novice at engaging with VR interfaces. Then the ability to roam the Piranesi like streets to find alternate viewing angles and to record these positions for later reference

was a useful addition, enabling transfer to 'desktop' mode for reflection and interpretation on the image captures after the VR session.

By contrast, iVR historian prototype 2 enabled an open ended and metaphoric engagement with the competition drawings. Occupying this abstract space of drawings afforded the possibility of prioritising certain aspects of the imagery presented, especially in project A, whose façade has variously been described as a dam, curtain, face and stage set. Not fully realising the rendering means allowing these readings to be highlighted in turn, along with volumetric analyses of the compositions. The immersion grants the occupation of a drawing, affording not only close examination of spatial sequences, key routes and paths, but also the evocation of atmosphere, which with the envelopment of sound from the period was particularly poignant. Accompanying these evocative soundscapes were narrations of the projects from their extant reports by the design team, as well as key interpretations by scholars such as

Manfredo Tafuri, Alberto Cuomo and Thomas Schumacher. Moreover, aspects of contemporary drawing and painting styles, those of Terragni and his collaborator, the painter Sironi, can be embedded in the rendering of line, shade and colour without the finality of verisimilitude. The capacity to browse other reference images from within the VR scene and superimpose these while exploring the reconstituted drawings was a useful part of the interface, but further work is needed to enable easier placement and resizing of the images.

## CONCLUSION

We have articulated a position for a non-photorealist approach to the use of virtual reality for the interpretation of unbuilt architecture based on the affordance of the technology. This position is based on a collaboration between a design researcher and an architectural historian who describe the importance of not rushing towards photorealism but, rather, a deferral, a 'room for play' (Spielraum) which involves a 'realm of thinking' (Denkraum), in art historian Aby Warburg's terms. Only by opening up such a realm can interpretive insight be granted. Two VR prototype applications have been developed to explore this position, with the Palazzo Littoria competition providing the context for evaluation. As discussed above we have received an initial positive response to these prototypes from our collaborating design researcher and historian. We will refine the prototype and undertake fuller evaluation with a number of historians and design researchers using survey techniques. The survey responses will be triangulated with tracking data that captures the user's movement, and identifies what interface elements are most frequently used. From there the intent is to undertake a series of case studies of unbuilt works, refining and developing other interface elements in response to different case study contexts and user feedback. The Unity authoring software has proved a robust platform, which has the additional advantage of being able to produce tablet, screen and AR output from the same code, albeit extra work is required on

the specifics of the interface. We are open to collaboration with other researchers interested in developing and using this approach to VR for history or other application contexts.

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