# REIMAGINING RELATIVITY

*Transitioning the physical body into a virtual inhabitant*

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**Abstract.** This paper explores the ideas and mechanics through a case study which generated a reimagined means of inhabiting a speculative immersive environment. Currently, many users reside within virtual environments for their own leisure, work, or any other reason desired from short amounts of time to extreme lengths. This paper shows the generation directly relative to the inhabitant, where gravity, orientation, scale, and locomotion is completely dynamic. Details within this paper experiment with the laws and bounds of the virtual space within a real-time game engine where reimagining the way one inhabits space compared to current norms of real-world inhabitation is possible with creativity and applied knowledge. Escher's lithograph of Relativity is the driving concept explored within this paper beginning with creating gravitational pulls in multiple directions within the immersive virtual reality environment to accommodate various sources of gravity. The result of the case study demonstrated the generation of new virtual relativity laws reimagining how the virtual space is inhabited, in short, omnidirectional flying, gravitation defined by the inhabitant to geometry relationship, controlled local scaling, and populating space with multiple inhabitants in a unique manner.

**Keywords.** Virtual Reality; Speculative; Relativity; Inhabitant; Architecture.

## 1. Introduction

Architecture is dynamic, relative to place, light, materiality, colour, form, acoustics and sequences, many spatial details in which details cannot be completely conveyed unless experienced firsthand (Senagala, 2000). The ability to move freely within a temporal and three-dimensional environment is not able to be replicated with conventional tools of representation. Drawings on paper and small models of card give the viewer an opportunity to interpret the experience of a design, but they do not ever fully comprehend the spatial qualities in a way that mimics the dynamic nature of the architecture (Mitchell, 1995). Immersive virtual architecture offers the viewer an opportunity to understand the dynamic nature of moving through architecture and the relationships between scales, perspectives,

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proportions and the like more accurately (Pandit, 2016). Strategically this remains the most efficient method to avoid situations where architects submitting drawings with the intended built form not turning out as they had expected, then having to perform alterations (Klercker et al., 2001). Virtual reality, being one of the most intriguing visualisation tools currently existing, although is virtual, is dealing directly with created forms of architecture, thus via modelling and scripting is defined as virtually built. The case study within this research, reimagining the way one inhabits space, can be applied within any style of immersive environment.

Architecture places a high level of importance on the occupant's perception and experience of residing within space (Krymsky et al., 2017). Virtual reality as a tool provides an exceptional opportunity for such spaces to be experienced before the concept and final design dissemination to an audience (Pandit, 2016). Various forms of immersive virtual architecture currently exist to serve many purposes, including evaluating unbuilt form, education, visiting remote heritage sites, social gaming and to simply reside within (Reid, 2004). Reimagining immersive architectural qualities in a specific way within the virtual space are the sole focus of this paper. Throughout case study investigations, a trilogy of virtual classifications, the speculative environment, the virtual inhabitant and the virtual built form, are defined as the vital ingredients to generate the reimagined experience and are all to be designed relative to each other, this paper focuses on the inhabitant section. This leverages computational design, digital locomotion mechanics and digital ephemera in a real-time virtual engine, a speculative environment is created comparatively to manipulating the physical laws of the physical world. Reconfiguring conventional elements of virtual space inhabitation, this work examines architectural properties such as orientation, scale, temporality, perception, virtual form and the possibility of a virtual body that can navigate an environment in a way unique to this research project.

Proposed is an alternative spatial experience of architectural dynamics to enhance such qualities in a highly sophisticated condition. Inhabitants residing within virtual reality environments create an opportunity for architects to virtually build physically impossible structures. Commercially the virtual space does not belong to architects, but rather game designers, however, they are beginning to turn to architects to help develop their worlds (Astbury, 2014). This concept wades into the notion of what immersive virtual reality environments can become with the ability to reimagine the norm of which a user inhabits virtual space (Dalton, 2016).

## 2. Methodology

The publication Digital Culture: An interconnective design methodology ecosystem (Rogers et al., 2018b), formed as a prerequisite for the knowledge and technicalities required for the generation of the concepts within the case study. This previous research specifically provided the formwork for the methodology exercised, focusing on designing the key components within the trilogy of virtual classifications within the immersive environment in an interconnective, dynamic and efficient way (Figure 1). Studying design processes allows the architect to explore the benefits and hindrances for certain tools (Wiggins 1989), combining

the art of study and practice together provides viable inputs and outputs in order to create a successful design cycle or framework within the architectural design (Schnabel 2004).

In order to reimagine relativity within a virtual environment, the body becomes a virtual inhabitant, the most significant of the three virtual classifications. The methodology diagram shows the virtual inhabitant components of spatial locomotion, spatial orientation, local scale and user population, these were designed relative to each other and the speculative environment classification components of visible environment boundaries, atmospheric qualities and the audio experience. These were then tested for successfulness in reimagining relativity with various geometries, orthogonal, polygonal, curvature, fractal, and minimal surface.

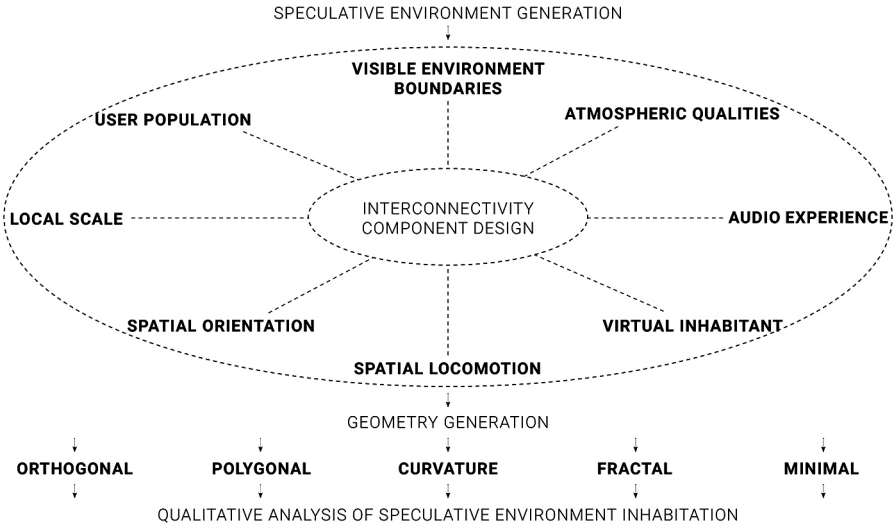


Figure 1. Methodology Diagram Adapted from (Rogers et al., 2018).

## 3. Trilogy of Virtual Classifications

To reimagine architecture, a trilogy of virtual classifications has been established, the speculative environment, the virtual inhabitant, and the virtual built form

The publication Future Virtual Heritage - techniques (Rogers et al., 2018a) formed as a critical prerequisite for developing the skillset and technical knowledge required to generate the reimagined relativity experience in relation to the speculative environment components. Tangible and intangible digital heritage: creating virtual environments to engage public interpretation (Silcock et al., 2018), was critical to developing the skillset and technical knowledge required to generate the reimagined relativity experience in relation to the user and inhabitant components which transitioned the physical body into a virtual inhabitant. Digital Design Ecology: An analysis of an intricate framework of

architectural design (Rogers and Schnabel, 2018) evaluated the procedures and tools from the Digital Culture paper in relation to education and professional practice. The evaluated tools gave critical insight into the way in which the built form was generated from a creative and efficient perspective within this case study.

This research within concentrates on the successfully generated inhabitant portion components. Resulting from this case study, this trilogy was immediately defined to understand the environment composition, thus concerning future work to develop components within these classifications, will still remain within this model. As new creativity advances, generating evolving components, the defining lines between the trilogy classifications may become blurred over time, just as how the Reality-Virtuality Continuum components have been blurred over time due to technology advancements (Milgram et al., 1995).

## 4. Inhabiting Spatial Geometry

Components outlined within this paper were tested within a virtual immersive environment through various geometries as the built form, orthogonal, polygonal, curved rotational fractals and a minimal surface (Figure 2). Within the immersive environment, the built form geometry modules were repeated to appear as an infinite mass like in figure 3 of the minimal surface. This allowed full exercising of the testing of the following components within this paper.

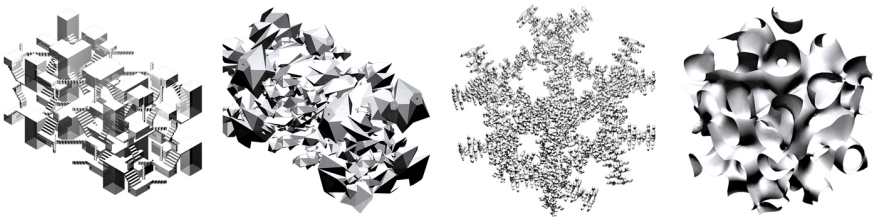

Figure 2. Four Geometry Tested Relative to the Inhabitant. Left to Right: Orthogonal Space, Polygonal Space, Curved Rotational Fractal Space, Minimal Surface Space.

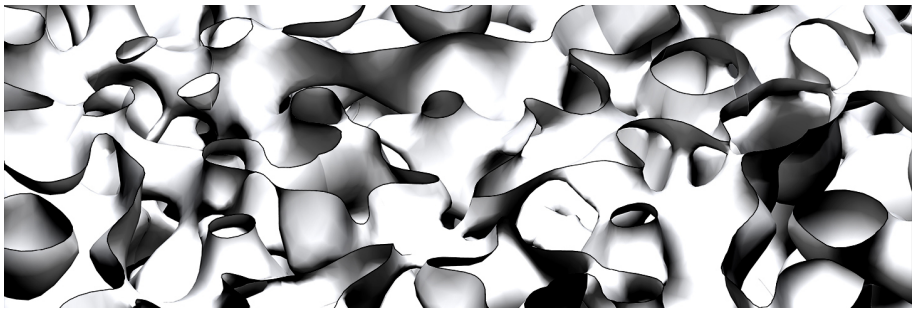

Figure 3. Infinite Minimal Surface Space.

## 5. Virtual Body

Physically, the body consists of many control points, a user represented within an immersive virtual environment has a limited number based on the technology available and designed for. Figure 4 shows a simplified version of the real bodily control points for a normal human, transitioning into a virtual body. The HTC Vive uses was limited to three main devices as control points i.e. the headset and two hand controllers, as there are also two audio sources to represent ears and eyes, these did not act as main control points, they are a sub-device to the headset.

As the transition within figure 4 is made evident, it is significant for the virtual body that no control points are in contact with the ground plane, suggesting the ground plane is as such, irrelevant. This notion opened new opportunities to completely reimagine the relationship between the inhabitant and the ground. As the transition of control points is important, equally so was the visibility. Within the speculative environment case study, the hand controllers were made invisible to the inhabitant. The visibility of them acted as a reference to the real world and usually cause the inhabitant to look at them and become distracted from the events taking place.

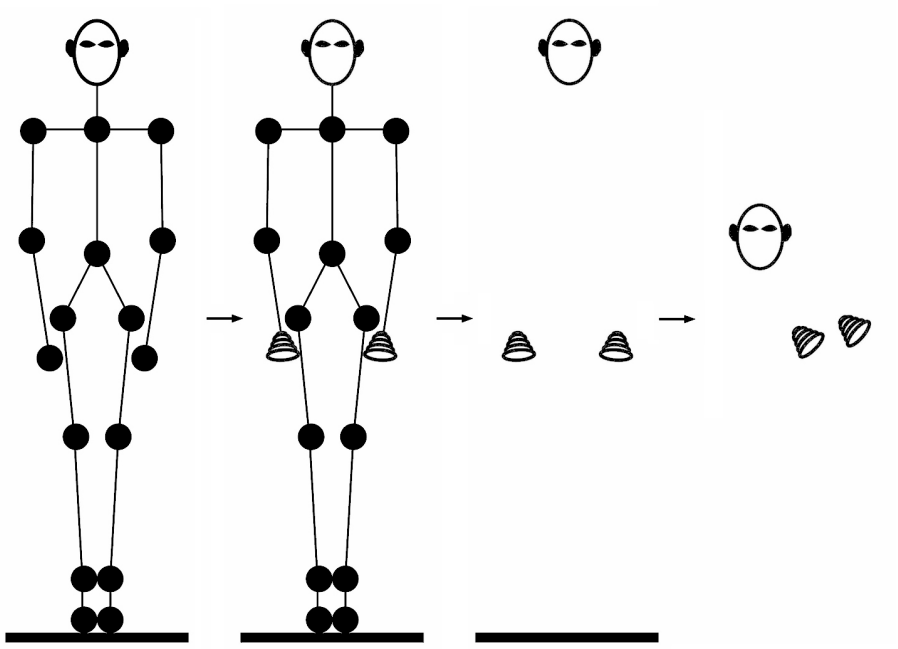

Figure 4. Physical Body to Virtual Body Control Point Translation.

## 6. Spatial Locomotion

Using one of the HTC Vive controllers, many architectural experiences utilise the default teleportation mechanism or glide-walking by holding the thumb track-pad down or navigating by thumb placement on the X and Y axis on the thumb track-pad to control direction. This case study created a C Sharp script which gives the inhabitant the ability to fly through space in any direction desired the controller is pointing on an X, Y and Z axis by pressing their thumb one of the controllers (Figure 5). This newly-designed general relativity law mechanic gives the user, the ability to 'fly' through space.

The script generated senses the touch of the user's thumb on a controller and drives them forward with a vector defined by the physical angle which the controller is in relation to the tracking set up and predetermined force deemed adequate to move through space. This is changeable in Unity3D to be at a fixed value within the immersive environment or implemented within a user interface within the immersive environment to be altered as the inhabitant desired. As a form of free spatial locomotion, this way of exploring a virtual environment reimagined the way in which humans might one day move through space while giving them the opportunity to experience such movement, advancing from the bounds of gravity in a three-dimensional space.

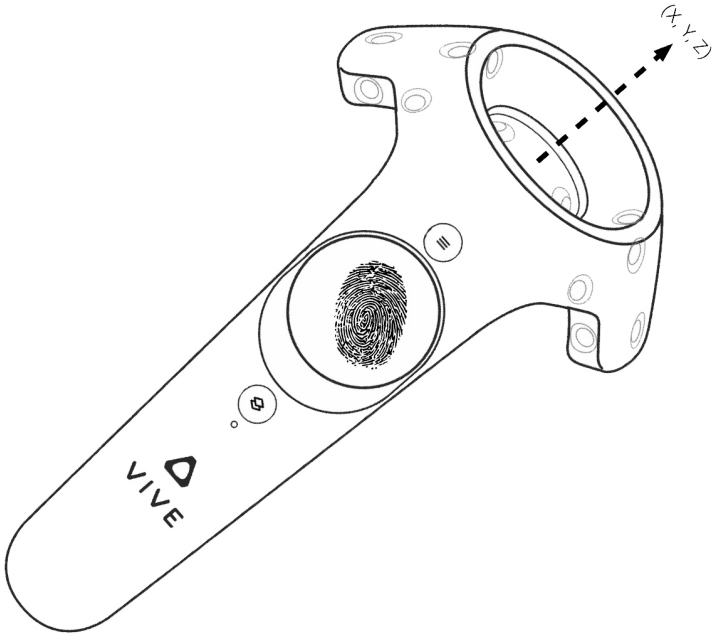


Figure 5. Spatial Locomotion using the HTC Vive Vontroller.

## 7. Spatial Orientation

Abstract forms of relativity portrayed by M.C. Escher (1953), depicts three orthogonal sources of gravity made evident by the orientation of a human figure. Within this case study designing the immersive environment within Unity3D, world gravity on the vertical axis was made to be zero. A general relativity law mechanic was generated via C Sharp scripting and applied to each virtual inhabitant, this defines their orientation and thus gravity source within the space. Generated real-time, the script generates five ray casts from the base of the inhabitant's virtual body in downward directions, one straight down, and the other four at 45-degree angles to the front, back, left and right. All rays produce a sphere collider on their end (Figure 6), the maximum ray length and sphere collider radius were fixed within Unity3D. Sphere collider contact with a geometry mesh surface orientated the inhabitant to the normal of that surface, keeping the geometry beneath the inhabitant. The ray with the shortest distance from the surface applies a smooth driving force in the direction of that ray 'gravitating' the inhabitant downwards towards that surface, giving the inhabitant the ability to 'stick' or 'walk' to any surface within the immersive environment.

The intensity of the transition depended upon the complexity of the geometry, the angle between two surfaces, and the inhabitant's speed. If different sphere colliders keep sensing new geometry, many fast transitions occur. This for some users caused slight discomfort, however, was quickly getting used to. Like insects crawling along walls and ceilings, this provides users to inhabit virtual architecture in a completely different way to the norm in which one moves through and exists within space.

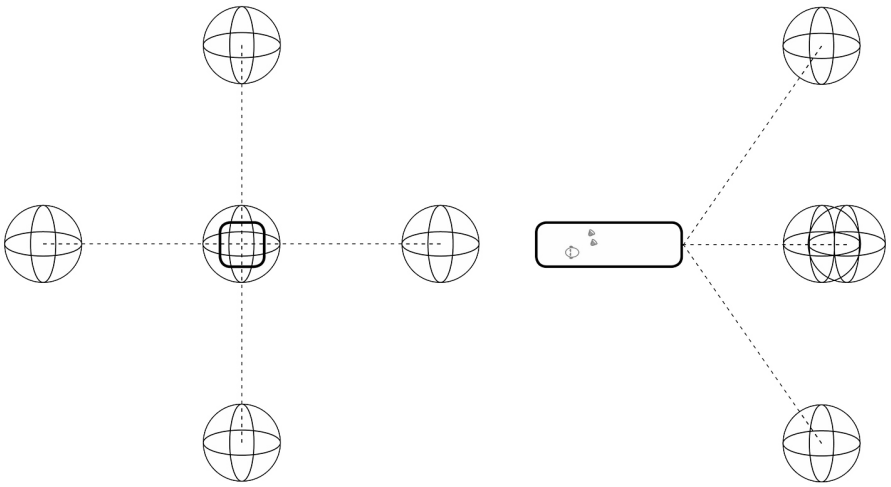

Figure 6. Sphere Ray Casting to Generate New Relativity Laws within the Virtual.

## 8. Local Scale

Human scale gradually increases and then decreases as one gets older with age. This C Sharp script applied within Unity3D generated a dynamic environment to virtual inhabitant relative scale change. Here the inhabitant controlled their ability to increase and decrease their local scale, by swiping their thumb up on the trackpad on one of the controllers to increase scale and swipe down to decrease scale (Figure 7).

As also shown in figure 4 as the physical body transitions into the virtual body, combined with this additional local scaling mechanic, the physical height of a person becomes irrelevant within the immersive environment. This changed the user's perception of the space drastically. Upon entering the space, the inhabitant's scale is an exact representation of reality, which then was interacted with.

Inhabitants having a dynamic scale reimagined their spatial inhabitation, as any place within the architecture could be reached or accessed. The ability to see a smaller portion of the space or the entire form of geometry.

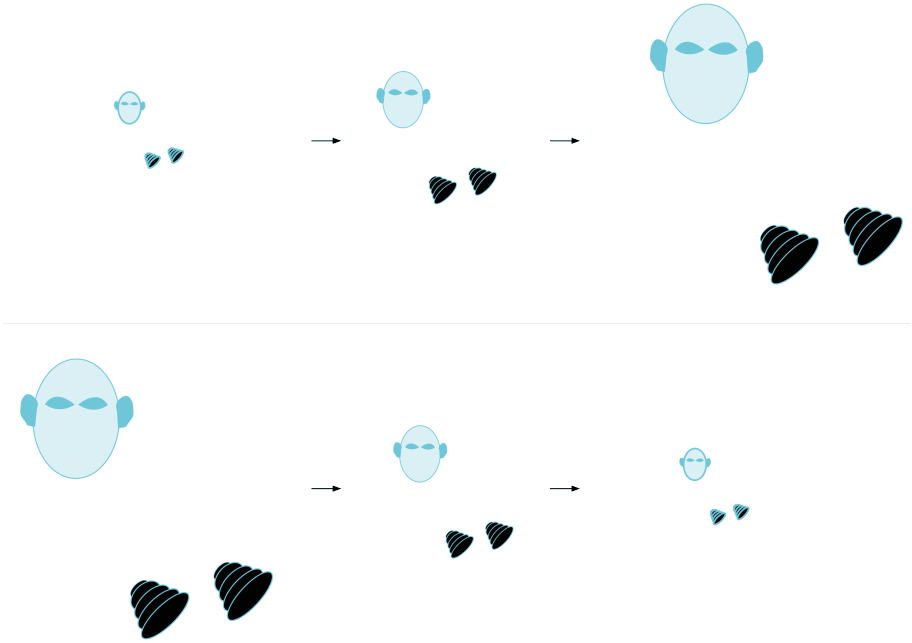

Figure 7. Beginning of Scaling Law Creation within the Virtual.

## 9. User Population

Essentially classified as multiplayer with time as a design variable. Using this networking script, multiple game files were connected via local networking with the virtual inhabitant bodies synchronised real-time. This allowed the inhabitants to see each other's exact moves at exact times. However, the time in which the

events were unfolding within the immersive environment was relative to when the inhabitants individually entered the space. One might be looking and interacting with an object (Figure 3) whereas the other would see them interact with an entirely different form (Figure 8) based on if they entered the immersive environment before or after the other. This effect created confusion when collaboration within the architectural space was desired. But was also an extremely unique and special feature as reimagined within an abstract world.

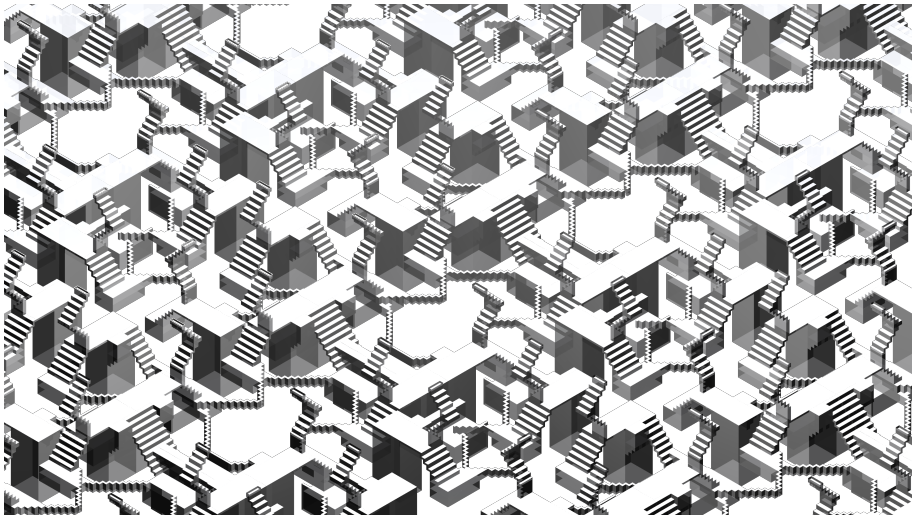

Figure 8. Infinite Orthogonal Space.

## 10. Conclusion

This research establishes a trilogy of virtual classifications. The speculative environment, virtual inhabitant and the virtual built form. These coalesce to generate a new quality of immersive architectural space. Components outlined within this paper of the virtual inhabitant consisted of the virtual body, spatial locomotion, spatial orientation, local scale and user population.

The trilogy of virtual classifications has enabled us to reimagine relativity and experience the way in which one can inhabit space. Ultimately, the trilogy of virtual classifications gives the inhabitant the possibility of perceiving the environment and its architecture within from dynamic orientation, scale and position. At the same time, it allows architects to generate new creative horizons from which to consider the craft of designing space and form in virtuality.

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