Spatial Relationships: A Framework for Understanding the Relationships Between Real and Virtual Spaces

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ABSTRACT
In this paper, I describe how representation, mapping, and interaction create the basis of a framework for discussing the relationships between real and virtual spaces and describe the design of an installation to illustrate these concepts.

Author Keywords
Virtual spaces, Frameworks, Installations.

ACM Classification Keywords
H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

INTRODUCTION
Systems that combine real and virtual spaces create different relationships between the two depending on their purposes and the technologies they implement. These relationships can be described in terms of the way the virtual space is represented, how it maps on to the real space, and the way that users interact with it. The ways different fields describe space, from its uses to its geometry, provide a basis for discussing how virtual space represents real space. The attributes of the real space that a virtual space takes on provide the elements of its mapping. The ways that interactors access virtual spaces influence how they understand and use them. These elements, which I will illustrate in the form of an installation piece, provide the beginnings of a framework that I will develop as my research progresses, which will catalogue and analyze different types of spatial relationships and their strengths and weaknesses for accomplishing their goals. My research questions include what are the ways real and virtual spaces relate to one another, and how do interfaces create or change these relationships.

TYPES OF SPACES
Descriptions of types of space come from all types of fields, from engineering and mathematics to architecture and media studies. In some cases, a division is made between real and virtual space, and often, the two are broken down further. Normal spaces, like parks and houses, contrast with non-spaces, described by Marc Augé as spaces void of culture meant for passing through [1]. Virtual spaces are often described using the same language, usually from architecture, as real spaces. Navigable virtual space provides a 3D environment through which avatars move and interact as people do in real space [2]. Even Novak’s Liquid Architectures, while reactive, behave spatially like buildings [3].

Another way to distinguish between types of spaces is the geometry that describes them. Euclidean geometry describes the world of our daily experience with rules stating that lines extend forever on an infinite plane, and that parallel lines never intersect. Non-Euclidean geometries change these rules in order to describe spaces that do not behave like we expect. One example of a non-Euclidean space is the surface of a Klein bottle. Klein bottles are non-orientable, closed surfaces with no inside or outside. On a Klein bottle, if a person were to walk in one direction, he would end up at the point at which he started; however, the top of his head would be pointing in the opposite direction. Figure 1 shows a two dimensional projection of a Klein bottle. The two vertical edges connect, and the two horizontal edges connect with a half twist, so the two x’s actually touch each other. While Klein bottles cannot exist physically in three-dimensional space, by creating a relationship between real and virtual space using embodied interaction, people can experience existing on the surface of one.

Representation and Mapping
The relationships between real and virtual space are created through two attributes of the virtual space, representation and mapping. Representation refers to the way the designer chooses to portray the space to its viewers. Just as maps represent real spaces as projections of points on to a two-dimensional plane, virtual representations of space illustrate data spatially. The data can be designed to create a virtual space analogous to a real space, as seen in video games like Second Life, or the data can be collections of data points, like weather data, that has been represented spatially for the sake of illustration. In the case of the installation that I describe later, the space acts like a real space with respect
to movement and interaction, but the space represented is not analogous to any real space. It is meant to be understood as a space that is not physically accessible but is physically comparable to the real space to which it relates.

Mapping refers to the relationship between the real space and the virtual space. Virtual spaces can have a one-to-one relationship with real space in which everything in the virtual space has an exact analogue to the real space. One example of this is the inSpace project, which reflects movements of real objects in analogous virtual objects [4]. Virtual spaces can be extensions of real space like in flight simulators, where the real space is a airplane cockpit and the virtual space is seen through the cockpit’s windshield as if it were actually the outside of a plane. Other mappings abstract different aspects of the real world and map them to a virtual world. One example of this is the Nintendo Wii, which maps movement in the real world to movement in a virtual world. In my installation, the virtual world is viewed as an extension of the real world, as in a simulator, although the space represented does not map to an actual real space.

Installation Design
The installation I proposed to build places the real space on the surface of a virtual Klein bottle. The virtual space extends outward from the gallery space in all directions and is viewable through framed windows on two sides of the gallery as shown in Figure 2. This situates the real space as a small part of a much larger virtual space. Objects in the physical room are also visible in the virtual space, as if the viewer can see around the entire surface. Moving physical objects changes the position of the virtual objects. Lights shined on the walls of the gallery at the correct place glare in the windows to the virtual world. These interactions allow the viewer to create a mental map of the larger space of which the gallery is a small part.

The installation will use a combination of projectors and computer vision to create these effects. By projecting the virtual space to look like it is outside of a window, the sense of perspective can create the illusion that the virtual space exists in the same world as the real space but is not directly accessible from it. The objects will be designed to be easily tracked by computer vision and their location will translate to a position in the virtual world. The virtual space will most likely be designed in a game engine like Unity, which will take input from the computer vision system and keep track of the locations of the virtual objects. Over the course of the next semester, I will research and test tools and techniques for creating the desired effect.

Conclusion
Different ways of representing space virtually, mapping it to real space, and interacting with it, lead to many possibilities for enhancing the display of and connection to data, whether for entertainment or instruction. By looking at existing examples of systems that combine real and virtual space and designing new systems that show novel applications of these relationships, I can begin to explore which types of relationships are appropriate for different applications and enhance the way people understand their relationship to the world around them. The design of this installation is a first step towards those goals.

REFERENCES