Visual Space After Virtual Reality

Steven Schkolne
Caltech

Daniel Keefe
Brown University

Abstract

We investigate the visual elements that will inhabit everyday environments after virtual reality becomes commonplace. Virtual forms have a richer, more flexible material than traditional metal, wood, and plastic. Both borrowing from traditional 2D techniques and inventing its own processes, VR enables artists and designers to push the envelope for physically constructed objects and redefine the visual space of film, video, and the interactive space of VR itself. We describe the contemporary edge of VR design tools. Then we look to potential forms of tomorrow.

Introduction

Our visual space is increasingly occupied by humanly constructed objects. These shapes are defined by the processes that create them. Traditional human-made forms arise from rigid materials. Wood and stone objects hard and heavy. These materials must be carved with slow, deliberate motions. Metal and plastic objects are cast or forged; clay is sculpted and assembled. All of these three-dimensional, real world forms are inherently *solid*. This solidity is determined by the wood, marble, plastic, or clay that composes the objects. It also reflects the often slow and physical process of working with these materials. Creating three-dimensional form in the real world lacks a flexibility and fluidity readily available in traditional, artistic 2D media, such as oil paint or charcoal.

In contrast, 2D media are much more flexible in how they can be arranged on a surface. They are supportive of a rapid juxtaposition, either of a homogeneous material of varying color or a collage of different elements. These media have a rich, highly flexible nature that allows a great deal of variability in style because their inherent materiality is *fluid*. Blood, oil, ink, and watercolor stretch and spread across a surface in a variety of finely delineated, easily controlled, and highly variable patterns.

Our vision of the shape of virtual reality is one where this fluidity of form is lifted from the 2D canvas to 3D space. This transition is important because virtual objects will have a prominent place in our future environment. Complex structures that can only be created with the aid of VR technology will exist in virtual form and in physical form, as the new fabrication technologies that they demand become realized. The boundary between solid and fluid is smudged, allowing an ephemerality and motive expression in three dimensions. These shapes are delimited by the tools that construct them. We describe herein two prototype design tools that allow access to this richer 3D design space.

We close by exploring some future directions of virtual reality that no current design tools support. Shapes can affect their environment, or they can act as lenses which subtly modulate surrounding space. Connections that effect physical space can be made in information space. Different viewers can have unique experiences with the same object. Creating and controlling these new types of material is a future challenge for the virtual reality community.

Virtual Reality Design Tools

Two methods reflect the state-of-the-art in creating shapes in 3D space. Surface Drawing [1] captures traces of hand

Figure 1:. These three views of *fthr*, a Surface Drawing are difficult to resolve. This shape has a fluid 3D complexity that is difficult to conceptualize with 2D tools.

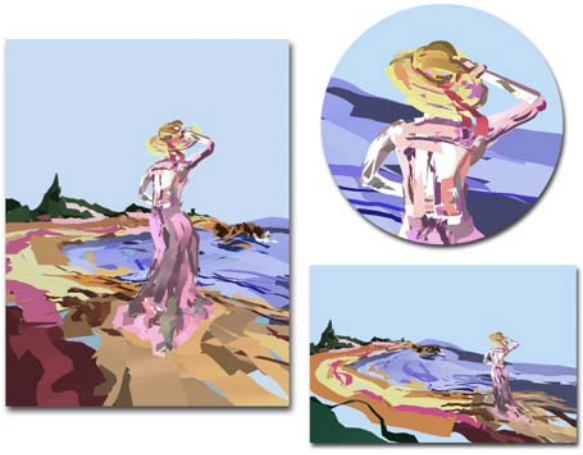

Figure 2: *Wedding Day*, a CavePainting, is made out of 3D brushstrokes. Its fluidity is difficult to create with solid media such as clay.

Figure 3: A chair that changes with the seasons. The chair evolves over time from left to right: original chair with soil, chair grows leaves during the spring, leaves change colors during the autumn, leaves fall off during late autumn, snow falls in winter, and snow melts so that the process can start over.

Figure 4: A lens integrated into a chair back. Four different lenses, from left to right, the lens blurs the scenery behind it, inverts the colors of the scenery, shows a distorted view of the area behind it (in this case centering its view on the nearest tree), and (d) shows a view of a nearby area

motions in space as strokes that can be combined to make a variety of organic shapes. The interface uses tangible interface tools and the Responsive Workbench to blur the boundary between the physical space of the user and the digital space of their creation. CavePainting [2] provides the user with a variety of brushes that deposit paint as they are moved through the immersive space of the Cave. Artists place their full bodies in and around shapes as they are formed.

Both of these systems are capable of making representational shapes, but to describe the unique avenues of imagery they open we will consider the least traditional examples. Consider *fthr* (Figure 1), created with the Surface Drawing system. Fthr is made by placing strokes in space from a common center while rotating the entire shape with sensed tong props. Although pieces of the whole do not touch one another, they are visually connected in the virtual representation. Such construction is not possible in the physical world where structural engineering is required to ensure that things stay together, and there is no way to connect things across a physical gap.

The constituent shapes are made by sweeps of a hand that bends as it traces an imaginary shape. A geometric idea is intuitively communicated through motion, and then directly and immediately realized in front of the user. Such rapid construction is difficult and time consuming in a physical medium such as clay or stone that requires many delicate manipulations to construct.

In this mode of construction material floats, is lightly spun and instantly placed at the speed of thought. This stream of interaction results in the development of rich geometric relationships that are not supported by traditional physical media such as clay and stone which are simply too slow. Because virtual reality is used, this rapid construction is far more bodily, physical, and intuitive than it would be in highly mathematical tools such as Maya and 3DS Max. This type of geometric intensity is exemplified by the three-dimensional structure of fthr. Looking at the three views of fthr pictured, one realizes that it appears quite different from each angle, as if these are three images of different shapes. Resolving the connections between the bent strokes of the shape to, for example, state the rotations it takes to move from one view to another is mentally challenging. For the creator of the shape, working in virtual reality, this conceptual difficulty simply does not exist as there is no translation between the 2D language of the paper and the 3D space of the shape itself.

Beyond looking at the shape, the user can wrap around and physically engage its space, gaining understanding through proprioception. This speaks, first of all, of the utility of a 3D interface in the creation of a shape which is difficult to understand and impossible to hold in 2D. Second, it indicates a wealth of similar complexities which can be physically understood as they are created. This not only increases the topological complexity of the environment, but also increases the human ability to conceive of rich

Figure 5: A lens that modifies the environment around a chair. This type of lens can help ease the sunny day seen on the left bu providing enough shade (center) to read comfortably or prevent sunburn. This type of lens blocks incoming light. Another lens (right) blocks outgoing light – for example allowing someone to sunbathe in privacy.

Figure 6: Three chairs (left) linked together by an invisible bond. Rotating (center) one chair causes (right) the others to move as well. Do the chairs affect the person in the image? Is this third party forced to take part?

topological structures. This methodology leads the way to a new language of structure and form that will affect not only the shape of cultural communication in film and video, but also the physical space of architecture and design that we inhabit.

In CavePainting, 3D structure is suggested completely through the use of three-dimensional strokes. Note the placement and volumetric layering of strokes in the woman's hat and dress in *Wedding Day* (Figure 2). Like charcoal lines or paint strokes, these marks are a fluid, highly flexible visual language that is brought to life by an interface responsive to the artist. While CavePainting offers many types of virtual brush strokes as tools, Wedding Day is an experiment in virtual painting using only the simplest virtual stroke. The entire painting is composed of simple, ribbon-like surfaces that combine to form a three-dimensional structure from which we are able to comprehend a great deal of meaning, including a sense of emotion and a loose, quick, impressionistic style.

Creating in CavePainting or Surface Drawing is a new way of working and thinking. While a painter often steps back from his work or a sculptor steps around his work or even holds it in his hand, a CavePainter stands up and walks *through* his work, grabs and rotates it by hand, shrinks or enlarges it on a whim, and finally manipulates color variations and stroke size, shape, and placement to create a visual representation for complex forms. Many of these operations have no counterpart in the physical world, thus they allow interactions and make possible the creation of a form that would otherwise not exist. For example, paint strokes would not be able to float or coinhabit the same volume in the physical world.

In prior media, artists had to choose between heterogeneous two dimensional tools (where visual forms could overlap) or homogeneous volumetric media. With these new developments the expressionistic characteristic of the paint stroke can go in and around shapes, defining their volumetric presence. CavePainting and Surface Drawing break new aesthetic ground because the visual form that they enable is novel and complex. Although their sophistication falls short of developed painting techniques with century-long histories, mark-based techniques will continue to evolve. With greater variety of interaction, richness of mark, and finer control these 3D tools will grow to be as powerful as pigments and canvas, as complex as nature in their visual manifestations.

Future Directions

The tools presented above expand our visual space because the allow artists and designers to control a new type of material: light that floats in space. Virtual reality allows richer types of material whose design tools have not yet been found. We investigate some of these forms below.

Defining Action and Interactivity

Interactivity permits going beyond geometry and topology to define the functionality of shape. These responses can be a reaction to an interactive tool or a change that occurs over time (see Figure 3). These effects already happen in natural space - wood burns and copper turns green. In virtual environments these behaviors do not depend on nature but rather can be defined by humans. The notion of creating a

Figure 7: A multiview chair. Each person looks at the same area, and each sees a different type of chair.

shape moves beyond its visual properties, the way it reflects light, to its physical properties, the way it reacts to forces.

Algorithmic reactive properties allow a shape to change its appearance and behavior at once. The incorporation of functionality allows inclusion of life and intelligence into shapes, and the personalization of objects as they are defined with individual preferences in mind.

Modification

Material can do more than just have a presence in the environment. It can also *modulate* its environment. Matter can have the property of absence, negating previously constructed forms so that they cannot be seen (see Figures 4 and 5). Unlike photographic negative space, these areas are not defined in terms of location amidst positive form. Instead, they are pure negation - existence that can only be perceived through modification of the already-existing. The territory between absence and presence can be filled by the concept of *lenses*. These can be thought of as regions of physical space that manipulate perceptual information that passes through them. Lenses modulate attention, making certain objects more visible.

Interaction Beyond Physical Plausibility

In the natural world, physical laws determine interactions between objects. Nature can be thought of as a massively parallel computer that resolves inter-object interactions. In VR this decision process is subject to human definition. Objects can physically move through one another without disruption. Visually small objects can affect much larger ones, or shapes can be connected across a vacant space (see Figure 6). A shape could exert a force some distance away from its boundary. The effects of an object can also move beyond the application of force in space to the modification of the functionality of another object. This could be changing its color, its pliability, or its melting point.

Multipresence, Multiperspective

Virtual reality is typically envisioned as the creation of a static world that mimics earth. Realizing that there can be more than one person in a virtual space, and that the structure of that space can change through time we posit that much richer combinations can be constructed. For a single spectator, an object can change as it is viewed from different angles. Multiple viewers can see individualized views that do not share a geometric consistency (see Figure 7). And shapes themselves can change with time. Imagine a maze that a participant is walking through. This maze can modify itself as it is being navigated, forming a structure that is not embeddable in three-dimensional space. These interactive geometries ask an experiential understanding which needs more than a single viewing experience to form.

These new possibilities of material are the constituents of environment after virtual reality becomes common. We do not know how these rich forms might be designed, we leave this (for now) as a thought experiment for the reader. Experiments in marking and painting space with light indicate that the future's visual space will be multivocal, complex – inherently more dynamic than the contemporary environment.

References

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