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Virtual Demonstrator for Spatial Presentations

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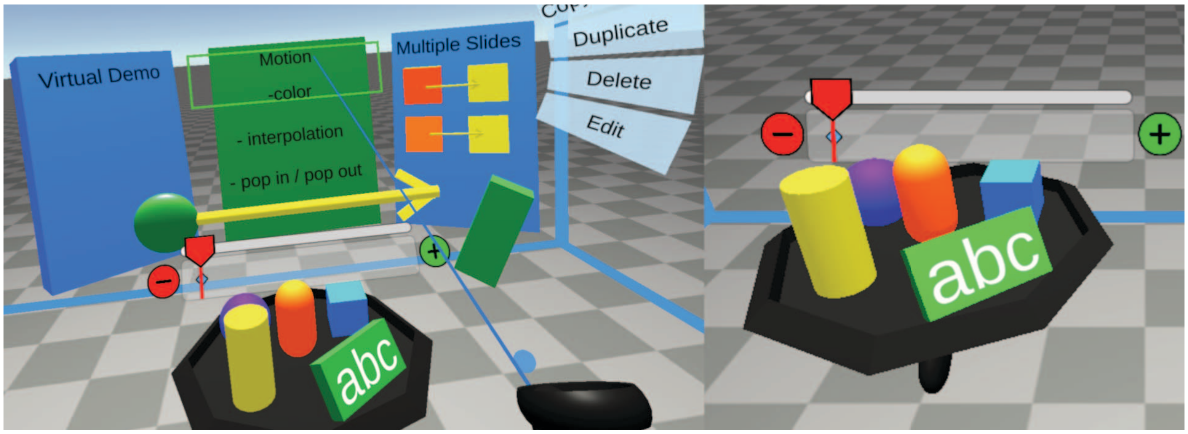

Figure 1: (Left) A sample slide illustrating some functions of the 3D presentation tool, Virtual Demonstrator. (Right) The current user palette with text and shapes that can be placed in the scene.

Abstract

To overcome the challenges of instructing on spatial concepts remotely, we propose Virtual Demonstrator, a virtual reality (VR) presentation software for educators. Virtual Demonstrator provides a suite of tools for creating spatial presentations in VR, analogous to 2D slide-based presentation software. Within our software, Visual Elements are combined across a spatiotemporal space, with discrete states akin to presentation slides. This educational resource is designed to address a growing need to learn without physical presence, and to leverage 3D spaces for learning complex spatial concepts. A timeline expands a 3D environment into another dimension, allowing for an expanded design space.

Index Terms: Human-centered computing—Human computer interaction (HCI)—Interaction paradigms—Virtual reality; Applied computing—Education—Interactive learning environments;

1 Introduction

The COVID-19 pandemic resulted in a rapid and chaotic transition from in-person to virtual instruction across the globe. Online teaching tools have been at the forefront of contemporary technologies for remote learning. However, very few educational environments have been able to leverage the potential of emerging media such as virtual reality (VR). Although immersive technologies have been previously used in simulation and education [3, 4], little work has been done on empowering educators to *create* the instructional content both within and for virtual reality.

In this paper, we propose Virtual Demonstrator, a novel 3D interface for teaching and presenting in 3D environments that takes inspiration from and expands upon slideware tools like PowerPoint, while allowing for dynamic content creation that cannot be done in traditional slide-based presentations. Slideware tools are well-known, but are limited in their 2D design space and their inability to immerse viewers in the presentation content. Virtual Demonstrator draws on concepts from these traditional presenting tools and reimagines how they can be utilized in a 3D workspace.

With VR, remote learning can benefit from the kind of presence that in-person learning affords, while allowing for content to be shared asynchronously. Furthermore, in VR, the educators are also unbound by the physical limitations of a chalkboard or a lab table. Rather than simply substituting for the in-person lecture, we are interested in examining how these principles can *advance* education. Our primary contributions include: an interface for educators to construct presentations in VR; the use of a timeline in a 3D Workspace to track and store spatiotemporal content; and a new presentation format that incorporates spatial awareness and motion, allowing instructors to create engaging visualizations.

2 Background and Related Work

Several works have been published on specialized training through 3D visualization, especially in medicine and anatomical study [1]. These studies have primarily focused on 3D visualization for its accessibility and lack of physical limitations. There's also a demonstrable benefit in certain fields of learning. Tan *et al.* has demonstrated a quantifiable improvement in test scores when students learn microbiology in virtual reality rather than a desktop environment [5].

In their book *How Students Learn*, Donovan and Bransford mention the importance of example-based learning, such as using real bridges when training civil engineers in bridge construction [2]. We aim to embody this philosophy in our work, by designing a tool that encourages educators to teach by example.

3 Virtual Demonstrator

Virtual Demonstrator is a novel spatiotemporal presentation tool that combines a 3D sandbox environment with a timeline. It is designed specifically for teaching concepts that benefit from spatial or tangible demonstration, such as physics. We analogize with 2D presentation

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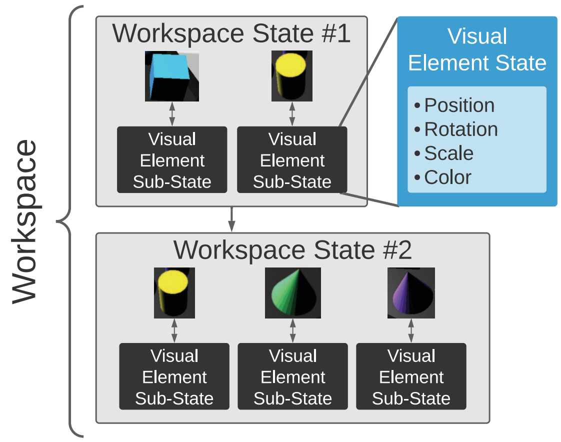

Figure 2: A diagram of the Workspace-Visual Element State system. This architecture is essential for defining interpolations between states. Visual Element States are contained in Workspace States.

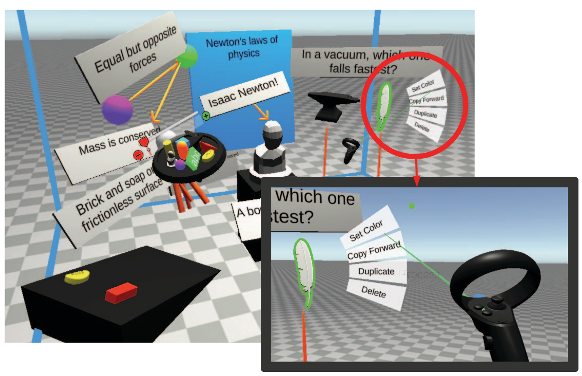

Figure 3: A zoom-in shot of the radial editing menu.

slideware, and explore how the concept of slides, text boxes, and shapes can be applied to a 3D virtual environment.

Within Virtual Demonstrator, there are four major components that make up the user's interaction space:

- *Workspace*: The spatial area the creator can add Visual Elements to. The workspace is subdivided into discrete states (slides). Each slide contains a list of all the visual elements within it and their properties: transform and color (Figure 2).
- *Visual Elements*: The content that makes up a presentation. The user has access to a selection of primitive geometric shapes, several imported 3D models, and text fields. Each element can be modified in the workspace through radial menus (Figure 3)
- *Element Palette*: A 3D menu attached to the creator's recessive hand that allows them to insert new Visual Elements into the Workspace environment.
- *Timeline*: A menu that allows users to navigate between slides and insert new ones. This menu is attached to the user's recessive hand behind the Element Palette. The user can drag on the timeline slider to switch between slides and preview visual element transitions.

When the timeline is dragged to a new slide, the current and new workspace states are interpolated between. This interpolation is calculated for every Visual Element in the Workspace, and is applied to each element's transform as well as its color properties. This timeline component is essential for the design space: users are not only able to manipulate objects in a three-dimensional environment (like in 3D sandbox tools) but also transform them through the fourth temporal dimension.

This architecture forms a valuable hierarchy open to scalable modifications. Differing from traditional presentation tools, elements are persistent from slide to slide until removed by the user. This creates a continuity between slides that contributes to the spatial nature of the content. Currently, a user is able to change the transform and material of a Visual Element, and all of this will be saved exclusively within a state. The preservation of Visual Elements across slides allows for transformations that are key part to presenting spatial concepts.

4 Example Use Cases in Physics and Engineering

Virtual Demonstrator can be used in different educational contexts. We can create a physics lesson on gravity in a vacuum by leveraging the interpolation between states. We first instantiate two elements, an anvil and a feather, at our eye level. To simulate their falling in a vacuum, a new slide is created where we translate both of the objects to the ground. To simulate their falling in atmospheric conditions, we can create one slide to show the anvil quickly falling to the ground, and multiple slides to show the feather slowly drift downward. The presentation can be annotated with text elements to describe what is happening in each scenario.

Our last example presents the engineering techniques of the Golden Gate Bridge. Using an existing 3D model of the bridge, we can scale it up and move through the virtual space to capture the bridge at different angles, or keep it small and rotate the model in our hand like a toy. With our temporal states, the presenter can easily direct attention to different parts of the model by just manipulating the model at that state, and provide annotations to accommodate. If the presenter is focusing the presentation on a single support structure, the viewer is not tethered to a single vantage point, and can walk around the structure or get up close to it to observe its intricacies.

5 Future Work and Conclusions

We presented Virtual Demonstrator as a new approach to organizing and presenting information. We leveraged the advantages of 3D virtual environments by using continuous motion between slides and by creating a unique, spatiotemporal workspace. We believe this makes Virtual Demonstrator a viable solution for remote learning.

Future work would require building out infrastructure to distribute and save content. Currently, a set of default meshes are used for the various elements as a proof of concept, while importing custom meshes, or selecting from a large asset library would be more desirable. Future versions could also include markup tools for drawing in 3D space during live presentations.

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