Mediate

A Spatial Tangible Interface for Large-Scale Mixed Reality

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Abstract

Virtual Reality (VR) renders immersive visual experiences, yet lacks tactile feedback for virtual objects. Shape Display Tangible Interfaces[1] provide solid sensations but are restricted to desktop-scale workspaces. This work represents a fusion - similar in concept to Robotic Graphics[3] - of mobile robotics, haptic props, Visually-Augmented Shape-Displays[2] and commercial Virtual Reality, to overcome these limitations.

We present **Mediate**, a semi-autonomous mobile Shape-Display that locally renders 3D physical geometry co-located with **room-sized virtual environments** as a conceptual step towards large-scale **tangible interaction** in Virtual Reality.

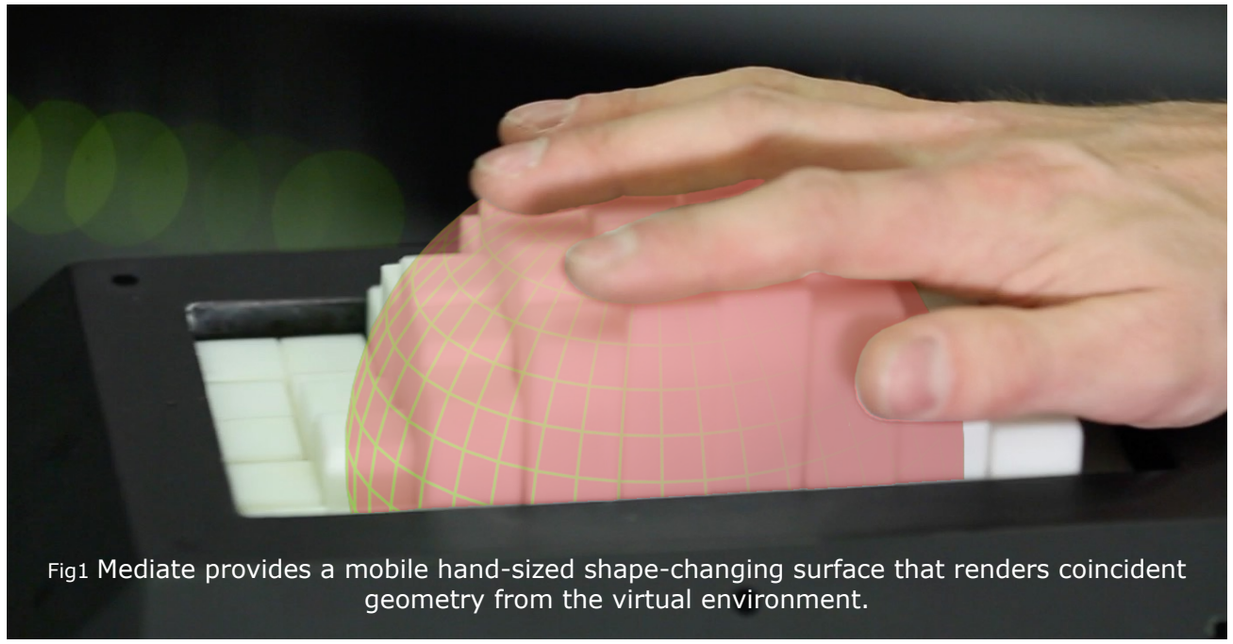

Fig1 Mediate provides a mobile hand-sized shape-changing surface that renders coincident geometry from the virtual environment.

Technical Implementation

Mediate is a small Shape Display mounted on a mobile robot. The robot follows the user's hand as they walk. The position of the display is tracked in 3D space, and the pins "display" any geometry that is present at its location, creating a small tangible "bridge" between the physical and virtual worlds.

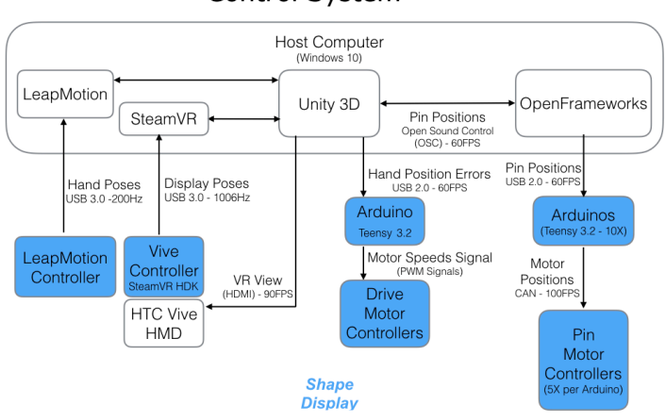

Fig 2
Standing + Hand Following

Interaction

Mediate functions similarly to previous Shape-Displays[1]. With only 50 pins (*Fig 1*), it has a relatively small resolution. However, during interaction, it achieves a large **effective *workspace*** by **moving itself** around the room while **tracking** the user's hands (*Fig 2*). The shape rendered is only a hand-sized portion a much larger larger virtual environment. The pins **conform** to mesh surfaces as the device moves, representing coincident physical and virtual objects. The independent mobility of this "on-demand prop" allows users to walk around and touch parts of large-scale virtual environments, in addition to seeing them (*Fig 3*) when used in conjunction with visuals from a VR Head-Mounted Display (HMD).

Fig 3
HMD + Tangible Interaction

Limitations and Future Work

The physical machine is restricted to 2D locomotion and vertical pin movement within a small height range, so it can not render 3D shapes such as overhangs, steep angles or vertical faces, or geometry high up or low down. Future versions of Mediate (Fig 4) will add these actuators, for full 6 degree-of-freedom semi-autonomous robotic displays.

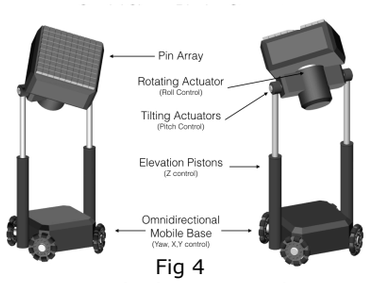

Fig 4
Spatial Shape Display (Future Concept)

Applications

The interface combines VR immersion with tangible forces in a unified visual/haptic experience. Unlike previous VR haptics[4] it applies external forces, and can be used to "explore" large room-scale virtual interactive environments. In addition to acting as a ***Spatial Tangible Interface*** for existing VR scenarios, we propose new interaction modes that utilize the novel tangible/spacial capabilities offered by *Mediate*.

- ***Mixed-Reality*** *Games and Experiences* such as touch-based hide-and-seek - without an HMD, a user must "guide" the device around the area, feeling for objects as they go.
- ***Telepresence*** *and* ***Remote Collaboration*** utilizing multiple synchronized Mediate devices to render the same virtual interactive object in different places for different users at once.
- ***Tangible Animation*** *of Virtual Objects* using Mediate's ability to precisely track itself and its pins in 3D space, allowing users to move objects around the room, or manipulate their shape, and record these motions.

[1] Leithinger, Daniel, et al. "Shape displays: Spatial interaction with dynamic physical form." *IEEE computer graphics and applications* 35.5 (2015): 5-11.

[2] Leithinger, Daniel, et al. "Sublimate: state-changing virtual and physical rendering to augment interaction with shape displays." *Proceedings of the SIGCHI conference on human factors in computing systems*. ACM, 2013.

[3] McNeely, William A. "Robotic graphics: a new approach to force feedback for virtual reality." *Virtual Reality Annual International Symposium, 1993., 1993 IEEE*. IEEE, 1993.

[4] Benko, Hrvoje, et al. "Normaltouch and texturetouch: High-fidelity 3d haptic shape rendering on handheld virtual reality controllers." *Proceedings of the 29th Annual Symposium on User Interface Software and Technology*. ACM, 2016.

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