"Hands-on": Leveraging Gesture Technology for Collaboration in Virtual Environments

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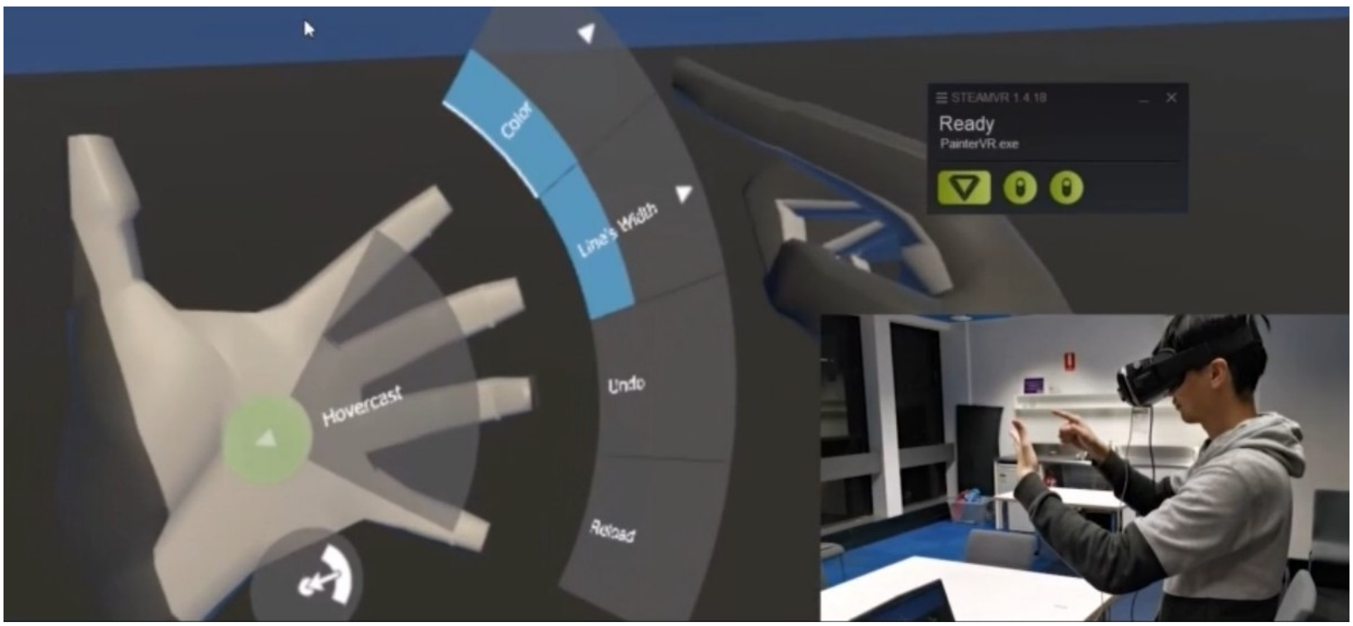

Figure 1: 'Hands On' menu in use.

ABSTRACT

Technology is making remote collaboration easier, but some physical group tasks are losing their natural and intuitive interactions in the process. 'Hands on' aimed to show that a task like collaborative drawing can transition to a virtual space more smoothly with the help of Virtual Reality (VR) and gesture technology. By combining an android phone headset and Leap Motion we were able to create a way to draw in 3D space with other people, using natural drawing gestures and an intuitive gesture-based palm-oriented menu. This work is an example that with advances in technology we are better able to extend physical group tasks into virtual space.

KEYWORDS

gesture, virtual reality, virtual menu design, hands on

*All the authors contributed equally to this project.

1 INTRODUCTION

In an increasingly connected world spearheaded by social media and technologies like smartphones, social computing and distributed technologies, there is a continued push to remove boundaries between people's interactions where practical. Communicating with each other and sharing information can be easy, but collaboration can be difficult depending on the task. For example, working on the same document in Google Docs or having a group discussion over a Skype conference call is fine. However, when the task is more complex, transcending text and voice, and traditionally done in the same physical space, this is an opportunity to find a new way to do that same task, leveraging technology in the process. To this end, virtual reality is a potential avenue to take, with the main barriers being accessibility, less so now with mobile VR, and more importantly, natural user interfaces. The usability and the user experience of certain technologies can be a big obstacle to adoption.

'Hands-on' demonstrates a new way to work together, aiming to take work from the real world to the virtual world. Part of the success in public engagement of this project relies on the seamlessness of the transition, with heavy dependence on how users can quickly and easily pick-up, learn and use the technology. Where there is no need to reinvent the wheel, 'hands-on' takes an approach that is familiar with users. In the same way that a painting artist holds a palette in their left hand and a brush in their right, 'hands-on' implements a menu in the left hand and a pointer in the right hand. Gesture technology is important here as it bypasses the need for any mouse and keyboard or controller and minimises the amount of learning whether the user is familiar or not at all with virtual reality.

In addition to the novelty of the user interface in 'hands-on', another novel interaction lies in the extent of its social application. While a painter can work on their own, there should be an opportunity for others to work on the same project as them, or at the very least view it as if they were physically there. This can then be a proof of concept that people can collaborate naturally in virtual environments, opening opportunities for collaboration on tasks not limited to painting.

2 RELATED WORK

Head Mounted Displays (HMDs) have become more accessible in recent years, thanks in part to the development of mobile VR headsets like Google Daydream. This has encouraged exploration into how users interact with this technology to make it more engaging and mainstream. Like Tilt Brush by Google before it, Oculus Quill showcased artistic activities in VR; however, they both require controllers [3] compared to the gesture-only approach of 'hands-on'.

Gestures can be extremely useful in communicating with computers but using and recognising the right gestures is a challenge [4]. Key to any application involving gestures is the menu as the user's toolkit. Work has been completed in this area, progressing from a fixed, floating menu that obstructs the user's view to an Open Palm Menu concept that affixed the menu to the user's palm [1]. Furthermore, the menu's style is important as there is a difference and advantage in radial over linear styles of menus [5]. Furthermore, organising users' commands into a set like a menu is important in how they interact in virtual reality [2]. The novelty in 'hands-on' comes from its unique implementation of a radial menu affixed to the user's fingertips.

Equally as important is the notion that 'hands-on' can involve multiple users working in the same environment, which was partially explored in this project using distributed computing. The multi-user component of 'hands-on' was inspired by existing social VR systems that usually allow users to communicate through audio and video [6].

3 SYSTEM DESCRIPTION

'Hands on' is a gesture-based Virtual Reality (VR) drawing program, that allows users to draw in 3D space using a natural pinch drawing gesture. There is a radial, multi-level, palm-based virtual menu system that allows users to select colours, change line width, summon a colour picker, undo actions, and clear the workspace. The menu is summoned or closed by selecting a button on the right side of the left palm. Menu options are selected by hovering over them, with visual feedback on how a selection is progressing. Change line width uses a slider, which is again selected by hovering. Going back one layer in the menu can be done by pressing a button on the palm, or by closing and opening the palm.

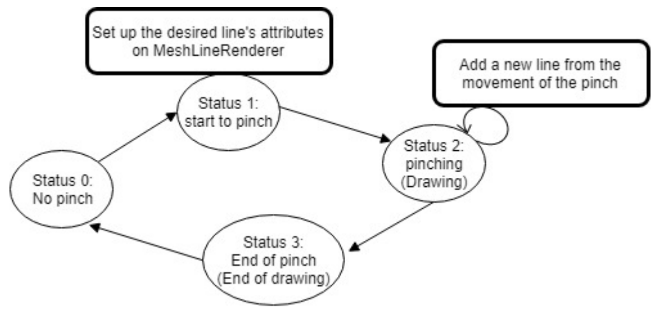

Figure 2: Model showing the events involved in the pinch gesture used to draw.

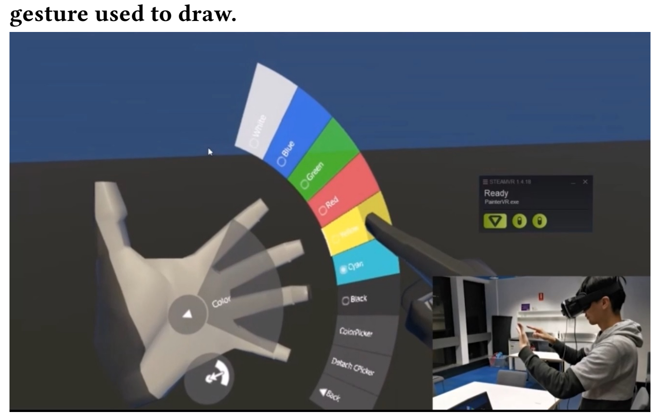

Figure 3: The menu where users can select the colour they want to draw with.

Menu Item Type	Usage	Where
Checkbox	A button that toggles an on/off state upon selection.	Undo button, Clear button, Call/Hide CPicker, Back button
Selector	A "trigger" style button with no on/off state.	Select white/red/yellow/... color
Slider	A "track" that represents a range of values, with a "handle" (a sub-item "Sticky" button) that moves along the track to select a value within the range.	Change the size of line
Text	A non-selectable item. Just display the value.	Everywhere

Figure 4: Table showing the different types of menu items, as well as how and where they are used.

3.1 Hardware

The hardware required to build 'hands on' was a Laptop, an android phone, a Leap Motion, and a phone headset (HMD). Leap Motion and the phone HMD were chosen because the team was familiar with them and had done projects with them previously.

3.2 Environment

’Hands on’ was made in Windows 10 using Unity, VRidge, and SteamVR. Programming language used was C# and the software framework was .Net version 4.x. VRidge is an android app that is part of RiftCat platform. It allows you to play PC virtual reality Apps designed for HTC Vive or Oculus Rift on your mobile VR headset. It works by streaming the game on your phone and sending the sensor data back to the PC via Wifi/USB cable. SteamVR gave us a platform to test the program during the development. This meant that it provided a platform so that we could test the program in a VR environment without needing to create a .exe file. It also provided the HMD camera transformations (position, rotation, etc).

3.3 System Tools

The system was made using Leap Motion SDK, Hover-UI-Kit, and Photon Unity Networking v2. The Leap Motion SDK provided our project with gesture recognition and the ability to track hands. The Leap Motion Interaction Engine package provided our project with the ability to grab and move around objects in a virtual environment. Hover-UI-Kit was used as it was ideal for designing a radial, multi-level, palm-based virtual menu. Photon Unity Networking v2 was used as the Network Manager to allow for multiplayer and seeing other users in the same virtual space.

4 DISCUSSION

’Hands on’ brings together work in VR, Gesture technology, and virtual menu design to create a novel interaction that allows people to collaborate naturally in a virtual environment. The VR component allowed us to extend the task of drawing by removing the physical limitations, going from traditional 2D to 3D. This has been done in other forms, such as video games and other media, but there remains a lot of potential to move and extend ordinary everyday tasks such as drawing into the virtual space.

The gesture technology allowed us to replicate the natural way that users would typically draw, by using a pinch gesture similar to how someone would hold a pen, as well as a pallet style menu on the left hand. ’Hands on’ shows the benefits of using natural interaction when moving physical tasks like drawing into the virtual space. This was seen as a improvement over other VR drawing applications that used controllers [3]. Gesture technology shows a lot of promise with regard to moving away from relying on mouse and keyboard to do tasks such as digital drawing, and bridging the gap between the physical performance of the task and its digital representation.

The virtual menu design in ’hands on’ is generalisable beyond just drawing applications. This study combined the use of embodiment, radial menus, hover selection, and selection feedback to create a menu that could be used for many other physical tasks. Embodying menus is seen as an intuitive way to incorporate them in a virtual space, and this study confirmed the benefits of palm-oriented menus in VR [1]. Radial menus have been found to be superior to list menus in terms of task-completion time [5], and combining them with hover selection rather than pinch gesture, and with selection feedback to reduce errors, we were able to create a virtual menu that was intuitive, efficient, and was resistant to errors. As technology is increasingly moving towards 3D virtual space, the importance of natural and intuitive menu systems is obvious, and building on advancements in virtual menu design the menu system used in this project presents a promising option going forward.

This project shows that by moving these everyday collaborative physical tasks into the virtual space they can be made easier and more efficient, as well as opening up the potential for new forms of collaboration beyond just video and audio [6].

5 LIMITATIONS AND FUTURE WORK

Firstly, ’hands-on’ is limited in both hardware and software. Hardware-wise, the main limitation in using mobile VR over a more advanced HMD like the HTC Vive is that freedom of movement is severely limited. Users are unable to raise or lower themselves or walk around and inspect their drawing from any angle. This restricts the potential of the drawing and equally as importantly, the opportunity for other collaborators to inspect and critique it as if the group surrounded it in a real, physical space. Part of the project involved setting up a server to connect other users into the same virtual room but they only manifested as block figures without being able to use and show their hands. With more resources, it should be possible to fully integrate those users. Moreover, it is important to consider that advanced HMDs are not as accessible as mobile headsets, but it should not limit the potential of the technology and groups who would want or need that technology.

Software-wise, more work could be done to provide feedback to users as they draw or select options. For example, when making a pinch gesture as if holding a brush, there should be a pointer that is highlighted upon the user drawing so they are aware of whether they are drawing or not. To make the application more viable, more painting tools should be built in to support users to flexibly draw as they would like to. Users can freehand as they go but drawing straight lines or getting the right proportions requires technological assistance, which could be added in the form of the system adjusting lines to be straighter or indicating lengths of recently drawn lines. In this way, the application would aim to preserve natural elements of real world drawing whilst empowering users’ accuracy and precision.

As for the utility of ’hands-on’, it is a painting application but more importantly, it is a glimpse into a future where virtual reality is not only accessible, but also practical for job types that cannot be completed over shared documents or a conference call. The hope is that the same radial, hand-affixed menu style can be retained and used for other applications, for example, building and manipulating a new office space in virtual (or augmented reality, if possible) reality. The limitation then might be in how to map functions to the menu or if other styles of menu are more fit for purpose - this would require the help of usability evaluations.

From a usability standpoint, a limitation of ’hands-on’ lies in the tangibility of the work being done. Painting is traditionally completed on a hard surface like a canvas and so it can be difficult to feel the brush and the strokes. While this can be a barrier to adoption, a potential work-around is overlaying grid lines or templates in the virtual environment to guide and help users have more control and accuracy in their drawings. Moreover, ’hands-on’ can use the infrared sensors in the leap motion device to create augmented reality so that users can draw a virtual picture on top of a real object. These approaches are an attempt at stepping in the right direction, but future work should be undertaken to find the right balance between combining the physical and virtual worlds to support collaborative work.

6 CONCLUSION

'Hands-on' project has showcased an accessible and practical solution to the increasing demands for moving ordinary tasks, which in this case is drawing, to virtual space and for enabling remote virtual collaboration on complex tasks, which transcend voice and texts. By creatively integrating VR and gesture technology, the natural user interface in our work was enhanced to address the limited usability of and to improve unsatisfactory user experience towards pre-existing designs that had been based on similar technology. As a drawing program, many designing aspects of 'hand-on', such as the placement of a menu and a pointer in the user's left and right hand respectively and the pinch gesture mimicking the gesture of holding a pen, took into consideration the natural interaction involved in this task with in mind the goal to minimise requirements for learning prior to its use. Under these guidelines, some innovative designs were born. For example, not only was the virtual menu system combining radial menus, hover selection, and selection feedback intuitive, efficient and resistant to errors, its potential to be generalized beyond drawing could contribute significantly towards a more extensive extent of VR and gesture technology applications across different tasks. Through these integrations and designs, 'hands-on' has proven that it is more than possible to retained natural and intuitive interactions involved in certain complex tasks while meeting the demands as mentioned earlier.

However, another critical aspect for enabling virtual collaboration in complex tasks was not fully realized due to both software and hardware constraints. The social application in this project is limited as users are unable to work on the same painting in collaboration with other users and they can only see other users manifesting as block figures in the same virtual space. Moreover, the lack of tangibility of the work done through the program was not addressed in our project. Though, these limitations could be overcome through some reasonable adjustments or improvements on hardware and software. With certain upgrades on the software, this project could even present a potential for empowering users' accuracy. Conclusively, 'hands-on' has given users a glimpse into a hopeful future where a multitude of complex tasks could be collaborated in a virtual space with the retention of their natural and intuitive interactions and sometimes, even with increased efficiency. More precisely, many distinctive designs derived from this project could also make significant contributions to the field of VR and gesture technology.

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