A Comparative Study of 2D and 3D Mobile Keypad User Interaction Preferences in Virtual Reality Graphic User Interfaces.

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ABSTRACT

Graphical User Interfaces (GUI) on mobiles involves user interaction of touch input on a 2D surface. With advances in Augmented/ Virtual Reality, possibilities of 3D GUIs will emerge. However, 3D GUIs do not have many design heuristics. This paper reports an experiment by collating quantitative and qualitative responses from 15 users, to explore usability problems that are likely to be encountered when a 2D interface element such as number keypad is replaced with a 3D element interface in Virtual reality. Would an interface with 3D elements perform better than the existing 2D GUIs is a moot research question? The results indicate user motivation towards using the interface inspired from 3D elements. The paper discusses issues of interaction in 2D and 3D virtual spaces with their possible implications for upcoming 3D VR environments.

CCS CONCEPTS

• **Human-centered computing → Human computer interaction (HCI)**;

KEYWORDS

Virtual reality, 3D GUI, mobile keypad, user study

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1 INTRODUCTION

Mobile phones today use GUIs that restrict them to the 2D screen, whereas certain situations have proven 3D spatial interactions better in reducing cognitive load [Lee et al. 2013]. Mobile devices have the ability to explore new opportunities in virtual world visualisations because these possess the ability to move 3D elements freely in space [Hürst and Helder 2011]. However, 3D interactions face a learning curve in shifting from 2D UI design. Several researchers have pointed out that care needs to be taken when using 2D techniques for 3D interfaces [Herndon et al. 1994]. Although extensive research has been performed in the fields of Virtual Reality and 3D interfaces, exploring opportunities in designing a spatial keypad, more specifically in the context of VR, requires the need for further study. Interaction via mouse-based input in a 2D GUI has references and defined guidelines, whereas interactions in the Virtual environment require explorations yet to be done in order to design such rules and heuristics. The paper reports a comparative study between spatial keypads inspired from 2D and 3D elements in the virtual environment. Results show higher user likability towards virtual keypad inspired from 3D interface elements. This study can be used to build design heuristics for 3D Graphical user interfaces.

2 METHODOLOGY

A user-centered design process was followed. Users were given the task of entering a ten-digit phone number with the two VR models, later they were asked to compare them using factors like efficiency, effectiveness, usefulness, and adaptability.

3 PROTOTYPES

Two VR based applications for spatial keypads inspired from 2D and 3D interface elements respectively were developed for Google cardboard using Unity3D [Unity3D 2017] and Vuforia SDK [Vuforia 2017]. 3D models for both interfaces were designed in Google SketchUp [SketchUp 2017]. The first interface includes a VR keypad inspired from the 2D Graphical user interface (refer Figure 1). The design was similar to conventional mobile keypads. Numeral data entry input was given via gaze pointer through head movement in the VR environment.

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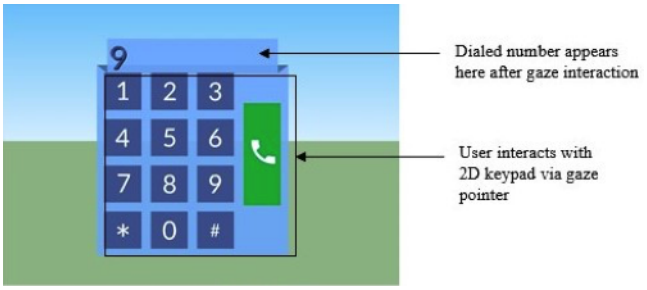

Figure 1: VR Keypad inspired from 2D Graphical User Interface.

Since the first interface was static with less of animation involved, the second interface was designed in order to address the question - How can motion of elements be depicted in a spatial keypad? This interface used 3D cubes as keys for dialling a number (refer Figure 2). These cubes were spatially arranged in a random order in VR environment. Pointing a key (cube) using gaze pointer animates it to reach a position forming a straight line with subsequently pressed keys, all arranged in front view (top panel). Once the number is animated to the top panel, a similar number key would reappear in its position. This is done to incorporate repeated entry. Since the design of 3D GUIs does not have many design examples, we are unaware of the arrangement of elements in 3D space. Virtual reality has no restriction of space as in the case of 2D mobile interfaces, hence elements can be placed anywhere in space. As a starting point to design the arrangement of elements, a random order was chosen to study user response and derive conclusions for further analysis.

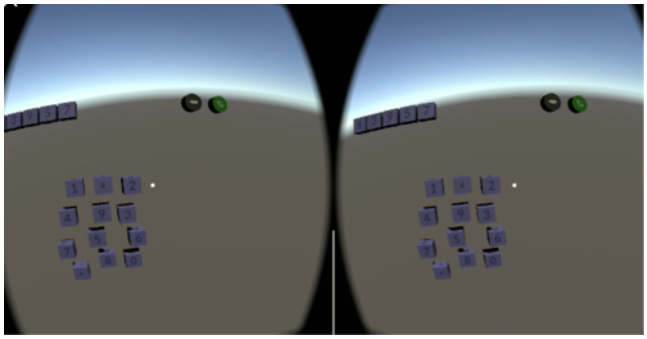

Figure 2: VR Keypad including 3D elements.

4 USER STUDY

A user study was conducted amongst 15 participant users of age group 18-22 yrs. The participants were briefed about the functioning of the prototypes at the beginning of the experiment. Users were then given a task to dial a 10-digit number using both 2D and 3D inspired VR interfaces. Semi-structured interviews were conducted to find out which interface was preferable and why? Time taken by each user to complete the task was recorded and screen recordings were studied. From the experiment, the average time taken in performing the task using 3D inspired VR interface (Average time taken = 28.26s, Standard deviation = 7.52s) is found to be comparatively less than that of 2D inspired VR interface (Average time taken = 28.66s, Standard deviation = 14.58s). Users expressed higher likability factor towards the 3D inspired VR interface, as 12 out of 15 users preferred using the 3D inspired VR interface to the 2D inspired VR interface if offered both. Users were asked to fill a questionnaire that tested two parameters - Perceived ease of use and Perceived usefulness. Results show that perceived ease of use is higher in case of 2D inspired VR interface. Since the users are used to the 2D keypad interface, they find it easier to use in comparison to 3D VR interface. In case of 3D keypad interface, better arrangement of number keys would lead to increase in perceived ease of use. The 3D inspired VR interface was found to have a better control of task, quicker accomplishment of the task, and was an easier interface for task completion. It was comparatively more productive, effective and useful.

5 DESIGN GUIDELINES

From the above research, following design guidelines for 3D GUIs have been formed: (1) Make 3D interfaces as adaptive as 2D, (2) Have provision for multiple feedbacks, for example, using animation, so as to minimise interactive lag periods, (3) Optimal use of space and cognitive load, in consonance with mental model of the user, (4) All responses in VR environment need to be dynamic and fluid as opposed to discrete responses in current 2D planar UIs, (5) Control of input via using users body orientation in VR space. This would increase precision and accuracy of the task performed thereby making use of technological advances in VR.

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