Towards a Usable Stereoscopic Augmented Reality Interface for the Manipulation of Virtual Cursors

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Abstract

The combination of Augmented Reality (AR) systems and stereoscopic display devices has created a powerful tool with which to 'supplement' our view. One application for such systems is for the augmented tele-operation of unmanned vehicles, deployed in remote or hazardous environments. Research in this area has highlighted the need for accurate 3D measurement techniques – such as through the use of virtual cursors.

This paper describes our work in the development of an AR interface designed to assist the accurate selection of positions in 3D space. We describe some preliminary experimental work using virtual cursors before discussing how we believe depth cues can be utilized to allow a user to make a more informed judgment of depth in unprepared environments. It is expected that the guidelines outlined in this report will be used as a benchmark for the development of further 3D AR cursors.

1. Introduction

Many applications of Augmented Reality (AR) will allow operators to 'annotate' and make measurements of real scenes. One possible application is the unmanned exploration of remote or hazardous environments [1]. To gain empirical knowledge about the world without the need for a physical presence we advocate that a user indicates three-dimensional (3D) positions within the world using a virtual cursor.

Investigating inhospitable environments means the environments are usually unprepared; therefore a virtual cursor would be unable to interact with the environment. Positioning of a 3D cursor in a monoscopic display without depth cues such as occlusion is a difficult task. Using stereoscopic displays can help increase the depth information available, however our preliminary work has shown this task to be highly prone to error [2]. It is assumed that the more depth information available, the more accurately a user may position a 3D cursor. To this end the purpose of this paper is to investigate the effect of additional depth cues on an AR system.

A comprehensive description of our AR system can be found in [1]. An initial experiment was conducted in order to discover the strategies adopted by users as they attempted to align a virtual cursor with a real world feature. Results proved contrary to the findings of previous work [3,4], suggesting that subjects were unable to accurately align a 3D virtual cursor with a real target. Observation of users suggested that the errors produced could be attributed to misuse of the interface. For instance, errors caused by users resting their hand upon the interface, as with a 2D mouse, causing an unintentional drift of the cursor.

Analysis of previous research led to the formulation of the research questions as follows: -

- What role do inherent depth cues play in cursor efficacy?
- Does knowledge of scale assist users in alignment tasks?
- What is the effect of the degree of cursor control on performance?
- Do shadows play a role in AR performance?
- Is Spatial Ability (SA) an Indicator of AR performance?

These research questions were designed to investigate the influence of additional depth cues and investigate the type of interface most suited to typical alignment tasks.

2. The role of cursor type

As in our previous work [2] we chose a simple upturned cone and a 3D crosshairs as our cursors. The cone cursor was further developed by the addition of a texture in an adaptation of Hou's findings [4]. Hou suggests that subjects more accurately align a 3D cursor with an object with a highly textured surface than those with a less complex texture. A cursor with a textured

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surface carries this texture information with it. Both cursor designs were chosen for their familiarity to novice users.

3. Knowledge of scale and absolute position

Knowledge of scale is vital to the comprehension of an object's size at distance. In unprepared environments, if a user cannot see a familiar object they may have no knowledge of scale. It is suggested therefore that users would benefit from the addition of a known scale representation placed in the environment. Once calibrated our system defines the position of the cursor in x, y and z co-ordinates, all calculations are then made in relation to an origin. These co-ordinates can be presented to the user in order to provide information about the cursor position. Although these co-ordinates may not relate to real world locations, they may assist the user in understanding the cursor's relative position. Positioning the origin near ground level may enhance the usefulness of this information, for example, a large negative y co-ordinate may indicate an error has occurred in judging height. Users may also use these co-ordinates to return to the origin, or a zero level in a particular dimension. Both the physical scale and the co-ordinates should increase the users confidence and knowledge of the world.

4. The role of shadows

Shadows are present in our everyday perception of the world but must be explicitly determined in AR scenes. Kersten et al [6] demonstrates how manipulation of a shadow can influence or perception of relative depth. It is assumed that if 'incorrectly' positioned shadows can detrimentally alter our perception of an objects position, correctly placed shadows should have a positive effect over scenes without shadows. As photo realistic shadows are computationally expensive to create, we proposed to investigate the role of 'token' shadows. These shadow approximations will be investigated in a correctly and incorrectly oriented fashion according to a real light source in order to investigate the benefit of behavior realism of shadows.

5. The role of the input device

Exhaustive 6DoF input devices may provide the user with too much control, particularly for static scenes where yaw, pitch and roll are superfluous. Our research has also shown that subjects are prone to errors even when using only 3DoF. Therefore we propose to give the user control over the individual dimensions. At the push of a button the user can 'switch on/off' the extraneous dimensions to avoid the possibility of unintentional movement.

6. The role of spatial ability (SA)

Studies have suggested that Virtual Environment (VE) learning does not yield the same quality of information as real world learning [6]. However, unlike VE, AR mixes real and virtual images and information. The increased focus on 3D information in the tasks discussed here suggests SA may play an important, even indicative role in AR performance.

7. Conclusions

The techniques described here are being developed to create a more accurate 3D cursor interface by increasing the depth information available to the user. Generally speaking, the more depth cues available, the more accurate a judgment of depth can be made.

Unfortunately at the time of writing comprehensive results are unavailable. However speculative results show that having control over all 3 dimensions has a dramatic effect over the system accuracy. Subjects with higher spatial ability (SA) also exhibited a higher accuracy compared to those with low SA. Less clear is the role of the other depth cues, scale, shadows and co-ordinates. Statistical analysis is underway to discover if one or more of these depth cues is useful in assisting user accuracy.

8. References

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