Improving Player Spatial Abilities for 3D Challenges

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ABSTRACT

In this paper, we describe the development of tutorial levels for navigation challenges requiring a 3D mini-map. Navigation in 3D game worlds is a common challenge for players, and it often forms a significant part of the game play in RPG and Adventure games. Navigation of the game world is typically supported by a mini-map which provides a 2D, top-down view of the game world. This mini-map might also display the position of key landmarks along with the position of the player's avatar and any other relevant actors in the game. In contrast to these 2D min-maps we have been developing a 3D mini-map to support game play that requires navigation in a 3D world. However, even understanding connectivity and structure in a simple 3D mini-map requires the player possess some complex abilities in terms of mental rotation and translation between 3D and 2D. Acquiring these skills is fortunately well studied in psychology and we draw on outcomes from this field to develop progressive challenges that can act as tutorial levels for players. The intention is to allow players to gradually learn how to interpret the 3D mini-map before advancing to more difficult levels in the game. This work encompasses two important aspects. First it draws on findings from cognitive psychology to support the design of spatial challenges in computer games and secondly it considers how computer games can be used in an educational capacity to help improve spatial abilities.

Categories and Subject Descriptors

H5.1 [**Information Interfaces and Presentation**]: Multimedia Information systems – *Artificial, augmented, and virtual realities.*

General Terms

Design, Human Factors

Keywords

Spatial skills, 3D Navigation, Mini-map, Tutorial levels

1. INTRODUCTION

Many computer games make use of challenges in the game play that require a player to possess 3D spatial skills. Some typical examples are puzzle challenges such as 3D Mazes and Tetris. Likewise, a range of spatial skills may be required to overcome navigation or wayfinding challenges. Both navigational and puzzle challenges are common elements in action, adventure and RPG genres [1]. Our project is looking at how to develop navigational tools to support players orientating themselves in 3D game worlds, especially complex 3D networks.

Many games provide 3D game worlds where the wayfinding challenges are supported by 2D mini-maps. It has been found that travellers tend to find their way using a combination of "survey, procedural and landmark knowledge" [14]. A mini-map provides *survey* knowledge for the game player, that is, an overview of relevant spatial information that lets them construct a cognitive map of the game region [14] (figure 2).

Figure 1. A pseudo top-down map view from Total War [2]

The mini-map in games is usually shown in a top-down view, like a traditional map. Occasionally, the map uses some pseudo-perspective to give the player some additional information about the game world (figure 1). However, mini-maps are predominantly 2D in nature, much like a traditional map. For example, games like *Total War* [2], *Infamous* [3] and *Prototype* [4] are set in open 3D worlds coupled with mini-maps and world maps that allow the player to access a 2D, top down, view. These maps indicate such things as locations, targets, threats, and in the case of *Infamous* and *Prototype* use up or down arrows indicating

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that the target is higher or lower than the player's position. Other games such as *Devil May Cry* [5], *Ninja Gaiden* [6], *Resident Evil* [7] implement game play with a room to room progression where the world exists on different levels. For example, the *Devil May Cry 4* mini-map shows a top-down (plan) view of the levels which are connected at limited places by stairs (Figure 2).

In our work we wish to support more complex networks were the game world involves a 3D network, which requires maze like navigation. A good example of the game play that might use this is from the *Descent* [8] series. In *Descent* the player flies a spacecraft that can move in any direction without the consequence of gravity. For example the original navigation challenge requires the player to fly through a network of caves in a mine on Pluto destroying droids and shutting down reactors throughout the mine. Although the game provides unique six-degree of freedom movement, the player is only provided with a map of the current level of the mine.

Because of the complexity of 3D navigation our goal is to provide tutorial levels in a game that allow players to progressively improve their spatial skills and hence overcome progressively more difficult challenges. Our investigation quickly enters into a field that has been much studied in psychology, that is, how to best educate or train an individual's 3D spatial abilities.

Figure 2. The mini-map view from Devil May Cry 4 [5]

2. SPATIAL ABILITIES

Spatial challenges in 3D involve a range of high-level cognitive skills, including the ability to visualise 3D space, mentally twist objects in the space, map between two dimensions and three dimensions and imagining how something looks from different directions [9]. Tasks such as mental rotation have been shown to be quite a cognitively demanding task [15]. Even the simple example shown in Figure 3 demonstrates this quite well.

Five factors have been formally identified as important in overcoming 3D spatial challenges [10]. *Spatial Perception* requires "the location of the horizontal or the vertical in spite of distracting information". *Visualization* involves the "ability to visualise a configuration in which there is movement or displacement among (internal) parts of the configuration. *Mental Rotation* is the "ability to rapidly and accurately rotate a 2D or 3D-figure". Interpreting *Space Relations* is the "ability to comprehend the spatial configuration of objects or parts of an object and their relation to each other". *Spatial Orientation* is the "ability to orient oneself physically or mentally in space. Therefore, the person's own spatial position is necessarily an essential part of the task".

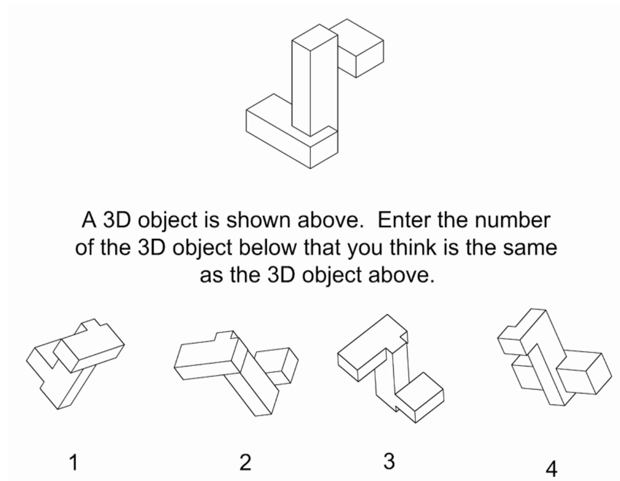

Figure 3. A typical spatial challenge

All of these spatial skills can be required when a player needs to overcome a challenge in a 3D computer game. Although we are focused on providing a tool that enhances a player's spatial performance in a game we expect this tool could also act as a learning tool with more general application to tasks such as 3D modelling. Indeed there has been a lot of work in the psychology domain to understand how individuals can improve their spatial skills. These findings support the use of 3D games as a learning tool. For example, it has been found that active exploration helps subjects develop a 3D understanding of the structure of objects [11]. Observers who actively rotated 3D novel objects on a computer screen later showed faster visual recognition of these objects than passive observers [12]. Likewise, active exploration of novel 3D objects leads to better performance on tests of object recognition and mental rotation [11]. It is also known that motor activities, such as exploratory tasks, are important in perception and cognitive development [11]. Furthermore spatial skills can be improved through practice that allows a learner to see the relationship between the 2D and 3D features of objects [13].

The familiar puzzle game of Tetris has also been used to study how users make use of information seeking or "epistemic" actions such as physical rotation of objects in a game environment [16]. Such epistemic actions contrast with "pragmatic" actions. Epistemic actions provide information, while pragmatic actions directly advance the player's progress towards achieving a goal. For example, in the game of Tetris it has been shown that direct physical rotation of objects is more time-efficient than the corresponding mental rotation and indeed this strategy distinguishes novice players from experts [16].

3. LEARNING TO NAVIGATE

Using these principles from psychology we have developed a 3D mini-map that can be used to assist navigation tasks at different levels of complexity. The full tool which provides three traditional 2D sections and a 3D perspective view (figure 4). The perspective view can be rotated and also provides a small (grey) orientation cube which indicates the orientation of the three 2D sections.

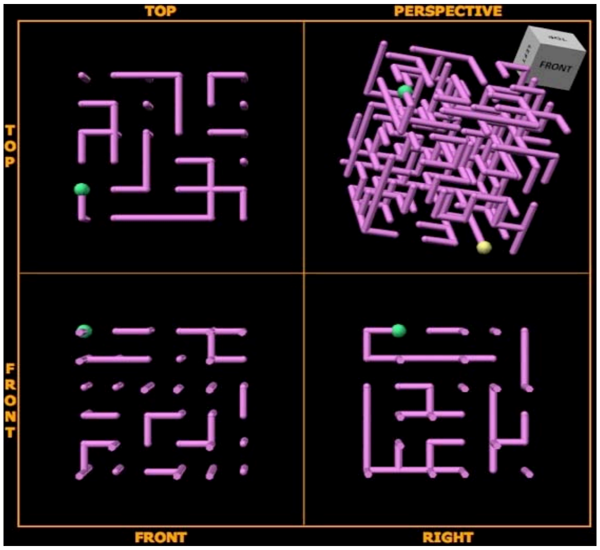

Figure 4. The full view of the navigational tool

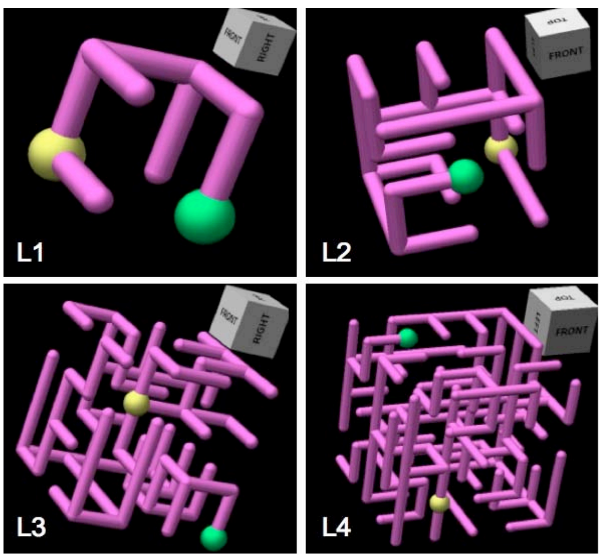

Figure 5. Tutorial Levels 1-4

For testing purposes we use this view as a maze like challenge where the player has to move from their position (green sphere) to the target location (yellow sphere). The network is automatically generated with the level of complexity based on based the tutorial level. Figure 5 shows typical examples from levels 1-4.

Hence this tool serves our purpose of supporting tutorial levels for navigational challenges within a game. We also note that such a tool may have more general implications as an educational tool for improving spatial skills which can be employed in other, more "serious" domains, such as 3D modelling, CAD drawing and architectural design.

4. CONCLUSION AND FUTURE WORK

We have developed a 3D mini-map that can be used to assist navigation tasks at different levels of complexity and to support tutorial levels in a game that contains difficult 3D navigation challenges. Before proceeding to integrate this tool into a complete game we intend to test this tool on a range of subjects and gather quantitative data about just how effective it is in training users.

We also note that this tool may have more general implications as an educational tool for improving spatial skills which can be employed in other, more "serious" domains, such as 3D modelling, CAD drawing and architectural design.

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