Virtual Planning Rooms (ViPR): A 3D Visualisation Environment for Hierarchical Information

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Abstract

The Future Operations Centre Analysis Laboratory (FOCAL) at Australia's Defence Science and Technology Organisation (DSTO) is aimed at exploring new paradigms for situation awareness (SA) and command and control (C2) in military command centres, making use of new technologies developed for virtual reality and real-time 3D animation. Recent work includes the conceptual design and prototype development of the Virtual Planning Rooms (ViPR), an innovative visualisation environment that displays multi-media information on the walls of immersive virtual rooms. The operator is able to view and interact with relevant information within the octagonal rooms, and to explore different levels of abstraction or alternative data sets by navigating through doorways to adjoining rooms. Random accessibility throughout the environment is also possible via interaction with a 3D map representing a high level view of the data. Potential uses for ViPR include course-of-action visualisation, planning or display of other hierarchical data sets. This paper provides an overview of FOCAL, followed by a brief description of ViPR that includes its conceptual design and prototype development, together with future directions.

Keywords: 3D user interface, Virtual Reality, Planning Rooms, Decision Trees, 3D visualisation, 3D rooms.

1 Introduction

Military decision makers are faced with an increasingly challenging task in a complex and highly dynamic domain that spans roles such as force-on-force operations, asymmetric warfare, global terrorism, and humanitarian aid. Technological innovations and new operational paradigms such as network centric warfare and effects-based operations are both providing and requiring more and more information to be made available to the commanders, and increasing awareness of cultural and legal issues. Future command and control systems will need to support commanders in this complex environment so that they can make the right decisions at the right time. Researchers at the Future Operations Centre Analysis Laboratory (FOCAL) of Australia's Defence Science and Technology Organisation (DSTO) are exploring new paradigms for situation awareness (Endsley 1995) and command and control in military operations centres (Lambert 2001) making use of the new technologies developed for simulation, virtual reality, and real-time 3D animation.

2 FOCAL

FOCAL is centred on an SGI Reality Centre - a semi-immersive, multi-user, collaborative environment that enables a command team to interact with each other as well as the large Virtual Reality (VR) display. The display comprises a 12' radius, 150° field-of-view spherical screen utilising three pairs of Digital Light Processing (DLP) projectors providing passive stereoscopic (VR) imagery. Image generation is handled by an SGI Onyx3400 using the IRIX operating system. The relevant challenges for FOCAL in this context include: how, what, where and when information should be presented to a command team and how can they interact with the information effectively within this unique environment. Figure 1 illustrates the scale of the FOCAL screen and the current operator seating locations.

Figure 1: FOCAL large spherical screen.

A range of traditional media items can be displayed in FOCAL, including text, images and video. Research is being directed at the development of novel media for FOCAL, including Virtual Advisers, Virtual Battlespace, Virtual Video and Virtual Planning Rooms (ViPR). For more details on these projects and their integration, refer to Wark et al. (2004). Additionally, parts of these projects can be seen in Figure 1, particularly FOCAL's Virtual Advisers left of screen and the Virtual Battlespace as the main backdrop.

3 ViPR

ViPR is proposed as a visualisation tool for course-of-action (COA) diagrams in collaborative semi-immersive environments. It could also be applied to other domains such as planning, or viewing any information at different levels of abstraction within the FOCAL environment. It aims to move beyond the desktop metaphor and provide an effective visualisation environment suited to 'natural' multimodal interaction with large display screens. The 3D metaphor, coupled with VR technologies, aims to allow the users to focus on particular details whilst maintaining contextual information in the background. The prototype system discussed in this paper is intended to elicit user requirements and allow validation of the concept.

3.1 Design

The initial motivation for the design of ViPR spawned from a requirement to display more information on nodes of decision trees, e.g. COA diagrams such as shown in Figure 2.

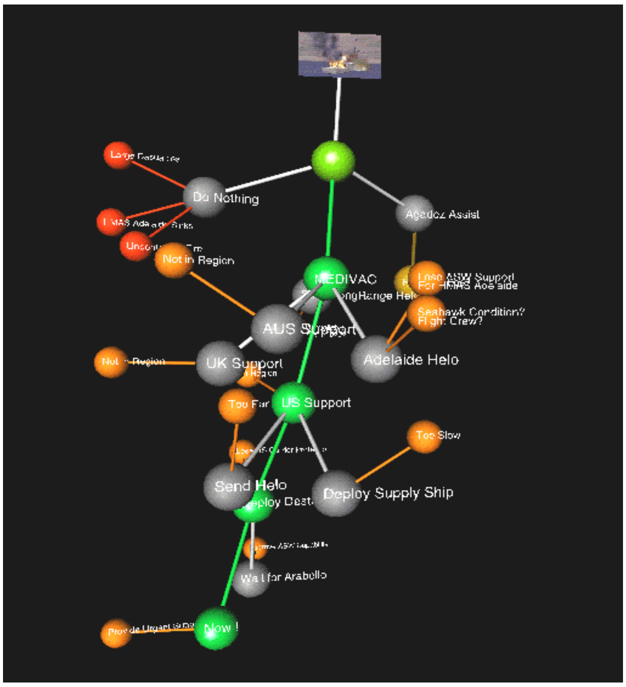

Figure 2. 3D COA visualisation

While visualisations such as those in Figure 2 can provide an ability to globally view a plan, finer details of the decision process at each node are not represented. For instance, any node within the COA tree represents a complex decision that was based on the information available at the time. Similarly, during the COA development process, it may beneficial to bring together relevant information pertinent to the decision making process into one single integrated application. This may include live data feeds such as target position and heading or weather information. Other information such as the terrain conditions, hardware capabilities, policies and doctrine may also need to be shown. Visualising this information on a 3D tree structure is difficult, as the information would create unresolvable clutter. ViPR addresses this by positioning additional information *inside* the node that it is associated with. The operator's viewpoint is placed inside the node to allow viewing of this information, or the exploration of other nodes within the diagram. The nodes of the tree become individual rooms when viewed from within, and the tree's edges become corridors between these rooms. The rooms provide natural containers for information associated with a node, whilst providing space to display this information.

This environment has the potential to display large amounts of information, however, this information needs to be managed correctly and provided at the appropriate level of abstraction, as too much information can actually hinder the decision making process (Omodei et al. 2003). The walls of the ViPR rooms allow grouping of related information, enabling the wall edges to become topic separators. For example, political information may be displayed on one wall, while weather information is displayed on the next, enabling the user's understanding by collecting related concepts (Gershon and Page 2001). Similarly, when the room represents a decision point, each wall can display an available option and its supporting information. Each wall with a doorway to a neighbouring room displays summary information of the adjoining room's content, cueing the user by providing information at a higher level of abstraction. The operator can immerse themselves within these rooms and view the information at a high level of abstraction or explore deeper for more detail as required. Additionally, the corridors between rooms may provide a transitional or temporal component. For example, end nodes could be used to view the consequences of a particular COA, through the use of Virtual Video technologies or other media.

Virtual environments that take on room characteristics for the display of information have also been proposed for other domains. The Web Forager (Card, Robertson and York 1996) provides a library type metaphor to HTML pages by grouping them into 3D interactive books (WebBooks) and positioning them on bookcases within a virtual environment. ViPR is also involved in the display of electronic information, however, ViPR positions most relevant information onto the surrounding walls, rather than using a book metaphor. The Task Gallery (Robertson et al. 2000) also places content on the walls, however, it doesn't use the rooms to contain related information. The rendering quality of imagery and textual content within ViPR, we believe, will be fundamental to its useability. Previously textured captions in 3D environments have been largely illegible in all but optimum viewing angles and distances, due to low quality texture maps being affected by perspective distortions and rotations. Encouragingly for ViPR, the recent advent of computing power and improved rendering techniques has demonstrated increased legibility in small fonts, even when substantially rotated about the vertical axis (Larson et al. 2000).

The ViPR environment is designed to be dynamically built from an XML description, relying on a library of pre-modelled components that can be combined in various configurations. The walls contain information panels that can provide static and dynamic media content, with ambitions of live data feeds and interactive applications available within the ViPR environment.

3.2 ViPR Interaction model

Unlike games, it has been decided that the selection and navigation model for ViPR should be constrained, by default, to aid user interaction (Bowman, 2001); a practise also implemented in The Task Gallery project (Robertson et al. 2000). This was implemented by reducing the available degrees-of-freedom (DOF) of interaction devices during navigation and selection tasks within ViPR. This was applied to the V-Wand (Fakespace) and the Australian National University developed hand-gesture recognition system (O'Hagan 2002), both 6DOF devices currently integrated into FOCAL. The V-Wand is an electromagnetically tracked selection device that also contains a thumb controlled joystick that we have mapped to viewpoint rotation. The hand-gesture recognition system recognises five discreet hand-gestures, with our implementation focused on the point gesture. Additionally we are exploring 'natural' interaction with FOCAL's large screen through the use of multimodal input. For example, being able to query specific content on the screen through the combination of spoken natural language and untethered hand pointing. This integrates automated speech recognition, natural language processing, dialogue management and the interaction devices (Wark et al. 2005). The ViPR environment provides the opportunity to develop a custom interface for these novel interaction technologies and to further explore their effectiveness in these unique environments. Due to the constrained DOF, ViPR also allows interaction via a standard keyboard and mouse, whereby the cursor keys are mapped to the viewpoint rotation and the mouse is used for item selection.

To simplify interaction, when an operator enters a room, they are positioned in the centre of the room automatically. This provides a first-person view of the available information and doorways to adjoining rooms by simply rotating the viewpoint. Turning around 180° shows the doorway back to where the operator has come from, as we do in the real world. Selecting any of the doors will take the person to the associated room.

ViPR is designed to be used in conjunction with a 3D tree diagram, similar to that shown in Figure 2. The 3D tree diagram may be utilised in several ways with ViPR. First it provides a global view of the information. Secondly, the 3D tree diagram can be used as a direct navigation tool, enabling the operator to switch their viewpoint to another room by selecting the corresponding node of the tree. This provides random accessibility to rooms within ViPR, rather than constraining the operator to traverse the structure in a sequential manner. An operator may switch between the ViPR room and the tree view, rather than exclusively use one visualisation method.

3.3 Implementation

From these design criteria, two implementations of ViPR prototypes have been developed. The first version, implemented in OpenGL Performer, received positive feedback from visiting staff and provided a suitable proof of concept, while the second implemented in TGS Open Inventor has overcome some previous limitations and has had more effort directed at refining specification and useability. From previous designs it was found that octagonal rooms were more efficient for presenting information than rooms with less wall segments, due to the ability to view more walls simultaneously. To allow for dynamic creation of ViPR, the rooms were made from a collection of predefined pieces. These pieces include

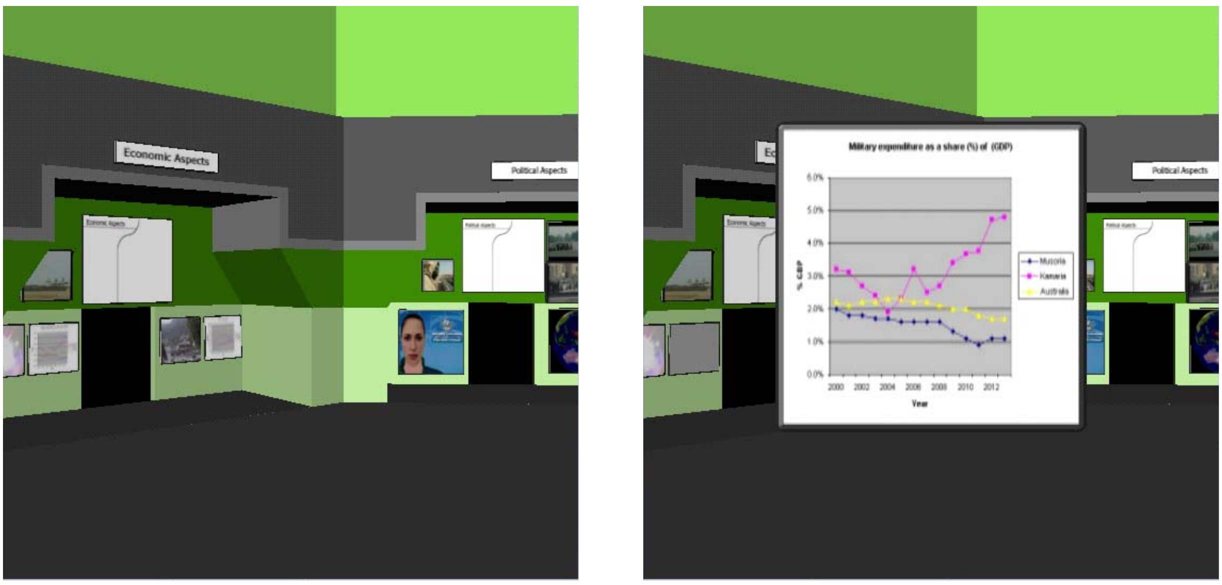

Figure 3. Two screenshots of a ViPR room section, demonstrating a media item before and after selection. The panel to the immediate left of the left doorway has been selected and brought forward to the user.

wall sections, image screens and other media panels. The room's outer structure was created from eight individual pieces arranged in an octagonal shape, with each piece constructing 45° of the overall room. These pieces each contain their own section of floor, ceiling and wall (essentially shaped like a slice of pie with the filing removed).

Additional implemented interaction capabilities include the ability to look into the room from outside its walls, the ability to magnify content beneath a hovered pointer, as well as bringing selected content off the wall into the immediate view of the operator as shown in figure 3. Viewing the room's contents from outside the actual room enables a wider viewing angle than can be achieved from within the room's confines. Previewing of media content is available by scaling media items under the cursor, providing a 30% zoom to aid legibility or recognition of distant media items. Additionally, media items displayed on the walls can still be selected, but instead of the viewer being moved over to the item's location, the media item is removed from the wall and brought to the viewer's location. The selected item is animated from its original location to a levitating position in front of the viewer. Further selection of the item returns it too its original location. This bringing of the media item to the operator, rather than vice versa, allows the contextually relevant information to be associated with the selected content.

4 Evaluation and Future Work

FOCAL provides an environment within which to evaluate and develop 3D technologies for C2 applications. ViPR is nearing a suitable level of development to enable an evaluation of its effectiveness as a visualisation environment for FOCAL, particularly its ability to provide media rich information at different levels of abstraction which is currently not available in conventional tree visualisation products. The legibility of displayed information and the overall usability of the tool will also be explored. Pending outcomes from evaluative studies, refinements and further requirements gathering will continue with the goal of developing a suitable visualisation environment for hierarchical information in a 3D environment.

5 Conclusion

This paper has provided the design of ViPR aimed at exploring alternate visualisations for course-of-action diagrams. Within ViPR, the operator is able to view and interact with relevant information, and to explore different levels of abstraction or alternative data sets by navigating to adjoining rooms. Random accessibility throughout the environment is also possible via interaction with a 3D map representing a high level view of the data. Potential uses for ViPR include course-of-action visualisation, planning or display of other hierarchical data sets.

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