The Parallel Worlds System for Collaboration among Virtual and Augmented Reality Users

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Abstract

We present an approach to asymmetric collaboration where participants seamlessly collaborate in parallel virtual and real worlds. We present a heterogeneous distributed environment that brings together multiple users and multiple interaction modalities. As a proof of our concept, we developed a working system applied to a chess scenario, where a novice is capable of learning the rules of chess in an augmented reality system, while playing against a remote expert, who interacts within a virtual reality system. An intelligent agent acts as a referee and a tutor to the novice. In addition, different interaction modalities, such as natural voice synthesis and speech recognition are added into the system. We envision that this collaboration paradigm and many of the built-in components can be reused for more complex tasks, such as remote maintenance and diagnostics and industrial training applications, among others.

Keywords: Augmented and Virtual Reality, Asymmetric Collaboration, Multimodal Interaction.

1. Introduction

We present a paradigm for asymmetric collaboration where participants seamlessly collaborate in parallel virtual and real worlds. A particular scenario of where this occurs is in novice-expert systems. In this scenario, a novice wears a head-mounted display (HMD) that gives him an augmented view of the real world. A distributed group of remote experts collaborate on virtual replicas of the real world through a virtual reality system, providing assistance and training. As a test-bed application, we developed a collaborative chess scenario, as depicted in Figure 1, where a novice is able to learn the basics of chess in an augmented reality environment while playing against a remote expert.

The setup of our demonstration consists of:

The novice interface: The novice sits or stands in front of a real chessboard with real black pieces. The novice sees the environment through a HMD and the view is augmented by overlaying virtual white pieces in the right positions as shown in Figure 1. An overhead camera mounted over the chessboard is used to monitor the novice's moves.

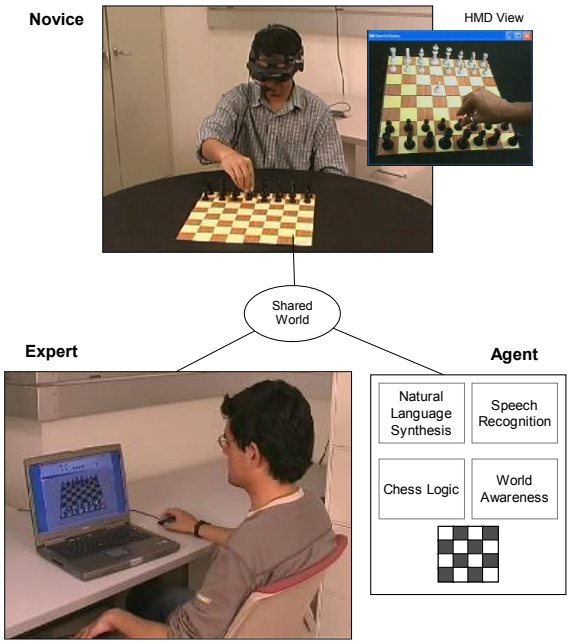

Figure 1. Asymmetric Collaboration

The expert interface: The expert interacts synchronously with the novice through a laptop. The view of the expert is a virtual reality replica of the game. The chessboard and the pieces are entirely virtual.

An additional novice interface will be setup mounted on a dummy head so we can show continuously the augmented view while visitors try the novice interface.

The Parallel Worlds demo requires space for three laptops (for the two novices and the expert) and the space for the chessboard. The setup for each of the novices includes a HMD with attached lipstick camera and their control units. The expert setup consists only of the laptop. Other equipment includes the tripod for the dummy head and the overhead camera with its own tripod.

2. Storyboard

Our demonstration is aimed to illustrate three key aspects of our system: asymmetric collaboration, intelligent agents and multimodal interaction.

Asymmetric collaboration is demonstrated through a collaborative chess game. A novice plays with real pieces on a real chessboard augmented through an HMD, against a remote expert who interacts through a virtual reality interface. The novice learns the basics of chess while playing against the expert and aided by different visual cues in the augmented view as well as by the feedback provided by the intelligent agent (IA). The intelligent agent acts both as a referee and a tutor as it provides suggestions to the novice and expert and feedback of their moves.

Multimodal interaction is necessary to provide a natural interaction with the system without obstructing the game play of both expert and novice. This is demonstrated using natural language synthesis of the IA's response and automatic speech recognition for the novice user. In addition, speech communication is enabled between the novice and expert using voice-over-IP.

The demo begins with a chessboard in its initial position. (Figure 3). When the VR user moves, the move is seen in real-time in the AR HMD and the agent provides feedback of the moves. We demonstrate our algorithm for real-time marker-less registration allowing the novice user to look around while standing in front of the

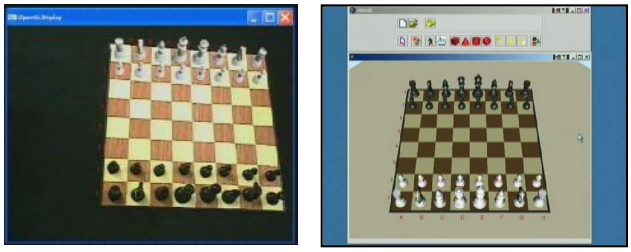

Figure 3. Novice and Expert view

chessboard.

We also demonstrate the capability to track the real pieces by allowing the novice to move the real pieces, as he/she normally would when playing against a real opponent

Figure 4. Novice view when moving a piece

(Figure 4). Whenever a piece is moved, the agent detects a move and provides feedback to both users. In the case of an illegal action, we demonstrate how the agent recognizes the illegal situation and provides an explanation on why it is illegal.

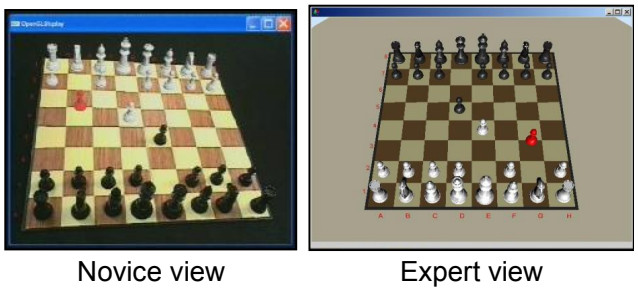

Figure 2. Novice and Expert view when moving a virtual piece

When capturing pieces, different approaches are taken depending on whether the captured piece is white (virtual) or black (real). For virtual pieces, it is easy to remove automatically the captured piece. However, for real pieces we rely on the intelligent agent and the novice. Whenever a real piece is removed, the agent indicates the novice to remove the captured piece, which is shown in the HMD view as marked with a red spot that sticks to the piece until it is physically removed (Figure 5). The agent maintains the state of the game and invalidates subsequent moves until the novice complies. We demonstrate these capabilities by letting the user ignore the agent and continue playing without removing the captured piece. We see in the demo how the game only continues when the agent has detected that the captured piece has been removed.

Figure 5. Visual cue for notifying the novice to remove a piece. The black piece (real in novice view), captured by the white pawn, has a *sticky* red spot below

Ultimately, it will be possible to allow the visitors to engage in a real chess game. One person will be wearing the HMD and using the AR system, while the other interacts with the virtual reality system.

Our system is demonstrated in the accompanying video at: http://www.caip.rutgers.edu/~cdcorrea/pw.mpg