A Video-Based Augmented Reality Golf Simulator

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ABSTRACT

Recent advances in augmented reality technology (AR) have opened a tremendous scope of applications. We describe a use of the technology in virtual golf gaming that exemplifies how the technology can be made to suit the specific needs of distinct applications. Various challenges involved, proposed solutions, and the results obtained are described.

Keywords

Augmented reality, virtual golf, fiducials, camera pose, graphics.

1. INTRODUCTION

With recent advances in computer video processing capabilities, augmented reality has become an important area of research.

We propose use of AR in virtual golf gaming. Virtual reality has also been used for this sport [1-2]. However, the proposed method is much more economical than the systems cited above. Additionally, augmented reality provides a higher fidelity *feel* of the game.

One of the major issues in AR is the accurate merging of the virtual world with the real world. It entails knowledge of the orientation of the camera (or the user's head) in the real world. Several approaches have been used to compute camera pose. We start with the self-tracking system of [3] and adapt it to our application by improving its real-time performance and making it more robust to imaging conditions.

In the golf application, another important issue is tracking of the golf ball in the video images. We developed a method for tracking the fast moving ball in video frames.

2. SYSTEM OVERVIEW

A camera mounted on the user's head grabs images of the real environment that includes the fiducial board [Fig. 2b] and the golf ball lying on the floor. The system processes these images in real-time to estimate the camera pose, track the golf ball, and display the augmented environment to the user via the head-mounted display (HMD) [Fig. 1].

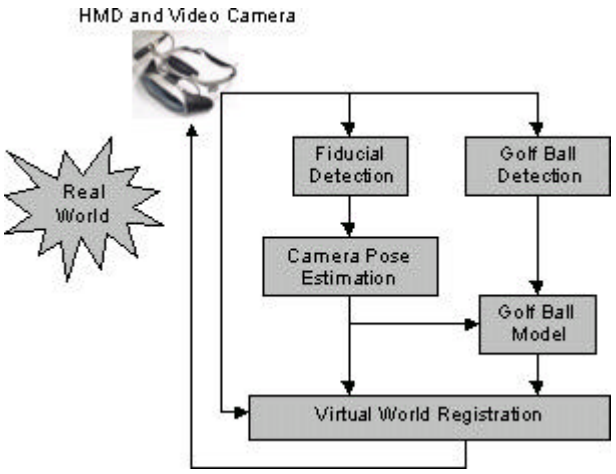

Figure 1. System block diagram.

3. IMPLEMENTATION DETAILS

3.1 Fiducials Detection

Fiducial detection is the first step in camera pose estimation and it is a computationally-expensive process. Carefully designed fiducials are placed on the ground. After evaluating different types of fiducials, we designed a square-shaped fiducial with some unique characters inside (Fig. 2a). The detection and recognition of the landmark are very robust.

Figure 2. (a) Fiducial, (b) board with calibrated fiducials.

3.2 Camera Pose Estimation

Once the fiducials are detected and identified, the system uses their screen positions to calculate the camera pose. In this work,

we adapted a recursive filter motion estimator, namely the iterative Extended Kalman Filter (iEKF), to perform 3D-motion and 6D-pose estimation [5].

3.3 Golf Ball Detection

Golf ball detection is an added requirement for this application of augmented reality. Thus, the computational requirements are further constrained. Additionally, the ball appears diffused even for a nominal putting stroke, so the boundaries cannot be traced reliably. We developed a variant of our technique [6] for ball detection.

3.4 Modeling and Graphics Rendering

Camera pose is used to obtain the 3D position of the golf ball in world coordinates. The z coordinate for the point where the ball is placed just before being hit is assumed to be zero. When the ball is hit, it remains in view for about three to ten frames. The speed and direction of the real ball is computed from these frames and the virtual ball is introduced into a virtual golf course with those same parameters.

4. SIMULATION RESULTS

Our system comprises a Toshiba video camera with F15mm lens, Sony Glasstron head-mounted display, a dual Pentium II machine (2x500Hz, 512MB RAM) with Windows NT Workstation 4.0, and Meteor II frame grabber card.

Playing the game-- The ball is placed on the side of the virtual putting green. The player hits the ball aiming it towards the virtual hole on the putting green. While the actual ball may follow any path, the motion of the virtual ball is computer-controlled.

The described system achieves a frame refresh rate of 12-13 frames per second.

Figure 3. The virtual golf ball moving towards the virtual hole, just after putt. Real ball is occluded by putting green.

5. DISCUSSION

The application of augmented reality to virtual gaming has been demonstrated. We learned that the image segmentation process is effective in reducing the overall computational requirements of the system, and thus appears to be the key to achieving real-time augmented reality.

6. ACKNOWLEDGMENTS

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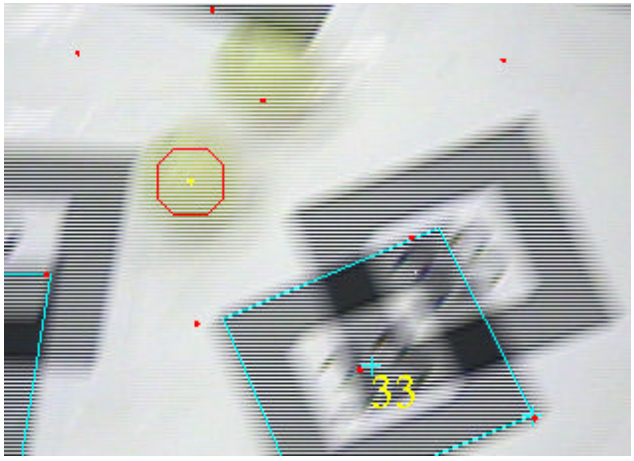

Figure 4. The fiducials and the golf ball being detected and tracked under fast camera motion.