CamBall – Augmented Networked Table Tennis Played with Real Rackets

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ABSTRACT
We present a computer system for natural interaction in an augmented virtual environment, enabling people to play table tennis over Internet/LAN with real rackets. No special hardware is required except for the web cameras. The pose of the rackets is computed by marker detection from the image. The players see each other in the camera image, which is streamed real time over the network. The multicast implementation enables a network audience to view the game, too.

Categories and Subject Descriptors
H.4.3 [**Information System Applications**]: Communications Applications – *computer conferencing, teleconferencing, and videoconferencing;* H.5.1 [**Information Interfaces and Presentation**]: Multimedia Information Systems – *artificial, augmented and virtual realities.*

General Terms
Algorithms, Experimentation, Human Factors.

Keywords
Virtual Environments, Augmented Reality, Network Games.

1. INTRODUCTION
Among various fields of computer graphics, real time marker detection from camera produced video stream is most closely related to Augmented Reality (AR). A popular application of AR technology is collaborative gaming [1]. For example, [2] describes an implementation of AR table tennis between two players, using magnetic trackers and sharing the same computer processing unit. Similar technology has also been used for a commercial arcade implementation [3]. On the other hand, the virtual reality (VR) table tennis game [4] is implemented over a computer network, but it does not involve video image augmenting and it is based on the traditional mouse interface.

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Our "CamBall" solution combines the virtues of these different approaches for an augmented table tennis game in a computer network system. Natural user interaction is accomplished by real-time marker detection from the camera image. Thus two people at remote locations can play virtual table tennis against each other using real rackets, with no special hardware required except for the web cameras.

2. IMPLEMENTATION
Figure 1 shows a schematic drawing of the computer system for the game. The hardware for each player consists of a PC workstation and a web camera. The PCs are connected with Internet or LAN network. The cameras are aimed towards the players, who hold in their hands real table tennis rackets. Each racket contains a marker, which enables the racket's pose (distance and angle) to be computed from the video image.

A computer program is synchronized between the players, defining a shared virtual ball, table and net. When the racket's location meets the virtual ball within given distance, a hit is registered, the new ball trajectory is computed, and the ball parameters (time of impact, new trajectory) are sent via multicast address to the other player. Additionally, hits and bounces are accented with sound effects.

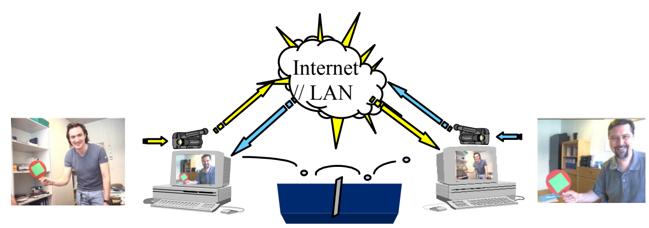

Figure 1. Computer system and virtual objects for augmented networked table tennis

3. MARKER DETECTION
In our application we only need to detected a single marker from the video image; also, it is sufficient to detect just the marker's normal direction but not the rotation around the normal. Thus we use the most simple marker we could think of, i.e., a colored rectangle of given size (10x10 cm) which is glued to both sides of the racket. Such a marker can be detected even from low resolution (176 x 144) image from the typical playing distances of 2-3 meters.

Green marker color was chosen, as it typically does not occur as often as other basic colors in room interiors or clothing. To preserve the bright green colors in the camera image, however, a relative good quality camera is recommended, otherwise the room's lighting conditions and/or the image brightness and saturation may have to be adjusted case-by-case.

For marker detection, the marker boundary pixels are determined by applying region growing to the found "green" color area(s), rejecting those being too small/large or having obscure shape. The marker corner points are then located by fitting two diagonals (with local max lengths) to the marker boundaries. The marker pose in the virtual objects' coordinate system is finally determined using laws of weak perspective projection. A detail mathematical description and performance analysis of our marker detection and pose calculation method is provided in [5].

4. PLAYER'S VIEW

Figure 2 shows a screenshot of the player's view of the game. Each player sees on his/her computer monitor a virtual racket corresponding to the pose of his real racket. The video image of each player is compressed in real time and streamed continuously to the other player, and shown at the other side of the table. VTT's proprietary MVQ (Motion Vector Quantization) software [6] is used for efficient video compression and streaming.

Figure 2. Player's view of the game

5. SOLO GAME

A simple solo game mode is provided for playing against a "wall". In the more interesting version, a player can actually play against him/herself, as the video image of the player is shown at the other end of the table (see Figure 2 again). Here we had to decide which side should then hit the ball, the "virtual me" (racket), or the "video me" (image at the end of the table)? Our solution is to have both sides hit the ball at the same time. Consequently, the game contains two balls, and the user has to hit the balls twice as frequently as normally.

6. NETWORK AUDIENCE

A network audience option facilitates viewing of game tournaments, for example. Thus the video stream and ball parameters from both players are multicast to the people in the network who have joined to watch the game. The audience members see on their screens the same virtual/video game content as the players, with the ball trajectory as an added component. The audience may also rotate the view to different sides and angles; see Figure 3.

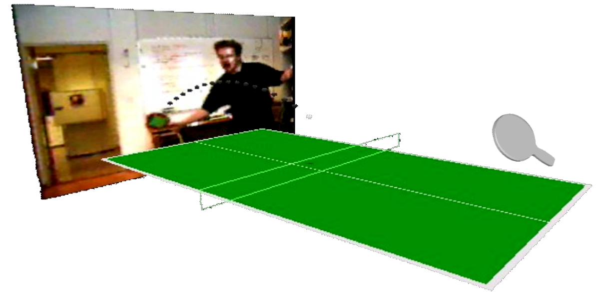

Figure 3. Audience view

7. SIMPLIFICATIONS

We have not attempted to implement full correspondence to the real game, to account for air resistance, friction etc. Adding more physics would be possible, but it may not be worth the effort. In our experience, the game can actually be more fun with some simplifications.

For example, to keep the ball "live" longer than normally, the ball is directed slightly towards the table, and hits are registered at a larger diameter than the actual racket's. Slow motion balls are most useful for practice, and they also provide a nice exercise tool for elderly and handicapped people.

8. FUTURE WORK AND CONCLUSIONS

Directions for future work include e.g. detecting the serve by gesture, audio component for chat between players, and implementing the game for video HMD glasses with stereo virtual objects. Also, marker detection accuracy could be greatly improved by employing two cameras for tracking [7].

The CamBall game is available by free download from our web pages [8]. The table tennis implementation described here can also be generalized to a wide variety of other augmented networked game concepts.

9. REFERENCES

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