Humanoid avatar plays a competitive game of table tennis

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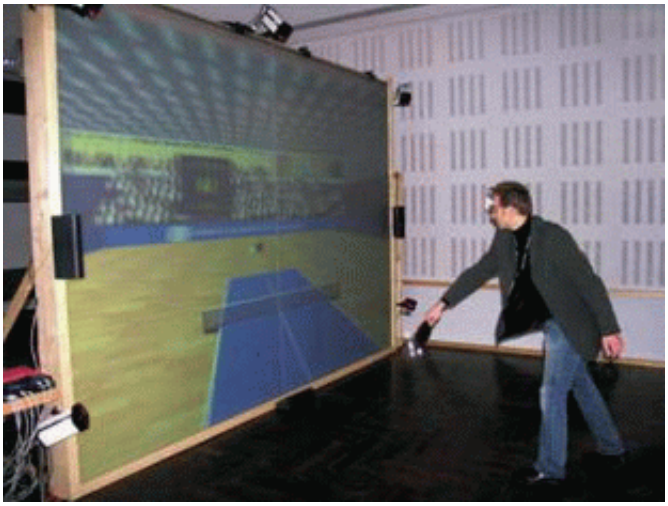
This screenshot from the running simulation shows the virtual player and background on the screen at an angle. Image Credit: Rusdorf, Stephan, et al. © 2006 IEEE.

Recently, scientists have designed and built an immersive table tennis (or "ping-pong") simulation that allows a human to compete against a computer. While most virtual reality environments support slow- or medium-speed user interaction, the new table tennis simulation can realistically respond to the top ball speed of most non-professionals—up to 15 meters per second.

The scientists—Stephan Rusdorf, Guido Brunnett, Mario Lorenz and

Tobias Winkler—from the Chemnitz University of Technology in Germany, wanted to determine how quick a response time virtual reality systems could achieve using standard hardware components. As part of that investigation, the game design had to have a high immersion quotient, making a human player forget he is in a virtual environment. To create such realistic surroundings, the scientists built a highly responsive system.

“All we need is a standard pc with an up-to-date graphics card which allows us to drive two LCD beamers,” Brunnett told *PhysOrg.com*. “In front of the beamers, polarization filters are mounted. The beamers project from behind onto a projection wall made of acryl glass.”



A user plays the table tennis game at the Virtual Reality 2005 event in Bonn, Germany. Image Credit: Rusdorf, Stephan, et al. © 2006 IEEE.

On this four-by-three-meter (about 12-by-9-foot) screen, a virtual opponent stands behind one end of the game table. In front of the screen stands the human player, whose polarization glasses and paddle are tracking targets for the simulation, containing five and six markers,

respectively. Four cameras mounted on the sides of the screen then track the movement of the objects, relaying the data to a software system.

“The player wears polarization filter glasses in order to get a stereoscopic impression of the scene,” Brunnett explained. “For the tracking of the glasses and the paddle, we use the infrared tracking system of A.R.T. systems.”

Synchronizing the avatar’s responding movements to the human player’s movements presented a large challenge in this fast-paced simulation. Because normal delay, or “latency,” would result in high error rates, Rusdorf et al. developed correction algorithms by enabling the system to predict the movements of the paddle and glasses based on their velocities in previous frames.

The scientists found that they could obtain smooth movements by knowing the precise position and orientation of the paddle at the time of collision with the ball, while predictions at other times did not have to be exact. In addition, collisions of the ball with the table/net/ground could be accurately computed in a smooth manner.

The avatar itself played quite human-like. It could adjust its level in response to its human opponent, in a sense mimicking the human—although the scientists programmed the computer to perform slightly superior to the human for greater enjoyment. By restricting the area of the table where the avatar hits the ball on the human’s side, as well as restricting the height and speed of the ball, the scientists could program different degrees of difficulty. Further, they could allow the avatar to make occasional mistakes by adding random noise, and even make the avatar fatigued by increasing noise over the game.

Through testing—as well as feedback at recent conventions—Rusdorf et al. have demonstrated that the fast-paced requirements of table tennis

can successfully entertain computer "athletes," even those unfamiliar with virtual environments. As confirmation of the reality of the simulation, the scientists observed some players try to put their paddles down on the virtual table after the game.

In the future, the group is looking to develop variations, such as allowing two remote humans to compete with each other, as well as doubles games. They also plan on improving the prediction abilities to accommodate professional players—the record "smashing" speed for table tennis, they note, is nearly 70 mph (31 m/sec).

"In the near future, games like this will be played at home with full immersion," said Brunnett. "Further, any applications that involve high speed interaction between a user and virtual objects could use this type of technology—for example, for control of a machine or process in emergency situations. The major difficulty in extending the system to other kinds of sports is the haptical feedback (which plays a minor role in table tennis). How do you give a human the impression of really catching a virtual ball?"

Citation: Rusdorf, Stephan, Brunnett, Guido, Lorenz, Mario, and Winkler, Tobias. "Real-Time Interaction with a Humanoid Avatar in an Immersive Table Tennis Simulation." *IEEE Transactions on Visualization and Computer Graphics*, Vol. 13, No. 1, January/February 2007.

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