AR Tennis

Anders Henrysson
NVIS
Linköping University
andhe@itn.liu.se

Mark Billinghurst
HIT Lab NZ
University of Canterbury
mark.billinghurst@hitlabnz.org

Mark Ollila
NVIS
Linköping University
marol@itn.liu.se

1. Introduction

Modern mobile phones combine a display and processing power with a camera, and so are ideal platforms for augmented reality (AR), the overlay of computer graphics on the real world. Henrysson [2] has ported the popular ARToolKit [1] computer vision library to the Symbian operating system which allows developers to build AR applications that run on a mobile phone.

AR Tennis is the first example of a face to face collaborative AR application developed for mobile phones. In this application two players sit across a table from each other with a piece of paper between them with a set of ARToolKit markers drawn on it. Computer vision techniques are used to track the phone position relative to the tracking markers. When the player points the phone camera at the markers they see a virtual tennis court overlaid on live video of the real world.

Viewing the AR Tennis Virtual Tennis Court

Players can hit a virtual ball over the net and play tennis against each other. Players serve the virtual ball by hitting the '2' key on the keypad. Once the ball is in play they can hit it back by simply moving their phone in front of it; there is no need to use the keypad any more. A simple physics engine is used to provide realistic ball motion. Bluetooth wireless networking is used to synchronize the ball movement between phones. Gameplay is further enhanced with audio and vibration haptic feedback. Each time the ball is hit there is a small sound played and the phone of the person that hits the ball vibrates.

AR Tennis uses a highly optimized version of the ARToolKit computer vision library that was developed for the Symbian OS platform and combined with the OpenGL ES graphics library. The game has been run on both the Nokia 6600 and 6630 phones, which have a screen resolution of 176x208 pixels and camera resolution of 160x120 pixels. The 6600 has a 104 Mhz ARM processor and ran at 3-4 frames per second, while the 6630 has a 210 Mhz ARM processor and achieved 7 frames per second.

2. User Feedback

AR Tennis has been shown in a museum setting with more than 3,000 people trying it over 4 months. The response was overwhelmingly positive. In addition, a formal user study was conducted to explore how useful the AR view of the game was, especially in providing information about the other player's actions [3]. Pairs of subjects played the game in each of the following three conditions: **A:** Face to Face AR, **B:** Face to Face non AR – where they could see the graphics only, not the live video input, **C:** Non Face to Face gaming.

Playing AR Tennis

Players felt they were more aware of what their partner was doing in the face to face AR condition (A) than in the non-AR face to face condition (B) or with remote players (C). They ranked the AR game condition as much easier to work together in than in the non-AR face to face game playing or with remote game playing. They also felt that audio and haptic feedback made it much easier to work together than in conditions with less feedback. From these results it seems that AR interfaces could provide a greater level of awareness in face to face gameplay on mobile phones than with more traditional game interfaces.

3. References

[1] ARToolKit website: www.hitl.washington.edu/artoolkit/

[2] Henrysson A. and Ollila M. *UMAR - Ubiquitous Mobile Augmented Reality* In Proc. Third International Conference on Mobile and Ubiquitous Multimedia (MUM2004) October 27 - 29, 2004, College Park, Maryland, U.S.A.

[3] Henrysson A., Billinghurst M., and Ollila M. *Face to Face Collaborative AR on Mobile Phones.* In Proceedings of the International Symposium on Mixed and Augmented Reality (ISMAR 2005), October 5th – 8th, 2005, Vienna, Austria.