Bridging the Gap Between Virtual and Physical Games using Wearable Sensors

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Abstract

We believe that game playing in the real world finds such large appreciation because it is based on interaction between people in a physical environment. In this paper we present an example of how the gap between virtual and physical games can be bridged using sensing technology from a wearable computer. Unmasking Mister X is a game we propose, which incorporates sensor data from all the players. It is a first step in enhancing real world games with wearable computers and sensing technology.

1. Introduction

Do you remember hiding in the closet waiting for your friend to find you during a thrilling game of hide and seek? Or trying to catch one of your friends in one of the various chasing games? Traditional children's games still find great appreciation in today's modern world. This is mostly because many emotions are experienced during the interaction with other children in a physical environment [4].

The fact that the interaction occurs in a physical environment may seem secondary at first glance. Many of today's computer games enable an interaction between people over a network. The network can stretch over two rooms or over half the world. The fact that the interaction occurs only in the virtual world is what can make these games less attractive.

With the advent of ubiquitous and wearable computing, more and more games are starting to appear that combine the physical and the virtual environments. *Pirates!* [3] is one such game, in which the players have to approach each other physically to be able to play a computer game against each other. The firm Cybiko (http://www.cybiko.com/) promotes a simple game console with which one can play multi-player games in the physical world using ad-hoc wireless communication. Often however, the physical interaction between players is reduced to being at the same location or in communication range of each other. The fact that mobile phone manufacturers and service providers are developing multi-player games shows that they believe in a large market for such applications.

Existing games only combine certain aspects of the virtual and the physical worlds without interweaving them. In *Pirates!*, e.g. the user still only plays the game on the console as soon as he has found a physical co-located opponent. We propose to use wearable sensors to measure physical parameters, which can be used in the digital world. For example by measuring the physical environment and the behaviour of a player we may bridge the gap between the physical world and the virtual game. Sensors can be used in different ways to do this. For one they can be used to make the interaction more physically realistic. The player may actually run and jump instead of just moving a joystick. Secondly, sensors can be used to bridge the physical environment from two different locations, by communicating the sensor values (see section 4). Thirdly, one can use sensors to provide a sixth sense to the user. The following section explores the last possibility by letting one player see the other user's sensor values.

2. Unmasking Mister X

Unmasking Mister X is a multi-player game in which a group of people have to find Mister X. The game can be played both indoors and outdoors. Each player is equipped with a sensing device and a PDA or a head-mounted display. The game is played by walking around and approaching people to find out who is Mister X. The only information each player has are the sensor values of Mister X. They are displayed on each player's display. They reflect the movement as well as the physical environment of Mister X. Therefore one can unmask Mister X by checking if the sensor values match the physical environment and the behaviour of another player. Mister X has to act in a way that he does not attract the attention of the other players, regarding their observations and his own sensor values.

The players have several possibilities to reason about a person's identity. For example if Mister X is walking around this would show in his accelerometer values. If he

Proceedings of the 6th International Symposium on Wearable Computers (ISWC'02)
0-7695-1816-8/02 $17.00 © 2002 IEEE

is talking aloud his microphone readings would indicate a higher variance. Further, a player could enter a room and switch the light on and off. If Mister X is in that room he will not be able to flee from the light changes.

Using this explicit reasoning the player can make conclusions about the identity of Mister X. But besides just looking at Mister X' sensor values, he could also compare the values with his own using specially designed functions. In the following section we will show how a distance measure can be given by calculating the correlation between the audio signals. Similarly a function can be implemented for the light changes. These techniques could be used to give distance indications such as "cold", "warm" or "hot".

Many variations of the game are imaginable. Instead of everybody looking for the same Mister X, everybody could be assigned their own Mister X they have to find. This means that each player would have to play both roles at the same time, seeking Mister X and hiding as Mister X. Here the key to winning the game is finding a good balance between behaving without attracting to much attention and searching actively.

The experiments presented in the following section are part of a larger concept we call *Semantic Proximity*. In [5] we decribe how this general concept can be used to compare sensor values from two locations.

3. Experiments

The experiment presented here shows how the distance between two sensing devices can be estimated by calculating the correlation of the audio signals assuming a constant noise level (approximately 65dB, normal conversation). For this experiment we used sensor-boards (incorporating a microphone, a light sensor, an accelerometer, a temperature sensor and a force sensor) as they were developed in the Smart-Its project [1]. To distribute the sensor data amongst the players we developed a computing framework which runs on standard laptops or PDA's and can communicate over a wireless-LAN network. This gives us a simple but powerful platform for prototyping multi-player games and conducting various experiments.

Figure 1 shows a plot with the correlation values of three sets of measurements. First we recorded a test signal (440Hz tone) with two microphones. We took 9 measurements varying the position of one of the microphones between 10 cm and 3 m. The same experiment was performed for a music signal and the sound of people talking. The plot shows that it is possible to detect an increase in the correlation value at a range of 1 to 1.5 meters. Louder noises, such as people shouting would show a correlation over greater distances. During the game the player could receive distance measures such as "cold", "warm", or "hot" depending on this correlation value.

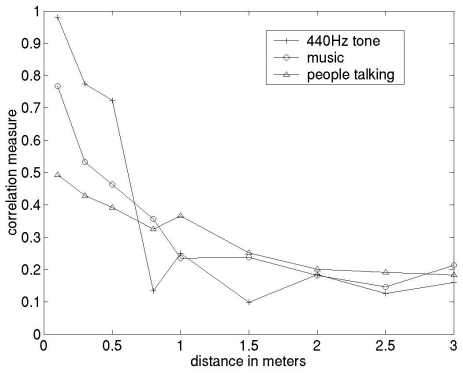

Figure 1. Correlation measure between two audio signals recorded at distances from 10cm to 3m.

4. Discussion and Future Work

Unmasking Mister X gives us a first insight in what can be achieved by enhancing multi-player games with wearable computers and sensors. Beyond this game there is a wide range of traditional games, such as hide and seek or chasing games, which could profit from the enhancement with sensor data. Further we believe that these technologies will enable a whole set of new games with novel interaction styles and story boards. One such category of games could enable people in different places to play games together in a way which might come closer to actually being together. Sensor data of one person's physical environment could be transferred to the other players and give him the feeling the other person is co-located. This concept has already found application in office environments as presented in [2].

Acknowledgments

This work is funded in part by the Commission of the European Union under contract IST-2000-25428, and by the Swiss Federal Office for Education and Science (BBW 00.0281).

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