Racetime: Telepresence Racing Game with Multi-user Participation

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Abstract
In this study, we implemented a telepresence racing game that enables real-time, face-to-face interaction between the players. Both the spatial and social aspects of presence were achieved by integrating mature devices, which resulted in commercial RC cars equipped with both smartphones and augmented reality tags. Users drove their cars using the physical RF controllers and the interaction between the RC cars and the environment were guided by two laptops (one for each player) using a Wi-Fi network. Finally, a field demonstration was conducted and avenues for future studies are suggested.

Author Keywords
Telepresence; Racing game; Smartphone

ACM Classification Keywords
H.5.1 [Multimedia Information Systems]: Artificial, augmented, and virtual realities.

Introduction
Computer games nowadays provide higher quality graphic rendering and 3D modeling to allow for a more immersive gaming experience. This is because the game is more enjoyable when the virtual environment is immersive. And when games involve avatars, this immersive environment makes the players feel like they are actually in the virtual

space, which is called telepresence[8]. However, advanced graphics rendering or 3D modeling by themselves are not sufficient to provide the players with a complete telepresence[3], because they do not deal with chaotic or unpredictable situations that frequently occur in the real world[9]. The player can never totally believe the realistic rendering scenes, but must suspend their beliefs when they look at the display[6].

Figure 1: Racetime: a telepresence racing game implementing multi-user interaction

Several studies [9, 6, 2, 1] tried to solve this problem by building a robot to navigate a real space controlled by a distant user. The robot sends sensor signals in the form of human sensory stimulation and feed it to the user in real-time. This is called tele-embodiment [9] and makes the user believe the scene is real and unpredictable to get them to immerse into the current situation and experience a more concrete form of telepresence. However, almost no studies implement tele-embodiment gaming experience, which is quite surprising considering gaming satisfaction is deeply related to telepresence experience [10, 5].

Another requirement for telepresence is social presence[7]. While tele-embodiment can mediate the spatial aspect of telepresence, this social aspect requires an interaction between users. As reported in [10], the different types of opponents in online-games influence the experience. A higher value of presence was measured for human-controlled opponents than the computer-controlled ones. This suggests that gaming applications should consider including real-time multi-user participation to increase telepresence.

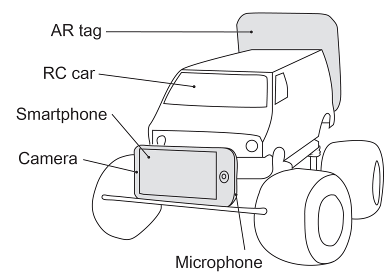

Figure 2: Configuration of a RC car used in the implementation

In this study, we suggested and implemented a telepresence racing game (see Figure 1) that enables real-time multi-user participation. Both the spatial and social aspects of presence were achieved by using two commercial RC cars equipped with smartphones and augmented reality (AR) tags. Users drove their cars using the physical remote controllers and the interaction between RC cars and environment were guided by two laptops (one for each player). Finally, a field demonstration was conducted to find improvements for future studies. In the following section, we summarized previous studies of tele-embodiment.

Related Work

A study[2] implemented a small robot to explore live insect colonies. The robot was equipped with a micro-camera and was capable of moving in 2D coordinates to watch down upon the insects in a terrarium in a museum and was controlled by the visitors. While the attempt was successful in its educational purpose, the robots motion was limited in order to not harm the insects and there was no advanced interaction between the user and insects or their environment.

On the other hand, a different study [1] focused on boosting the social presence between tele-conference participants. During the tele-conference, each participants face was selectively displayed to the others to promote a social presence to some degree. They also developed a small robot that operates on a desk with a final version including a mobile base, two 3DOF arms, and a display mounted on a 3 DOF neck. The robot could be controlled by mimicking the attendants gesture and displaying the attendants face on the display. After testing with a human subject, they found that the presence was larger when using the robot with gestures than the static one.

Another study[6] implemented a racing game using a RC car. The car was equipped with a stereo-camera and several vibration sensors to transfer the signal to the player in the form of human sensory stimulation. The player controlled the RC car with a haptic steering wheel connected to the main computer and watched the real-time video feed through the display. Although the researchers proposed using the application as a game, there were no other interactions that could distinguish the work from a simple driving situation. Additionally, there were no opponents, which is not typical of racing games.

Finally, a media artist group named sputnic recently published a telepresence racing game (http://www.sputnic.tv/racer) imitating the commercial package 'Wipeout'. An RC car equipped with a camera was used in their implementation and a physical small-scale track capable of measuring the time lapse was installed. A remote player used a driving wheel to control the car and could watch the captured scene through a display that also showed the traditional gaming visualizations. However, this system also lacked interaction with other people, so there was little social presence.

System Architecture

Hardware

We used two commercial RC cars (385mm×290mm×225mm, 1.56 kg, Tamiya Inc.) resembling monster trucks in 1/12 scale. Each of these cars was equipped with a smartphone (iPhone 4S, Apple Inc.) and an AR tag printed on a board (see Figure 2). The detailed implementation of the tag was first introduced in the reacTIVision framework, which provides up to 216 black and white indicating markers that are decoded as index numbers (ID). The camera on the smartphone fed real-time video in the drivers point of view to make the players feel as if they were actually riding in the car. The AR tag was attached to the tail of the car chased by the opponent's camera during a race. The bundle controller of each RC car had a small steering wheel with a lever used for both the accelerator and brake. We prepared two laptops (MacBook Pro late 2011, Apple Inc.) that were both equipped with a webcam and microphone, which were used for each players main computer. The control signal was sent to the cars via RF signal while the video streaming between the computers and smartphones was done using a Wi-Fi network (see Figure 3).

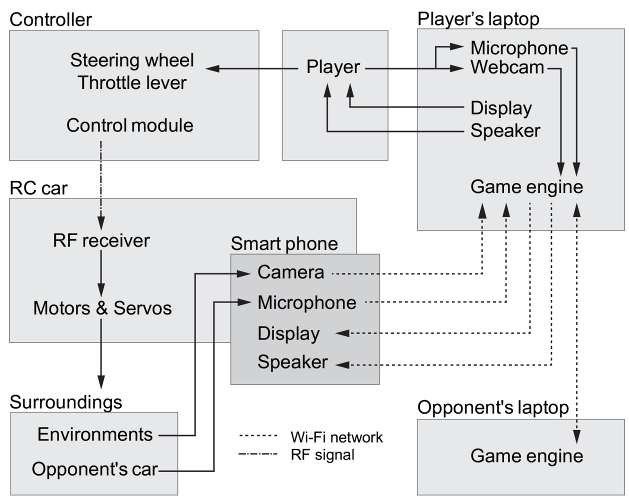

Figure 3: Architecture of the system

Software

All interactions between the smartphones and laptops were processed by the main software developed by the Unity3D game engine and installed in each laptop. Each program made a video call to its corresponding phone on the RC car using the laptops webcam and microphone. Because each players face is shown on the smartphone as each cars driver, there is a face-to-face interaction between the players when they get encountered by the other[1]. An AR module in the main program analyzed the image stream sent from the smartphone to extract the identification number of the tag, which were used for activating a certain effect later on in the game. Two laptops communicated with each other using a networked multi-play module offered in the game engine.

Game Design

Interaction Design

We designed the game to be a fight between two RC cars. The basic goal is to capture the tail tag of the opponent as frequently as possible. When a car captures the tail tag of the opponent, the durability value of the captured car that was set in the beginning of the round gradually goes down. The first player to reach zero durability loses the game. Another way to influence durability is to capture the tags randomly distributed in the arena. Depending on the type of tag (fuel or dangerous item), this could add or subtract the durability. Thus, players needed to find the fuel tags when they had little durability and avoided taking picture of the dangerous tags. All possible interactions are summarized in Figure 4.

	Car-to-car	**Car-to-environment**
Possible effects	Capture opponent's tail tag; (–) Subtracting opponent's durability	Capture fuel tags; (+) Adding player's durability
		Capture dangerous tags; (–) Subtracting player's durability

Figure 4: Description of the gaming interaction

Visual Design

We carefully designed the graphics overlaying the screen showing the status or effects being applied on the car (see Figure 5). A study [4] about a player's effectance, which is the perception of receiving immediate feedback from the game world, showed that it was a key factor in providing players game satisfaction. Hence, immediate interaction and clear visualization is very important in game design.

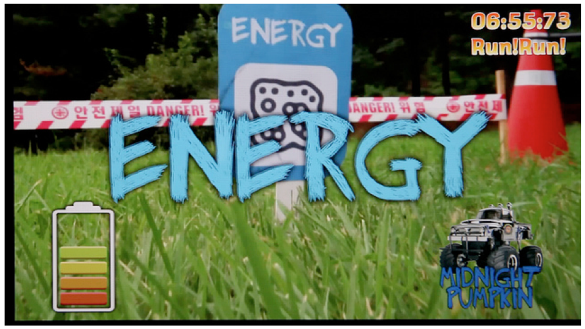

Figure 5: Visualization of status and interactions

Prototype system with a Pilot Study

We demonstrated the system at a meadow (Approx. 10 m 10 m, see Figure 6) with a small number of participants from local university to see the potential limitations. We set up a WiBro network beforehand to make the smartphones and laptops communicate with each other, and the video calls resulting frame rate was about 15 fps. There were 5 to 10 environmental tags on the field, which were randomly scattered by the demonstrators. Laptops were located on a table at one side of the field. Five people played the game for about an hour and were asked to make suggestions for improvement at its conclusion. The application was quite robust and the participants enjoyed playing the game.

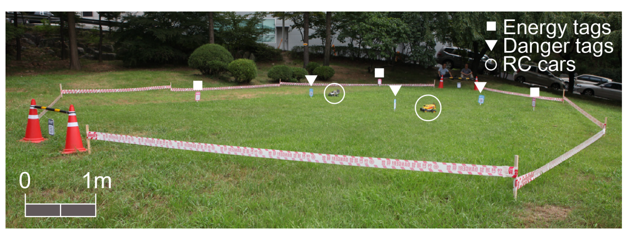

Figure 6: Field demonstration setting

Discussion

The smartphone is a mature device fully optimized for enabling the advanced interaction between people. It already consists of precise sensors and a high-definition display, which are easily integrated into various forms of applications using commercial APIs. In this study, we focused on the integration of mature devices like smartphones, RC cars, and laptops that could make the system robust and guarantee real-time capacity.

However, there were several suggestions given by the participants of the demonstration. First, the racing suffered from very sudden changes in image stream, so the AR tags were sometimes not sufficient for continuous recognition. The players had to stop frequently to capture a static scene. In addition, players felt it was hard to perceive the global location of their cars as well as that of their opponents. Consequently, they sometimes had to look at the racing cars on the field rather than the display to reduce the difficulty in finding the opponent.

Although these problems reduced the games satisfaction value to some degree, the overall operation was assessed to be robust and controllable. Additionally, there are many sensors in the smartphone that were not fully utilized in this study like the accelerometer, gyroscope, brightness sensor, and GPS, which could be used to solve the issues in future developments. For example, the GPS could be used to indicate the location of cars and by implementing a mini map for a racing game on a larger field. Furthermore, the accelerometer and gyroscopic sensor could be used to transfer the haptic signal to the player and the brightness sensor could make the game world react to the light in the surroundings.

Conclusion

In this study, we proposed a racing game to maximize the spatial presence experience by adapting tele-embodiment. In addition, multi-user participation was used to enhance the social presence. All of these were done by integrating mature devices and services like commercial smartphones, RC cars, and laptops operated through video calls and Wi-Fi network. This guaranteed the robustness and real-time application of the system, and a simple demonstration was conducted to see the potential limitations and possibilities. Although several issues arose, the demonstration showed that the telepresence racing game was more immersive, robust, and controllable for the player.

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