Exertainer: An Interactive Entertainment System for Pervasive Running Applications

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Abstract

We developed Exertainer, a sensor-enabled, interactive running entertainment system to support advanced exercise applications. We developed a multiplayer racing game called Swan Boat on top of the Extertainer and conducted a user study.

Introduction

Recent progress in ubiquitous technology has brought new opportunities to redesign characteristics of exercises. There have been many academic efforts to make monotonous exercises like running more enjoyable, for example, by assisting runners based on real-time measurement of the runner's physiological condition [6], or by giving incentives and feedback to motivate runners [1][2][3][5]. It has been shown that combining exercises with games not only make them more enjoyable but also enhance social bonding among players [4].

We envision that, in the future, diverse advanced exercise applications will emerge, featuring much richer interactivity and more immersive game play. We propose Exertainer, a sensor-enabled, interactive running entertainment system to support such applications. We expect Exertainer to be an effective replacement for traditional treadmill running. Although people can run in different environment, we target treadmill running since it is a common, convenient,

widely deployed and safe way to exercise especially in urban environments. The core of Exertainer is Interactive Treadmill, an advanced treadmill with rich human- and application-interactivity. Exertainer also consists of runner-wearable Sensor Bracelets and Player Space Director, a game platform for supporting contextual interaction [7].

We developed Swan Boat to demonstrate the capabilities of Exertainer. Swan Boat is a racing game that uses hand and arm gestures as well as running itself as game inputs, while providing physical feedback such as variation in treadmill speed and incline. Swan Boat is also designed to stimulate interaction among the players. For example, a high degree of coordination between team-mates, similar to that in three-legged races, is required to steer their boat.

Exertainer

Exertainer is an interactive running entertainment system for new exercise applications. It features intuitive interfaces involving running pace, hand gestures and realistic feedback. Exertainer facilitates development and employment of various Exertainer applications that entertain treadmill runners. As shown in figure 1, Exertainer consists of three major components: *Interactive Treadmill* with a built-in PC and network connectivity, a pair of runner-wearable Sensor Bracelets, and PSD (Player Space Director). We developed Swan Boat as an example application running on Exertainer.

Interactive Treadmill

We developed Interactive Treadmill, a new type of treadmill distinguished by rich human- and application-interactivity. A runner on Interactive Treadmill continuously interacts with the treadmill; it detects the runner's position using an embedded ultrasonic sensor and adjusts its speed automatically to the runner's pace. This feature allows the runner to run naturally, rather than merely following the pace set by the treadmill.

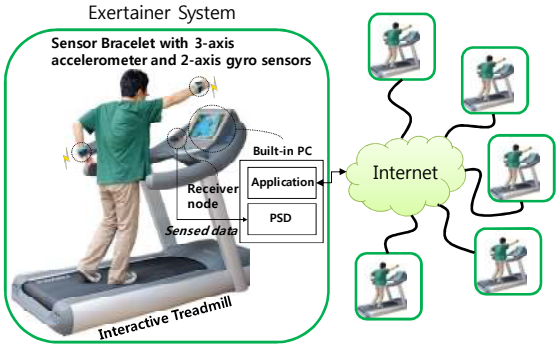

figure 1. Architecture of the system

Interactive Treadmill includes application-controllable speed and incline control motors. These controllers provide realistic feedback to the player according to the application's controls. The interactive treadmill additionally includes a 17-inch touch screen and stereo speakers. (see figure 2).

Sensor Bracelet

Sensor Bracelet is a custom designed wearable device where various types of sensors can be mounted. In Swan Boat, Sensor Bracelet is equipped with a 3-axis accelerometer and a 2-axis gyro sensor to utilize player's gestural inputs such as punching, shaking, and flapping. These gestural inputs enrich the game with intuitive interface. Sensed data is transmitted via the Zigbee protocol to PSD.

figure 2. Interactive Treadmill

PSD, Player Space Director
PSD is a game platform supporting gestural interactions and facilitating the development and operation of diverse pervasive games. PSD can easily define a number of gaming interactions and interpret raw sensed data as those interactions. Using PSD, we could easily experiment with a number of gestural interactions, and have identified that gestures using hands and arms, such as punching, flapping, and shaking, are most appropriate for Swan Boat. Further details of PSD can be found in [7].

Swan Boat

We developed Swan Boat fully utilizing the functionalities provided by Exertainer. Figure 3 shows a team playing Swan Boat and a screenshot of the screen seen by the players. Swan Boat is a racing game where teams compete against each other by cooperatively controlling the speed and direction of their boat using running itself as one of the main game interactions. Hand gestures are also used as input for additional game activities such as attacking opponents.

figure 3. A team playing Swan Boat (left). Game Display(right)

Swan Boat enhances the bland experience of running on a treadmill with rich interaction among players, encouraging intensive collaboration with their teammates as in three-legged races. The difference in speed between team members determines the direction of their boat, so if a team wants to steer their boat to port, the member in charge of that direction should run faster than her teammate. A player continuously changes her running speed, to the degree of fine-tuning the speed of her individual steps to adjust to the running pace of her teammate; this is possible because of the speed of Interactive Treadmill is automatically adjusted. This kind of close synchronized interaction immerses the players in the game experience.

Synchronized gestures and game items also encourage active communication between teammates. Runners may suddenly increase the extent of their interaction to change the direction of their boat for acquiring or dodging special game items, like obstacle items that can slow down the boat. They excitedly yell "faster" and "slow down" and adjust their pace according to teammates. If weighed down by such an obstacle, the team members can both flap their arms like wings to get free of it. Also, if an opponent's boat is in range,

the players can use a punching motion together to attack the opponent's boat, hindering their movement. For an attack to be successful, punching should be performed not only faster than the opponent, but also synchronously with teammates.

Swan Boat also allows players in other locations to play and interact together over a network. They meet other runners of various skill levels and styles in Internet virtual communities.

User Experience

We conducted a two-week preliminary user study of Swan Boat with 11 university students and 6 professors. According to user interviews, many participants said that the interaction methods in Swan Boat were enjoyable and interesting. Several participants liked the hand gestures, especially the punching. They even said that while playing Swan Boat, they became unaware of the passage of time. One said that he would be more motivated to run on treadmills if he could play Swan Boat. Our quantitative observations also supported such statements. When just running without Swan Boat, participants typically ran or even walked at an average speed of 4~10 km/h. They, however, ran surprisingly faster while playing Swan Boat at 11~14 km/h for men, and 10~12 km/h for women. We even observed average speeds as high as 17~18 km/h from a few athletic participants.

Conclusion & Future Work

We developed Exertainer which is an interactive running entertainment system, and Swan Boat as an example application utilizing our proposed system. Our preliminary user study has shown that interactions supported by our system are effective for enjoyable exercising games. In further research, we plan to incorporate safety measures into the design of exercise applications.

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