

A Multiplayer Whack-A-Mole Game Using Gestural Input in a Location-Sensitive and Immersive Environment

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Abstract. By utilizing recent information and communication technologies, many researchers have been investigating entertainment computing applications. In this paper, we propose an immersive entertainment environment combined with gestural input and location recognition technologies. Inertial sensors are used for recognizing players' gestures, and optical markers are used for recognizing players' locations and orientations. We have developed an entertainment application called ARHunter, which is a multi-player whack-a-mole like game. User studies of ARHunter indicated that it could enhance the level of players' engagement and excitement. Several issues to be investigated in our future work are discussed.

1 Introduction

By utilizing recent information and communication technologies, such as mobile computers, Internet, computer graphics and so on, many researchers have been investigating entertainment computing applications. It is suggested that one of the main purposes of entertainment computing is to develop entertainment technologies and applications that can raise the level of players' engagement and excitement. For this purpose, various types of interaction techniques and interactive environments for entertainment applications have been developed.

In this paper, we propose a novel entertainment application that has the following features: (1) By overlaying computer-generated graphics onto the real world, an immersive environment for playing a game is created; (2) Locations and orientations of multiple players moving around in the real world are used to affect a scenario of a game; (3) Players' gestures or actions are captured and used as input to the application.

Various systems that utilize mixed reality technologies to enhance immersiveness [1] or that implement positioning technologies [2] to allow players to interact with real-world objects, have already been proposed in the field of entertainment computing. In this paper, we integrate a gesture input technique with these existing technologies, in order to construct an entertainment application with a high degree of engagement and excitement.

A prototype application, a multi-player (two players, in this study) whack-a-mole like game, called ARHunter is presented in this paper. Players are required

to exterminate enemy monsters which are displayed on the floor or a table. ARHunter recognizes each player's action and location. A player tries to strike or sweep away monsters with a hammer-like device, and they escape from the player when he comes close to them.

2 System Architecture

In ARHunter, we use the basic technologies originally developed for Toss-It [3]. Each player holds a gesture recognition device (in this paper, we call it a hammer). The hammer embeds inertial sensors and infrared (IR) LEDs. Each hammer is connected to a laptop computer which recognizes each player's actions through the outputs of the inertial sensors. The laptop computer is connected to a server computer through a wireless LAN. Although each player places his laptop computer at a fixed position in the current setting, he can carry it on his shoulder, in order to make the cable between his hammer and computer more unobtrusive while playing ARHunter. A stereo camera is further installed to the ceiling so that it captures IR LEDs on each player's hammer to identify his location.

The server computer generates monsters and visualizes them on a floor through an LCD projector installed to a ceiling, or on a plasma display placed on a table. The software running on the server makes monsters move around in a game arena. When a player conducts an action (swing vertically or horizontally) with his hammer, his laptop computer recognizes the action and sends its data to the server computer. The server computer then judges whether the player strikes a monster successfully based on his action, position and orientation, and monsters' positions.

3 How to Play ARHunter

A player can strike a virtual monster by vertically swinging his hammer. When he correctly strikes a monster, the monster is killed. A player can sweep monsters away from the game arena by horizontally swinging his hammer. The time required for a swept-away monster to return to the game arena depends on how strongly and accurately a player has swept them away. When a player tries to strike or sweep monsters, he brings his hammer close to them. ARHunter provides players with visual and auditory feedback to let them know if they have successfully struck or swept monsters away. In the current implementation of ARHunter, two players can play a game at the same time. We prepared two different modes: the match-up mode for competitive play and the tag-team mode for collaborative play, respectively.

In the match-up mode, each player is required to annihilate his monsters only. A player has to strike a monster with his hammer twice in order to exterminate it. If a player annihilates a monster of the other player by mistake, the total number of his monsters increases as a penalty. When a player approaches monsters, they escape from the player in order not to be exterminated. A player wins the game



Fig. 1. ARHunter in use (left: using a projector, right: using a plasma display)

when he has annihilated all his enemy monsters in the game arena faster than the other player.

In the tag-team mode, players are required to annihilate the enemy monsters collaboratively. In this mode, monsters of different colors appear: Blue-colored monsters move slowly and die by being struck twice. Yellow-colored monsters move a little more quickly than blue-colored monsters, and die by being struck three times. Red-colored monsters, which are the strongest ones, move most quickly and die by being struck five times. The players win the game when players have annihilated all the enemy monsters in the game arena within a specified time-limit.

The time-limit is set to 100 seconds in both modes. If the time has run out, the game is regarded as a draw in the match-up mode and a lost in the tag-team mode. We prepared three stages for both modes. The time-limit is fixed through all three stages. When players advance to the next stage, the total number of the monsters increases; therefore, the difficulty of the games increases.

4 Experiments and Discussions

Informal user studies to evaluate ARHunter were conducted. Four subjects (all male, university students) were divided into two pairs and played the game in the match-up mode and the tag-team mode. They were also asked to play ARHunter in the two settings. One is with a projector (Setting 1) and the other is with a plasma display (Setting 2). Before each pair started playing the game, a brief introduction to the usage and the rules of ARHunter was given.

Subjects played the game as shown in Figure 1. All subjects could easily understand the rule of the game. In the post-experimental discussion, the feedback we received was overall very positive.

In the match-up mode of ARHunter in Setting 1, one player frequently interrupted another player with his arm or his body. Such physical interactions excited players and raised the level of their engagement. In another case, a player concealed the other player's monsters with his shadow caused by intentionally intercepting the light from the projector. Although a shadow on the projected screen is usually regarded as one of the major obtrusive factors for users, it is interesting that players could take advantage of the drawback of the system.

In the tag-team mode, players often divided the projected screen in order to efficiently exterminate their enemy monsters. For example, one player was responsible for exterminating monsters that appear on the right half, and the other player on the left half. Although this kind of collaboration was effective for winning the game, it rather seemed to decrease the level of players' excitement, because assigning different tasks to individual players reduces opportunities for their interactions. Therefore, we think there is a room for exploring the design of the tag-team mode to enhance players' interaction.

We also observed several differences between Setting 1 and Setting 2. One of the most obvious differences is that players were not bothered by unintended shadows in Setting 2. Therefore, players could chase and strike monsters more smoothly. However, physical interactions described above were observed less frequently in Setting 2.

In comparison to a real whack-a-mole game, one of the missing features in the current version of ARHunter is a physical reaction which is given to a user when he hits a monster. Tactile feedback, such as vibrating a hammer, should be given to a player when he hits a monster successfully.

5 Conclusions and Future Works

In this paper, we described an entertainment application called ARHunter. ARHunter is a multi-player game using gestural input in a location-sensitive and immersive environment. ARHunter has two play modes: the match-up mode (competitive play) and the tag-team mode (collaborative play). Informal user studies suggest that ARHunter could raise the level of players' engagement and excitement by providing them with an athletic feeling and enhancing physical interaction. Several issues remain to be investigated; We will conduct more intensive user studies to evaluate ARHunter and improve its functions. The size of the game arena, currently about 1.2 meters by 0.9 meters, is critical if we want to allow more than two players to participate in ARHunter. We further plan to investigate in more details the opportunities of how we combine immersive environments with gestural input technologies in entertainment computing.

References

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