

Arcade Video Game Platform built upon Multiple Sensors

Hyoil Lee¹, Heekwon Jeong², and JungHyun Han^{1,3}

¹Computer and Communication Engineering Department, Korea University, Seoul, Korea

²Interpark Games Inc, Seoul, Korea

³Institute for Information Technology Advancement

Abstract— This paper presents an arcade video game platform with a natural and tangible interface. The platform is built upon position tracking and velocity computing systems. The position tracking system uses radio frequency transceivers and ultrasonic sensors to compute the 3D position of the game player. The velocity computing system uses the 2D coordinates of two infrared ray grids to compute the trajectory and velocity of the physical game object thrown by the game player. The implementation results prove that the new type of natural and tangible interface can be useful for the next-generation arcade video games.

I. INTRODUCTION

RECENTLY, one of the major issues in game and entertainment is how to provide a natural or tangible interface for smoothly connecting the physical space and the virtual space. The natural interface allows the game player to use, for example, pointing gesture, and often replaces the traditional pointing devices used to interact with the virtual space. A good example is EyeToy in Sony PlayStation2. A tangible interface enables the game player to interact with the virtual space through the real-world physical objects. A good example is the controller of Nintendo Wii.

Such a natural or tangible interface is essential especially for arcade video games, which have competed with home entertainment platforms and have to provide the game player with some distinct features largely inaccessible to home users. Such a strategy of the arcade video games has proven to be quite effective, as shown in the case of Dance Dance Revolution.

This paper presents a natural and tangible interface to a virtual space, which can be easily adopted for arcade video game development. The interface has been built upon multiple sensors. The user location is tracked by a combination of radio frequency (RF) and ultrasonic signals, and the velocity of the game object thrown by the user is tracked by infrared (IR) sensors.

II. ARCADE VIDEO GAME PLATFORM

The physical space for the arcade video game platform is illustrated in Fig. 1. In front of the LCD screen, a pair of IR-sensor grids is placed. The grid pair is used to compute the velocity of the game object thrown by the game player. Four beacons are located at the four corners of the first IR-sensor

grid. The beacons are used to track the position of the game player. The position tracking system is presented in subsection A, and the velocity computing system is in subsection B.

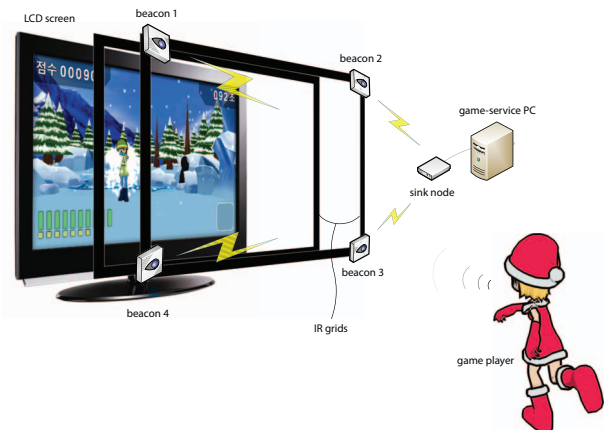


Fig. 1 Arcade video game platform

A. Position tracking

There have been needs for an accurate position-sensing system for indoor applications. The most well-known systems is Cricket [1], where ceiling- or wall-mounted active beacons send RF and ultrasonic signals to passive receivers carried by mobile users. The receivers calculate their approximate distances from the beacons using time-of-flight methods. Jee *et al.* [2,3] proposed an extension, where the beacons work in a passive mode, and multiple devices' pose data can be recognized. The game platform proposed in this paper uses the position tracking system of [2,3], which has been simplified such that only a single player needs to be tracked.

The beacons wirelessly communicate with the sink node through RF signals whereas the sink node is wired to the game-service PC. The beacon is equipped with a wireless sensor node which has an *RF transceiver* (transmitter and receiver) and an *ultrasonic sensor*. The node is also embedded in the head band of the game player. The sink node has only an *RF transceiver*, and synchronizes and coordinates the head band and beacons.

Initially, the sink node sends the 'start' RF message to the head band and the four beacons for *synchronization*. The head band sends an ultrasonic signal to the beacons, and each beacon estimates the distance of the head band using the standard technique of *time-of-arrival*. It then transmits the

estimated distance to the sink node in an RF message. Fig. 2 shows the data collected by the sink node, stored in a 10-byte packet. The packet is sent to the game-service PC, which then discards the largest value among the four, and finally computes the head band's position using the trilateration method. Currently, the position is tracked at 30Hz.

0	1	2	3	4	5	6	7	8	9
START	d1	d2	d3	d4					END

Fig. 2 Packet format for recording distances

B. Velocity computation

The grid of IR sensors has long been used to estimate the 2D coordinates of pointing or touch screen devices, and is currently being extended to provide various functions [4,5]. For the proposed game platform, the velocity of the game object thrown by the game player is determined using two grids of IR rays.

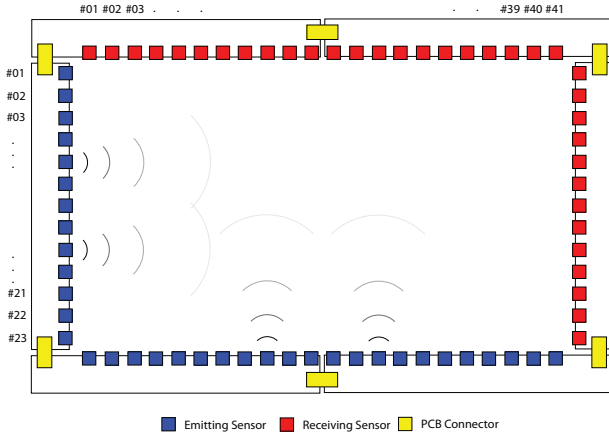


Fig. 3 IR grid

Fig. 3 shows the structure of a grid frame. A linear array of IR emitters fills the bottom and left borders of the frame whereas the top and right borders are filled with an array of IR sensors. Horizontally, we have 23 emitter-sensor pairs. Vertically, we have 41 pairs. The grid frame presents an invisible web of IR rays, and can be taken as a 2D Cartesian coordinate system, the resolution of which is 41×23. The object thrown by the game player works as an occluder in the IR ray grid, and the 2D coordinates of the occluder can be computed.

In order to prevent multiple sensors from receiving the IR ray from an emitter, each emitter emits IR ray in a distinct frequency. If a vertical pair of emitter and sensor loses its connection due to the occluder, the exact x -coordinate can be identified. Similarly, the y -coordinate of the occluder can be also identified. Consequently, the (x,y) -coordinates of the occluder can be determined.

0	1	2	3	4	5	6	7	8	9	10	11	12	13
Start	X1	X2	X3	Y1		Y2	Y3		End				

Fig. 4 Representation of the game object's (x,y) -coordinates

The game object should be large enough not to pass through IR ray grid. Then, multiple rays can be occluded by the large-enough object, both vertically and horizontally. The current implementation assumes that at most 3 adjacent parallel rays can simultaneously collide with the game object. Fig. 4 shows the representation of the x and y coordinates taken by the occluder in the IR ray grid. The data are currently sampled at 240Hz, and passed to the game-service PC. (The LCD screen and IR grids are connected to the game-service PC through cables.)

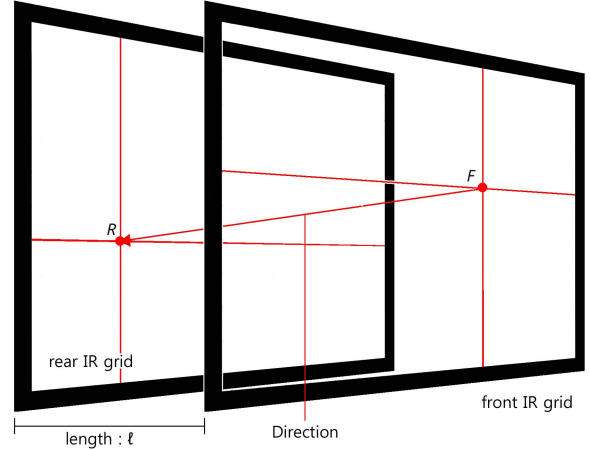


Fig. 5 A pair of parallel IR grids

Fig. 5 shows two grids of IR rays in the game platform. The two grids have the identical dimension. When 2 or 3 parallel rays are occluded by the game object, their mean value is computed. Therefore, an intersection point is obtained per grid. Let us denote the intersection point by F for the front IR grid, and R for the rear grid.

Suppose that the distance between the grids is l . Then, the direction vector of the moving object is defined as follows:

$$D = \begin{bmatrix} R_x - F_x & R_y - F_y & l \end{bmatrix} \quad (1)$$

Suppose that the elapse time between the grids is measured as t . Then, the velocity is computed as follows:

$$v = \frac{D}{t} \quad (2)$$

III. IMPLEMENTATION

In the proposed platform, the sensor and sink nodes for position tracking are fabricated from off-the-shelf components. They are tiny and sufficiently light to be easily placed in an indoor environment. For example, the sensor node can also be easily attached to the head band. In contrast, the velocity computing system is heavy, as shown in Fig. 6 where the IR grids are in green color. Each IR grid communicates

with the game-service PC through RS232 (Recommended Standard 232) 56000bps.

A prototype game, named Pang Pang Snow, has been developed. See Fig. 6. It is a snowball fight game, and a networked game with two remote players involved. The position tracking system makes the remote user's movement be reflected on the screen. If the game player throws a snowball to the remote player on the screen, the snowball hits the LCD screen and then bounces. However, the virtual snowball simultaneously appears in the screen and flies in the virtual space. The velocity of the snowball computed by the two IR grids determines that of the snowball in the virtual space.



Fig. 6 Hardware game platform

Fig. 7 shows the screenshots of the game. The game has been implemented in C++ and DirectX10 on a PC with Microsoft Windows Vista, Core 2 Duo 6600, and Nvidia GeForce 8800GTS.

IV. CONCLUSION

This paper presented an arcade video game platform, built upon multiple sensors. The game platform provides a natural and tangible interface. Such a user-friendly interface plays a key role in game development, as demonstrated in the case of Nintendo Wii [6]. The natural interface presented in this paper can break down the wall between real space and virtual space, and can lay the foundations of the next-generation arcade video game.



Fig. 7 Screenshots of Pang Pang Snow

ACKNOWLEDGEMENT

This research was supported by the Korea Culture and Content Agency as a research project for culture content technology development, and also by the Ministry of Knowledge Economy, Korea, under the ITRC (Information Technology Research Center) support program supervised by the Institute of Information Technology Advancement (IITA-2008-(C1090-0801-0046)).

REFERENCES

- [1] H. Balakrishnan, R. Baliga, D. Curtis, M. Goraczko, A. Miu, N. Priyantha, A. Smith, K. Steele, S. Teller, and K. Wang, "Lessons from developing and deploying the cricket indoor location system," 2003. [Online]. Available:
- [2] H. Jee, D. Eom, T. Kim, H. Park, H. Lee, and J. Han, "Multi-player VR Game built upon Wireless Sensor Network," *Proc. 2nd International Conference on Ubiquitous Information Management and Communication*, Suwon, Korea, Jan.31-Feb.1 2008, pp.542-544. (Poster)
- [3] D. Eom, T. Kim, H. Jee, H. Park, H. Lee, H. No, J. Park, J. Han. "Wireless Sensor Network for Multiplayer VR Game," *Information Sciences* (under review)
- [4] Y. Tsukada, and T. Hoshino, "Layered touch panel: the input device with two touch panel layers," In *CHI '02 Extended Abstracts on Human Factors in Computing Systems* (Minneapolis, Minnesota, USA, April 20 - 25, 2002). CHI '02. ACM, New York, NY, 584-585.(Poster Session)
- [5] M.B.Mirkovic, Z.N.Milivojevic, and M.C.Stefanovic. "Touch Signal Detection in the Presence of Gaussian Noise and Interference," *Information Technology And Control, Kaunas, Technologija*, 2005, Vol. 34, No. 3, 285 - 289.
- [6] A. Shirai, E. Geslin, and S. Richir, "WiiMedia: motion analysis methods and applications using a consumer video game controller," In *Proc. 2007 ACM SIGGRAPH Symposium on Video Games* (San Diego, California, August 04 - 05, 2007). Sandbox '07. ACM, New York, NY, 133-140.