

# Earthlings Attack! A Ball Game Using Human Body Communication

Masato Takahashi<sup>†</sup>, Charith Lasantha Fernando<sup>†</sup>, Yuto Kumon<sup>†</sup>, Shuhey Takeda<sup>†</sup>,  
Hideaki Nii<sup>†</sup>, Takuji Tokiwa<sup>‡</sup>, Maki Sugimoto<sup>†</sup> and Masahiko Inami<sup>†</sup>

<sup>†</sup>Graduate School of Media Design, Keio University  
4-1-1 Hiyoshi, Kohoku-ku, Yokohama, Kanagawa, Japan  
{masatoo, charith, yuto-kumon, tkd, nii, sugimoto, inami}@kmd.keio.ac.jp

<sup>‡</sup>Future University Hakodate / Graduate School of Media Design, Keio University  
116-2 Kamedanakano-cho, Hakodate, Hokkaido, Japan / 4-1-1 Hiyoshi, Kohoku-ku, Yokohama,  
Kanagawa, Japan  
takujitokiwa@acm.org

## ABSTRACT

In this paper, we describe a ball game "Earthlings Attack!" that uses the contact between users and an active ball device as an information channel to the game content. When the ball device with built-in transmitter comes in contact with the user who wears the receiver, this system transmits information from the ball device to the receiver through user's body with the human body communication. With this method, we aim at the interaction improvement of the augmentation of the interaction in such a way that presenting information on user's body according to the contact between each ball device and each user. This system also enables to use in a wide range field in the same network by managing contact information of both collectively.

## Categories and Subject Descriptors

H.5.3 [Information Interfaces and Presentation (I.7)]: Group and Organization Interfaces—*Computer-supported cooperative work*; B.4.2 [Input/Output and Data Communication]: Input/Output Devices—*Channels and controllers*

## General Terms

Design

## Keywords

human body communication, wearable computing, game design

## 1. INTRODUCTION

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Figure 1: Image of Earthlings Attack!

Recently, few there are some researches on interactive contents using physical ball devices got famous. These contents are the techniques for building a microcomputer based ball, and presenting information according to the value of built-in sensors or for detecting the location information of the ball by installing the sensors on a surrounding environment[2][5][8]. It pays attention to both, the characteristic of the ball, and I/O of some information channels. However, there is no technique for detecting from which user the information from which user to user, the ball moved because, detected information is controlled by built-in sensors. Moreover, to detect when the position of the player was sensed, it requires rather large scale equipment and it often limits the detection range and this is a major drawback in physical multiplayer game deployment in a large area. the range of use was often limited because large scale equipment is required.

In this paper, we attempted the improvement of those problems by using the human body communication for the contact detection between the ball and the user. It becomes possible to use the contact between each ball and each user by this method as a new information channel. Moreover, the configuration of the system setup doesn't limit the range of use because this system is a data processing method between the ball and the user when in contact.

Earthlings Attack! is an interactive content game using ball devices to digitalize the contact judgment, and to enhance physical interactions (Fig.1). In this work, a system that instantaneously transmits the information by using human body communication through user's skin contact was developed.

## 2. RELATED WORKS USING HUMAN BODY COMMUNICATION

In the human body communication technology, PAN (Personal Area Network)[9] by Zimmerman was the key research where human body communication was explained. Afterwards, Wearable Key[3] by Rekimoto et al, Firmo[4] by NTT and DiamondTouch[6] by Paul Dietz et al etc... were put to practical use. However, there are not many application examples intended or aimed for the entertainment until now.

Baba's et al. Freqtric Drums[7] did a research on the interaction that uses the skin electricity activity in relation to the human body communication. Moreover it emulates some This is electronic musical instruments that produce several kinds of drum sounds according to the body contact between two or more users plays together. Freqtric Drums can measure the strength of each contact between human bodies by measuring the amount of the current that flows to the human body through the skin impedance. Earthlings Attack uses a similar kind of system intended for the contact between the ball and the user, but it does not attach any importance to the detection of strength when in contact touches. Moreover, only the contact detection technique by the human body communication is used to achieve the data transmission when comes with contact.

## 3. SYSTEM OVERVIEW

### 3.1 Information Transmission System through User's Body

In the human body communication in general are two folds. , Aan electric field method and a current method[9] is used in general. In electric field method, the communication is through the electric field along the surface of the human body. Since it is weak weak to the in terms of noise, it can be used with on clothes on because it communicates directly without the electrode coming in contact with the human body. AThe signal carrier of from several MHz to tens of MHz is used for the communication. In this research we focus on the current method which is a method in the human body communication through the micro current when a human body comes in contact with an electrode. It has the unstable factor in the transmitter, receiver and the ground in the use state, but it is stronger than the electric field method in terms of noise. This method can use whole of the body if the user wear conductive clothes. A carrier signal from hundreds of kHz to several MHz is used for the communication.

OurThis system uses the current method to avoid false recognition in the contact distinction between the ball and the user. The unstable factor, Ground connection was solved by hanging the ground line down from each transmitter and receiver up to length in which it touched the ground.

This system consists of a belt that functions as a receiver and a ball as a transmitter. Each user wears the receiver belt. The receiver has athe FSK demodulator circuit which

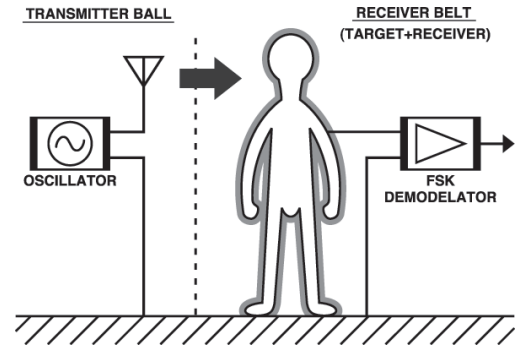


Figure 2: Configuration of this system

corresponding to the frequency band of the modulation wave that the transmitter ball outputs. Whenever there is a ball in contact with human body, the receiver reads data, and the transmission of information between the ball device and the user is achieved (Fig.2).

### 3.2 Data Transmission Method

This system transmits information by the pulse width transmission method. When the transmitter ball comes in contact with the user, the modulation wave outputs by the transmitter ball is sent to the FSK demodulator in the receiver belt through the human body contact. Pulse width of the High signal input is accurately measured by using the capture function of the microcomputer which is attached to the FSK demodulator. The start bit, logic high(1), and logic low (0) are defined according to different time widths. The data that the transmitter ball output is read by this method which constructs the original bit pattern which was transmitted. (Fig.3).

Current configuration id the system sets 4ms to "start bit", 2ms to logic high "1", 1ms to logic low "0" and installed intermediatethe 1ms of the low output respectively. Current configuration could reconstruct a 4-bit binary data followed by a start bit. This volume of data is enough to achieve the intended purpose of Earthlings Attack game. . The use frequencies are set to the values of Table 1.

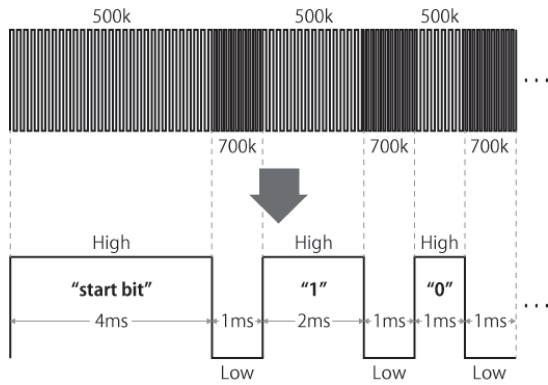
Table 1: Using frequency and FSK output

	Space	Center	Mark
Frequency(Hz)	500k	600k	700k
FSK Output	High	-	Low

### 3.3 Receiver Belt Design

The user wraps the receiver belt around the waist which then put the conductive pad whereich input electrode is connected to the body (Fig.4). The receiver belt has the following three functions.

- Function as receiver in the human body communication
- Information presentation by effect of lighting and effect of sound
- Data readout function to use with FSK demodulator and microcomputer



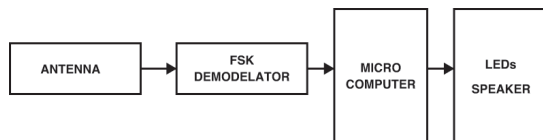
**Figure 3: Data treatment according to the High length of FSK output**

The FSK demodulator, PIC16F876 microcomputer, bar antenna, speaker, speaker amplifier, LEDs, and a battery are built into the receivers belt.

The data is read from the output data of the FSK demodulator with the help of microcomputer. The bar antenna uses together with a variable capacitor, and tunes it to the frequency band that complies with the transmission frequencies. The microcomputer also controls the output of LEDs and the speaker according to the acquisition data. Moreover, a shield line of about 80cm is hung down from the joining terminal in the ground line of the receiver circuit to ground.



**Figure 4: Appearance of the receiver belt**



**Figure 5: System figure inside of the receiver belt**

### 3.4 Transmitter Ball Design

The ball functions as a transmitter in the human body communication. This circuit includes a PIC16F876 microcomputer and the surface is covered with aluminum foil that connects the output electrode of the oscillator. (Fig.6). It keeps outputting specific binary data by switching the frequency of 500kHz/700kHz which represents logic high and logic low. Additionally, a shield line of about 1m is hung

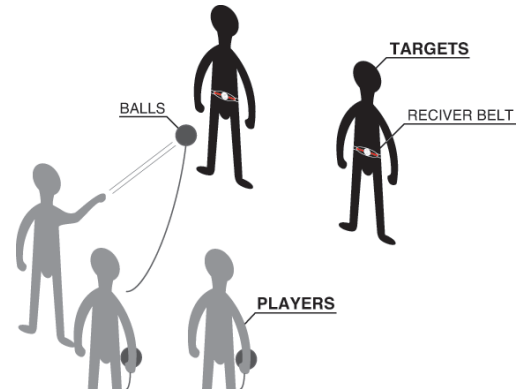
down from the joining terminal towards the ground to make better ground contact.



**Figure 6: Appearance of the transmitter ball**

## 4. RULES OF THIS WORK

Earthlings Attack! is an interactive content of the shooting form that hits the ball to one direction (Fig.7). The players throw out the ball toward the target. If the ball comes in contact with the body of the target, one LED of the receiver belt is turned off with the sound effect. This means the hit points of the target has fallen by one. The target usually runs around trying to escape and to avoid the contact of the ball. Different transmitter balls can be simultaneously thrown at different user bodies, but multiple balls throwing at one user body at the same time is not acceptable. This work is an interactive content of such a shooting game form.



**Figure 7: Image of game format**

## 5. USER STUDY

The user study was done at the 6th workshop collection[1] that was a workshop event for children (Fig.8). The number of participants for two days of period was about 200 people. We explained the game to children who were the first participants who experienced in this workshop. The game rules were explained as below.

- Throw out the transmitter ball towards the target.
- The hit point which represents the physical strength of the target decreases if ball strikes a target body.

- If all the hit points which represents the physical strength of each target disappear, it is the GAME OVER.

First experiment is conducted with 20 people. The number of transmitter balls prepared on the player side is three. The three targets who worn the receiver belt went up to the stage.

Those who intuitively experienced the system sooner understood the game logic, and enjoyed playing a game immediately. Especially, it was seen that few male children who saw the experience and got excited, immediately stood up and queue for the game play. On the other hand, there were some female children who were reluctant to hit a man's body. Another interesting fact we found was that children were interested in hitting all over the body, not just a specific area. The freedom in the game play where they can hit anywhere in the body makes it more interesting for them. At the end of this game, they were continuing to throw out balls for a while. They seemed to consider the targets to be the characters in the video game. Occasionally the study was interrupted by the cause of that the ground line got twisted or the ground line connected with the bowl is disconnected. Consequentially, a lot of those who experienced were able to enthuse about the game.



Figure 8: View of user study

## 6. DISCUSSION

The utility of this system is considered from the user study. First, the application to interactive contents with a ball device is considered. In the user study, the interactive content of which the theme shooting was used. It is thought that mounting the interaction according to the contact detection between the ball and the target was achieved from this user study. It is similar to the popular outdoor shooting game "paint ball" but with rich interactions such as players with different teams can be just derived from the data transmitted through the ball. For example, If team-A shoots a team-A player the strength will not reduced (friendly fire) where as shooting between different teams will lead the strength to reduce.

The unstable factor in the proper ground connection of the with transmitter and the receiver is a technical problem. The problem is dealt by hanging a ground line down from the transmitter and receiver towards the floor. However, under such conditions there is an obstacle in the movement of the player and the ball hit. The solution of this problem will be needed in the future.

In the use of this system in an application level game with a ball device, the improvement of the contact judgment accuracy and enhancing the interaction are expected. Additionally, use of presenting information in each user's body and managing the contact situation by wireless communication is assumed. Moreover, it is thought that a new game form can be created where the ball device has the rules to the game. Therefore, the creation of a new game and interaction is expected in using this system.

## 7. CONCLUSION

In this paper, a ball game interaction using human body communication and the system were described. The application and the scalability to interactive contents will be expected in the future while some technical problems are held at the present stage. It was a big result that those who experienced had intuitively understood this system and enjoyed contents as a result of the user study. However, it is necessary to avoid the barriers that interfere to the progress of the live game action and the movement of the player. Therefore, the trouble concerning ground, durability of transmitter ball and receiver belt will be improved in the near future.

## 8. ACKNOWLEDGMENTS

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