The Seventeenth International Symposium on Artificial Life and Robotics 2012 (AROB 17th '12),
B-Con Plaza, Beppu, Oita, Japan, January 19-21, 2012

Social Playware for Supporting and Enhancing Social Interaction

Kenji Suzuki[1,2], Kazuki Iida[1], and Tomoya Shimokakimoto[1]

[1] University of Tsukuba, Tsukuba 305-8573, Japan
[2] Japan Science and Technology Agency, Japan
(Tel: 81-29-852-5761, Fax: 81-29-852-6287)
(kenji@ieee.org)

Abstract: Social Playware is regarded as cyber-physical systems to support and enhance the experiences on play and social interaction among people by measuring and presenting physical contacts, spatial movement and facial expression. Several wearable or modular devices are used in this study, which enable behavior and affective measurements based on augmented human technology. It is aimed not only to integrate cyber and physical spaces by using developed wearable devices but also to show the possibility to help people develop their social ability throughout case studies.

Keywords: Playware, Wearable Device, Body Area Network, Heart Beat, Physiotherapy Application

1 INTRODUCTION

Several attempts have been done for playful physiotherapy, which is supposed to motivate patients to engage in and perform physical training and exercising for preventing potential health problems or rehabilitation. Researchers recently have been paid attention to playful therapeutic applications with the aid of recent advancement of sensing devices and display. For example, input devices by measuring body gesture such as Wii (Nintendo) and Eyetoy (SONY) are typical cases used for rehabilitation or clinical trials. Camera or sensors are used to measure human bodily movement, and visual and / or auditory feedback is given to people by using virtual / mixed reality technology.

In this domain, social interaction plays an important role in different situations during these physical training and exercising. There have been reported that the motivation is a critical factor at the physical therapy and rehabilitation, but it is not easy for people to keep it on performing physical exercising. There is another difficulty to establish a different level of communication between patients, or patient and therapist. In this matter, toys are interesting and playful tools to each other mediated through the interaction. Several studies about toys have been done, for example, it is known that children have general preferences on visual stimuli with warm-color lights, auditory stimuli with tones and scales, haptic and somatosensory feedback to the whole body. Also they have positive response to toy's movement itself.

In order to understand social interaction among people, several kinematic and physiological cues among people are investigated in these case studies, such as facial expression, gaze direction, head orientation, body gesture, physical touch, space / location, physical distance among people and objects, as illustrated in Fig. 1. We introduce several wearable or modular devices, which enable behavior and affective measurements based on augmented human technology.

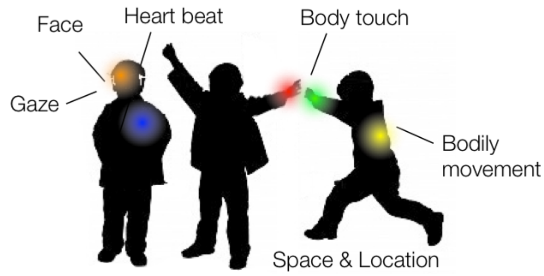

Fig. 1. Social Playware: Cyber-physical system to support and enhance the experiences on play and social interaction.

The concept of "Playware" is proposed and several works have been done so far in order to realize the playful interaction with interactive tools (see also [1, 2]). It is defined as intelligent hardware and software that creates play and playful experiences for users of all ages, and social playware is also defined as playware which aims at creating playful social interaction between several users.

In this paper, we introduce two examples of Social Playware; (i) Enhanced Touch: Sensing touches and identifying others can be done by the wearable device, (ii) HOTARU ("firefly" in Japanese): LED lights up in synchronization with the heart beat, and the color changes according to the calculated heart beat rate.

2 CASE STUDY I: ENHANCED TOUCH

We propose a novel bracelet-type device for sensing physical contact among people in order to support direct communication between people by inducing touching with appropriate visual feedbacks. The device detects and records the touches of users by simply wearing the device on their wrists (See Fig. 3).

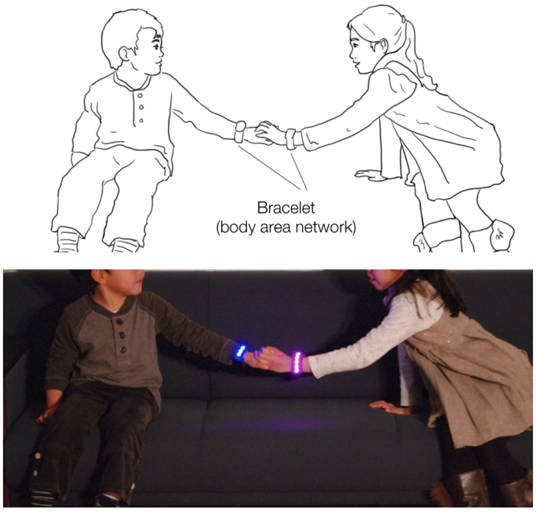

Fig. 2. Enhanced Touch: Sensing touches and identifying others can be done by the wearable device with electrodes.

Fig. 3. The six full color LEDs are installed in the bracelet, which are lit up when handshake occurs.

Physical touch is a fundamental element of human communication and several benefits and positive effects were reported at the communication and therapeutic domain such as Positive Touch and Deep Touch Pressure, for instance [3]. Typical symptoms of autism among children include avoiding direct touch with other people in addition to the tendency to lone activities. Some studies reported that training of touching by therapists contributes in the alleviation of these symptoms. Till now, human coders tried to observe their activity via recorded video but it is not objective measure and time consuming for checking all touches among people in a session. Measuring the time of touching, partner, frequency are desirable data, but there is no practical equipment for this purpose. Similar technology is used for the instrumental device [5], but users needed to grasp and hold the same device together.

2.1 System Overview

We use the communication technology based on body area network [4] in order to detect touching between people communication through human body. This technology was known as alternative solution of communication between humans and objects. Since the information is transferred via human body, it can be utilized for sensing physical contact among people. The developed device is used for sensing touches and identifying others, which can be performed by the wearable device with electrodes. The six full color LEDs are installed in the bracelet, which are lit up when handshake occurs. The pair of electrodes is located on the inside of the case as to fit the wrist. The device communicates with another device using a specific communication protocol. The received conducted signal is first amplified and demodulated, and then handled by the microprocessor. Every microprocessor tries to transmit a synchronous signal at random intervals within $10\,[\mathrm{ms}]$ to detect if touching has occurred and to synchronize with other device.

Several visual effects are programmed to visualize not only the physical touch but also the touching condition such as duration of physical touch and history of past touching. For example, colour blending is implemented for effective visual feedback to show the duration of touching. A unique color is assigned to each device; the three primary colors (Red, green, blue).

When a user wears the devices and touch to another person with the developed device by their hands, both devices light up LEDs with its unique color. While keeping the shake-hands, Two different colors change and are then blended gradually as long as the touching lasts. In other words, the degree of color blending represents the duration of the touching time. The LED colors in the two devices in touch become the same color. This manner of lighting allows our proposed method to measure the duration of physical contact along with the device's ability to identify other devices.

Table 1. Time during different style of physical touch

Style of physical touch	Time (S.D.) [ms]
Hand Clap	50.7 (12.1)
High Touch (Normal)	44.8 (10.9)
High Touch (Slow)	187.5 (22.1)

2.2 Touching and response time

In order to confirm the performance of the developed device, we first conducted a simple experiment to measure the time during different style of physical touch. Fig. 1 shows the averaged times in [ms]. We obtained that the averaged touching time is $94.3\,[\mathrm{ms}]$ at different style of physical touch such as hand clap and high touch.

Due to the characteristics of communication protocol, the response time of the developed device has some variance. The response time is regarded as the period of time from the moment the touching occurs to the moment the LEDs of the device are lit up. Two subjects touched fifty times by the tip of the fingers and these touches was recorded by a high-

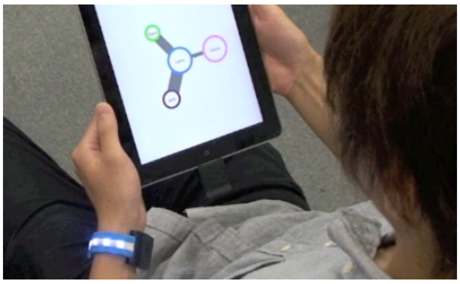

Fig. 4. A correlation diagram among users by exporting the data to another device with a Tablet device.

speed camera with 1200 [fps]. The response time was calculated from the number of frames between those two actions. From the experimental results, we obtained that the average of response time is 27.7 [ms], and the standard deviation is 19.2 [ms]. The minimum value is 6.7 [ms], which is almost equal to the transmitting time plus receiving time, thus the value is valid. The maximum value is 80.0 [ms]. These results show that the response is signitifant for recording daily life touching or for games that include touching activity, even in the worst case of response time.

2.3 Correlation Diagram on a Tablet Device

The device is be able to record and show the physical contact log among people, such as the number of shake-hands and/or amount of touching time over a long term. These logs show the degree of friendship or relationship among people. We developed a Tablet device with electrode in order to show a correlation diagram among users by exporting the data to it. A correlation diagram is shown in Fig. 4. This diagram appears when the user touch and hold the device. Where the circles indicate users, and the lines show the relationship among these users as the line’s width indicates the degree of friendship between two users. Such application will provide a new measuring method of relationship in an easily understandable way.

3 CASE STUDY II: HOTARU

In this study, we propose a novel method of heart beat tracking and develop a wearable device to visualize the heart beat, namely *HOTARU* (”firefly” in Japanese). These are a number of systems and devices for heart beat measurement, which can be used to measure heart function or exercise volume, psychological barometer such as stress or relaxes. However, since the measurement of biological signals are not stable due to the unexpected several noises, the user is asked to firmly attach the sensor, for example electrode, and also to keep quiet even for the measurement of the heart beat rate, Fast Fourier Transform (FFT) is used as the traditional method of the measurement of heart beat rate, while the signals with unexpected noises in the measured signal are ignored.

Fig. 5. HOTARU (”firefly” in Japanese): The conceptual image of using the developed device.

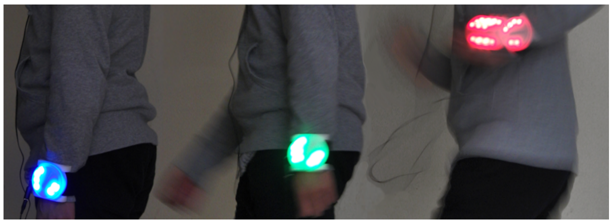

Fig. 6. The developed device in use. LED lights up in synchronization with the heart beat, and the color changes according to the calculated heart beat rate.

3.1 System Overview

A wearable device is developed to indicate the heart beat in real time with different color of LED. The color changes according to the heart beat rate, and blinks in synchronization with the heart beat pulse. The developed system is able not only to track the heart beat but also to interpolate it from the noisy signals in real time. The heart beat is extracted from the original signal of the photoplethysmographic (PPG) sensor, which contains the noise delivered by body movement or other unexpected causes. In the proposed method, when the system is not able to determine the heart beat due to the sensor ’s alignment or temporary no pulse, the heart beat is interpolated based on the past signal and liner prediction algorithm.

3.2 System Overview

The developed device *HOTARU* consists of a microprocessor, LEDs display, and PPG sensor that can measure heart beat pulse by using optical absorptance of human body. The user is asked to attache PPG sensor that is a clip-type interface on the ear, and to wear a bracelet-type interface with LEDs on his or her wrist. The brightness of LEDs changes in synchronizion heart beat and its colors corresponds to the heart beat rate (HBR). As shown in left of Fig. 6, blue means that heart beat rate is less than 60, green means that heart beat rate is from 60 to 80, and red means more than 80.

3.3 Methodology: Real Time Heat Beat Tracker

Traditionally, since the measurement of heart beat is focused on the heart beat pulse itself, but the tracking accuracy depends upon the environment. It is usually not stable because of the noise, and users are asked to rest during the measurement. The intervals of heart beat pulse are low frequency from about 0.5 to 2.0 [Hz] and these intervals is assumed not rapidly change. But precise intervals are difficult to be recognized from the measured signals only by using peak detection due to the noises, which are usually impulse noise and look like heart beat pulse. FFT is used as the analysis of it.

On the other hand, we propose a novel method of heart beat tracking. The pattern-matching is carried out between the measured signal $\mathbf{P}(x,t)$ and the ideal heart beat pulse $\mathbf{Pc}(x)$, which is prepared in advance. The cross-correlation $\mathbf{z}(x,t)$ is calculated with the fixed time window which is the same as the length of the ideal heart beat pulse. The matching result $\mathbf{z}$ is expected to be a periodical signal, and it is synchronized with the real heart beat pulse. The computational cost to obtain the coefficients of all possible cross-correlation values is very high and not suitable for real time calculation, only limited coefficients are used in this process. In addition, in order to reduce the computational cost, the cross-correlation values are obtained only at the certain time, which is estimated at the linear prediction process.

Then, a modified peak detection algorithm is employed by combining Kalman filter to predict the intervals of heart beat, which is based on the linear prediction and uniform distribution function. Assuming that these intervals do not rapidly change, next heart beat interval can be estimated from transition of previous several intervals. And center value of probability density function (PDF) is solely used for detection of peak candidate in $\mathbf{P}$. The peaks are detected within the $\mathbf{z}$ time range of reliability based on this PDF.

3.4 Experiments

We conducted an experiment to compare the proposed heart beat tracker with electrocardiograph (ECG) signal from 10[s] data in different situations of user's resting and moving. The experimental result shows 100% accuracy for resting state and 94% for moving situation where traditional FFT or peak detection algorithm does not give any significant heart beat tracking.

4 DISCUSSION AND CONCLUSIONS

In this paper, we introduced two examples of social playware. It is aimed not only to integrate cyber and physical spaces by using developed wearable devices but also it can be used to help people develop their social ability throughout case studies.

The devices for sensing the human contact can be used to recognize the social network based on physical contacts. The bracelet-type device lights up - with a different color for each - when the wearer shakes hands with another wearer. Not only sensing the contact but also the electrical communication is also used to identify and share the device ID. We believe that the proposed device could provide a novel playful interaction method between humans. We now plan to verify if the device contributes to motivate touching among users by lighting LEDs or by playing interactive social games. On the other hand, we presented another device for presenting current heart beat with different color. LED lights up in synchronization with the heart beat, and the color changes according to the calculated heart beat rate. The developed device allows users to freely move and play without attaching the sensor or electrode firmly. Potential applications include the tool for kids to promote social interaction. The user testing with several people is planned. We also will implement the sound feedback according to heart beat pulse for computer games and VR avatar.

Throughout these case studies, we would like to expand the playware technology for supporting and enhancing the experiences on play and social interaction among people by using playful devices. The device mediates between humans without missing fundamental properties of human activities. We consider that social playware is a cyber-physical system by measuring and presenting human physical activities such as physical contacts, spatial movement and facial expression, where psychological and social aspect of human activities could also be enhanced.

ACKNOWLEDGMENTS

This work is supported in part by JST PRESTO, Japan Science and Technology, and also by the FIRST Program, funded by the Council for Science and Technology Policy.

REFERENCES

[1] Lund HH, Klitbo T and Jessen C (2005), Playware Technology for Physically Activating Play. *Artificial Life and Robotics Journal*, 9(4):165-174

[2] Marti P, Giusti L, Lund HH (2009), The Role of Modular Robotics in Mediating Nonverbal Social Exchanges, *IEEE Transactions on Robotics*, 25(3):602-613

[3] Pardew EM, and Bunse C (2005), Enhancing interaction through positive touch. *Young Exceptional Children*, 8(2):21-29

[4] Zimmerman TG (1996), Personal Area Networks: Near-field intrabody communication, *IBM Systems Journal*, 35(3.4):609-617

[5] Baba et al. (2007), Freqtric drums: a musical instrument that uses skin contact as an interface, *Proc. of NIME*, 386-387