Dancing Game by Digital Textile Sensor, Accelerometer and Gyroscope

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Abstract - **A novel dancing game, comprised of pressure sensors on socks with accelerometer and gyroscope to detect the movement of the player, is presented. The firmware in microcontroller can judge the movement of the player with enough accuracy such that the player would not be limited by wires and resident equipments. We designed a novel wearable entertainment system to provide a mixed reality game in which users can play dancing game.**

Keywords: **sensor in textile, accelerometer; gyroscope; body movement; dance game, mixed reality game**

I. INTRODUCTION

Novel input techniques have received popular attention in computer game research since the spread of Wii by Nintendo. With augmented reality, one can create interfaces that merge virtual objects and signal data with the real world, promoting flexible people-machine and people-people interactions. The pioneer is, without question, the Nintendo Wii console. Another successful example is Dance Dance Revolution, DDR. However, both Wii and DDR have taken advantage of only one type of sensor to detect limited body movement. Our research employs multiple sensors to detect multiple sources of body movements, representing sophistication of the input technology in multi-dimensional space.

Our initial goal was targeted in rehabilitation and home healthcare [1][2][3]. We have further made it into a dance game [4]. To detect the movement of lower limb has been a key technology in rehab, now it may be applied to interactive games. In our previous studies, we applied digital textile sensors to detect posture or estimate human gait. On the other fronts, we have realized much research has disclosed body movement detection systems based on wearable accelerometer and gyroscope.

Thus, we attempt to integrate gait analysis technology with accelerometer and gyroscope to create a novel dancing game. We place interface devices onto pants and socks and derive input signals based on the movement of hips and feet when playing the game. Also using ubiquitous wireless network to gather signals from wearable sensors, the player can explore the virtual world without being limited by the sitting down or standing up position on the same spot due to the constraints of fixed equipment and wires.

II. MATERIALS AND METHODS

A. System Description

The game system, as shown in Figure 1, is comprised of four dome-shaped pressure sensors fixed on a pair of socks and copper wires sewn to pants for transmitting the signals from socks to the control box. This control box is for data acquisition and processing; interfacing to a computer program to also tracking movements by the player. The control box contains an PIC24FJ256 micro controller (Texas Instruments) with 100 Hz sampling rate, an MA7361L tri-axis accelerometer with ±1.5 g full range and frequency response at 400/300 Hz, an IDG-500 gyroscope with ±500 ° /sec full range at 2.0 mV/° /sec sensitivity, and a Bluetooth wireless module. The player is shown in Figure 2, wearing the socks, pants, and control box. Figure 3 shows the sock and its schematic.

B. Dome-shaped sensor

The dome-shaped sensor, as shown in Figure 4, is comprised of a base layer cloth where two tin-plated copper wires are knitted on, and a silicon dome with conductive graphite is also installed on the base layer. When the dome is pressed by a force greater than 300 grams, it will cause the conductive graphite layer to touch the two tin-plated copper wires to be electrically connected. Each sock is knitted with two dome-shaped sensors, one placed under the big toe and the other under the heel.

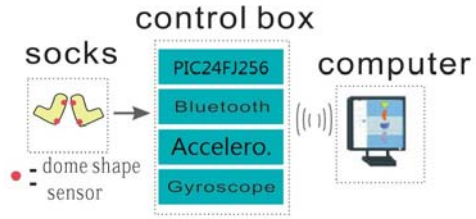

Fig.1. Schematic of the dancing game system

Fig. 2. The player wearing socks & pants

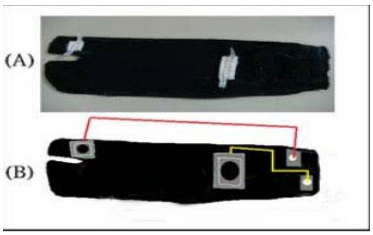

Fig.3. (A) The socks, (B) Schematic of the socks

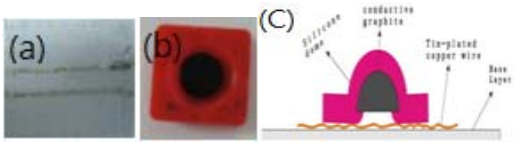

Fig. 4. (a) Base layer with t-plated copper wire. (b) Silicone dome with graphite inside. (c) Schematic diagram of the dome-shaped sensor.

C. Firmware to record player's movement

The firmware in micro controller records the movement of the player not only by the sensor on the socks but also through the accelerometer and the gyroscope, as shown in Figure 5. The firmware checks the status of the dome-shaped sensors and integrates the output of the accelerometer and the gyroscope to make a path diagram, from which the firmware can interpret whether the player is stepping forward or backward, turning left or right.

D. Computer program

The dancing game is comprised of three modes. The player should play by the order of mode 1, 2, and then 3.

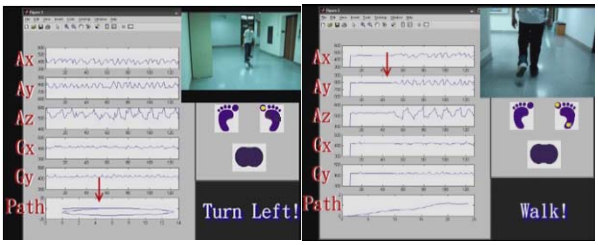

Fig. 5. The firmware interprets the player's movement by signals from the 4 pressure sensors, accelerometer, and gyroscope.

Mode 1:

Similar to DDR game, arrows of different directions scrolled through the screen one by one while popular music playing and the player should follow the arrow in the middle of the highlighted area. For example, when a right arrow is present, the player should raise his right foot and then touch the ground, as shown in Figure 6. For the forward and backward arrow, either foot can do the motion. The corresponding arrow in the white square to the left would turn green if the player dances with the correct foot; turn red if wrong. The program counts the number that the player has made with the correct movements. The program would turn to Mode 2 after the count reaches 100. In Mode 1, only signals from the bottom sensors on the socks are counted, the signals from the accelerometer and the gyroscope will be ignored; therefore, the player does not have to be concerned about body movement to keep it simple.

Mode 2:

Similar to Mode 1, but foot prints instead of arrows are shown scrolling through the screen, as illustrated in Figure 7. The signals from the accelerometer and the gyroscope are taken into count; therefore the player has to really move his body accordingly. One correct movement gets one point, and the program would turn to Mode 3 after reaching 100 points in Mode 2.

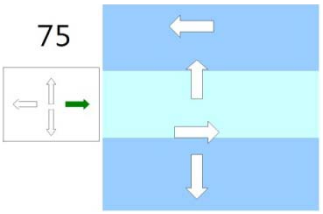

Fig. 6. Mode 1 screen.

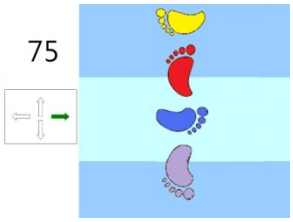

Fig. 7. Mode 2 screen.

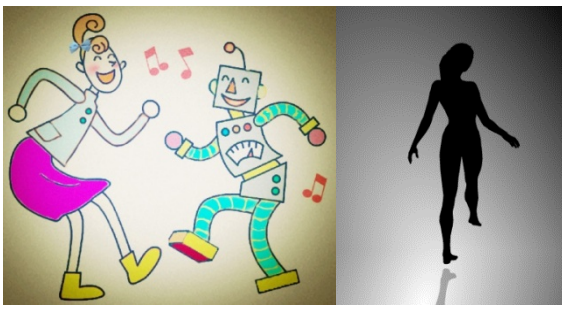

Fig. 8. Mode 3 screen (left for amusing young dancer wanting a partner; right for serious single dancer)

Mode 3:

Mode 3 is a mixed reality game. For beginners, young with amusement in mind, the computer screen is shown with two virtual characters, one of them (the girl or an image chosen by the player) reflects the motion of the player herself, and the other (the robot or the player's favorite mate) is controlled by the program, as illustrated on the left block of Figure 8. For serious dancers, a desirable image will be displayed based on the player's motion and her model dancer, as illustrated on the right block of Figure 8. The player follows the specified choreograph and the rhythm of the music, to dance with a virtual partner of her choice, or to see herself emerge as an expert dancer. The latter capability is still in design stage, requiring camera input and much more interpretation algorithms.

III. RESULTS AND DISCUSSION

The major problem we have had during development of the game has been with the shoes. Some players said that the program did not count the correct movement, or the response was delayed significantly. We found several times that the inside bottom of the player's shoe was distorted badly but the user never felt anything wrong with the shoe. Fortunately for

most of the players, this kind of problems was rather minor. The player can still enjoy the game even with the software was buggy.

Our socks also caused some problems. When the player wore socks with the wrong size, or when the socks lost its tension, the bottom switches would not stay in the correct position, which increased the probability of mistakes.

The accelerometer and the gyroscope had similar problems to the extent that the opposite direction was recorded. We found that often times it was due to the fact that the control box was not fastened. Some players just left the belt unbuckled.

A problem was also reported when the player felt that the accelerometer or the gyroscope did not respond to his movement. This is absolutely true because the Signal to Noise ratio (S/N) of the accelerometer or the gyroscope is not high enough to distinguish it from the noise. We therefore set the program with specific threshold to ignore the noise while not ignoring the signals. In fact, the accelerometer and the gyroscope we deploy are designed for use in consumer products such as hard disk and digital camera to avoid disk head crash or hand vibration. It is not designed to sense small signals. To detect signals similar to the noise level, we have taken advantage of the microprocessor features, however, more efforts on hardware or firmware filtering are necessary.

IV. CONCLUSION

A dancing game system is presented which is comprised of dome-type sensors made of textile on socks and pants, employing an accelerometer and gyroscope in the control box, utilizing program control and display in a computer. The program will prompt the player from the entry level Mode1 to Mode 3, where a mixed reality game can encourage the player to practice, improve and dream on. It presents several advantages in terms of portability and wash-ability. However, many challenges still prevail in weak and loose signal detection, scaled up motion detection, mixed reality presentation, etc. Inspiration and continuous usability are especially critical for wearable devices with the proper form of attractiveness in design. We are in the process of incorporating broader multi-disciplinary expertise to address these challenges such that the dancing game can cater to a broader audience for various purposes.

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