Design and Implementation of a Virtual Electronic Dart with a Tablet System

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***Abstract*-- In this design, we propose a virtual electronic dart which contains a microcontroller, a tri-axis accelerometer and a Bluetooth module. The players only need to wear a ring and a bracelet to swing this virtual electronic dart in the air. The controller will transmit the space coordinates of the virtual electronic dart to the specific tablet that calculates the hit location of the dartboard by using the flying path of the projection equation. The results are then displayed in the tablet's screen.**

I. Introduction

Traditional darts which just use a plastic dart head to reduce the risk of injury use either the photoelectric switch or direct sensing of the dartboard to detect the location of the shot [1]. The current popular family video game achieves human posture game control by using a digital camera to intercept the player's actions. Nowadays the number of wearable products has gradually increased. A user now uses a computer's keyboard, mouse or touch screen to operate these new products; but when operating them, the user's hands must be at a fixed location [2].

There are many appliances that can be remotely controlled in the home. A universal remote controller can combine all remotely controlled appliances. The disadvantages are both the size and the operation problems. Therefore, the users use a wearable remote control device to solve operational problems, by means of a motion towards a sensor ring which sends commands to a middle device that in turn will send the infrared remote command to the appliances. In this way one can utilize a small wearable feasible remote control for all appliances [3]. Through the use of two tablets and laptop computers as an intermediary transfer, the user just downloads the application on to two tablets and connects them to a wireless network. Sensors then can sense movement on the tablet, and the upcoming tablet hands serve as a virtual racket to strike the ball. Each user uses a tablet which serves as a paddle in the game. A combination of a wireless network and a projector display simulated real motivation onto the wall when the player is batting [4].

In this paper, we design a virtual electronic dart game with no physical dart. The players only need to wear both a ring and a bracelet, which communicate with a tablet in order to begin a virtual electronic dart game. The players simply directly download the application, and pair the virtual electronic dart with the tablet and begin their game. The virtual electronic dart consists of an embedded microcontroller with a tri-axis accelerometer and a Bluetooth module which is used to send the location of each player's hand. When players swing their hands in the air, the relative acceleration values will be generated. Then, the projectile motion formula can be used to calculate the amount of the expected displacement in order to determine the potential hit location of each dart.

II. Hardware Architecture

The wearable electronic dart hardware architecture consists of three parts: a ring, a bracelet and a virtual dartboard, as shown on Fig. 1. The ring includes a tri-axis accelerometer and two reflective photoelectric switches (RPS). The benefit of using an optical sensor element is that players do not need to use a lot of effort to hold down the button. The player simply uses his thumb to cover the window of the optical element. An optical sensor element is mainly used to determine the starting point and the final emission hit location. The other optical sensor element is used to set up the initial value.

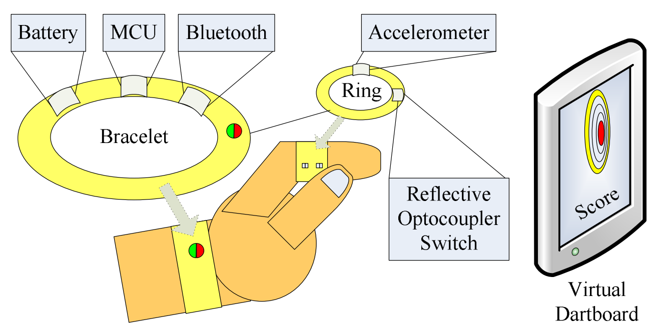

Fig. 1. The wearable electronic dart hardware architecture.

The low power micro controller unit (MCU) has several functions. First, it reads the continuous value of the accelerometer when the player swings his hand. When also determining whether the optical sensor switch has been pressed or not, the MCU will send back the acceleration values to the tablet.

III. Application Software Architecture

In a typical electronic dart game machine, the distance between a target and a player is fixed at 2.37 meters and the high is 1.73 meters. Because these locations are fixed, the height of the dart flying to the target can be calculated by (1).

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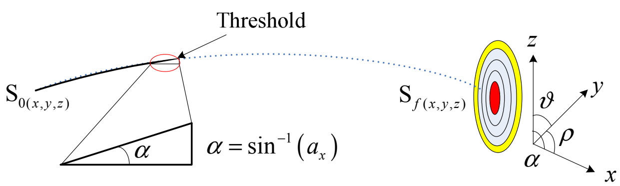
$$\begin{Bmatrix} V_f = V_i + at \\ S_f = V_f t + \left(\frac{1}{2} \times at^2\right) \end{Bmatrix} \quad (1)$$

Where V_i is the initial velocity, a is the acceleration, S_f is the final distance they must calculate three times in three axis. In the first, $V_i = 0$ and a is the value obtained from the accelerometer. When this design calculates, the total distance can be divided into two major parts, a swing dart and virtually left the hand. The first part is the measurement phase, whereby the a_x, a_y and a_z can be measured by a tri-axis accelerometer which can find a velocity on three axis. The vertical-axis is affected by the gravity, so the gravity value directly is replaced by " a_z " in (1). The trajectory of the throwing depends on two major parameters, the initial velocity (V_{lx} , V_{ly} and V_{lz}) and the angle (α , ρ and ϑ) both of which are calculated by (2) and Fig. 3.



$$\begin{Bmatrix} S_{fx} = S_{0x} + V_{lx} t \cos\alpha \\ S_{fy} = S_{0y} + V_{ly} t \cos\rho \\ S_{fz} = S_{0z} + V_{lz} t \sin\vartheta - \left(\frac{1}{2} g t^2\right) \end{Bmatrix}$$

$S_{0(x,y,z)}$: That is the initial position

$S_{f(x,y,z)}$:That is the target position

Fig. 3. Calculate the dart trajectory.

$$\begin{Bmatrix} \alpha = \sin^{-1}\left(a_x / \sqrt{a_x^2 + a_y^2 + a_z^2}\right) \\ \rho = \sin^{-1}\left(a_y / \sqrt{a_x^2 + a_y^2 + a_z^2}\right) \\ \vartheta = \sin^{-1}\left(a_z / \sqrt{a_x^2 + a_y^2 + a_z^2}\right) \end{Bmatrix} \quad (2)$$

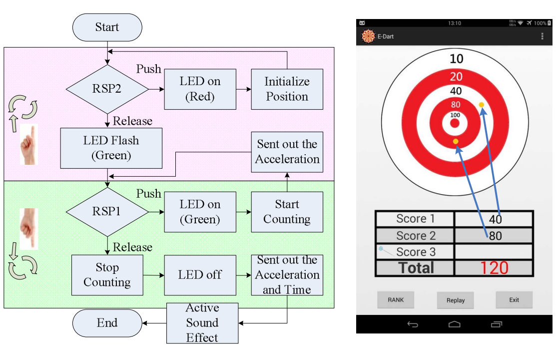


Fig. 4. The flowchart and the screen of the tablet.

The left side of Fig. 4 shows the flowchart of this design. At first, the dart model has to pair with the Tablet. The player just presses the switch (RPS2) to initial the zero position. When the user finishes the initial setting, the user holds the other switch (RPS1) and the LED indicator will become red and flash red to indicate the dart may be thrown. When the player releases the RPS1 the LED will turn "green" and the system will start to calculate both the flying path and the impact point. The right side of Fig. 4 shows the scoring.

IV. Implementation Results

When the system is in standby, the accelerometer module consumes 0.17 mW power, the bluetooth module consumes 12 mW, and the MCU consumes 43.3 mW, thus making an overall power consumption of 53.8 mW. During the game, as all modules are at work, the full power consumption will increase to 160.12 mW. This design uses a piece of paper as the dartboard which sticks to the wall. The tablet is used to display both the scores and the hit points.

Table I is a comparison table of our design with others. Design A, a traditional-style darts game, does not consume electricity, but because it uses the metal needle darts with a traditional sisal dartboard there will be a greater risk for people to be hurt. Design B is a medium-sized E-dart game machine. Users still need to throw plastic darts. In addition, the designed sound effects and lighting instructions will make the dart module consume more than 7 watts. As a result of a comparison with several other designs, our design will be safer because the user does not really throw anything out.

TABLE I
COMPARISON WITH OTHER DESIGN

	Design A	Design B	Our Design
Risk	High	High	Low
Standby Power Consumption	None	1.2W	53.82 mW
Gaming Power Consumption	None	7W	160.12 mW

V. Conclusion

The major advantage of a virtual electronic dart with no darts design is that this dart not hurt anybody and does not limit the space needed for this type of game. This design calculates a virtual electronic dart tracking when a player swings his hands. We add two photo switches and an LED into a ring and then directly connect this device to the bracelet. In future designs, the accelerometer and buzzer will be inside the bracelet and add memory to store more gestures to replace the switch, in order to achieve a more convenient way of playing this dart game.

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