# Design and Implementation of a Virtual Electronic Dart System

Chi-Huang Hung, Ying-Wen Bai* and Jen-Hung Yang*
Graduate Institute of Applied Science and Engineering, Fu Jen Catholic University, New Taipei City, Taiwan, R.O.C.
Department of Information Technology, LEE-MING Institute of Technology, Taiwan, R.O.C.
Department of Electrical Engineering*, Fu Jen Catholic University, New Taipei City, Taiwan, R.O.C.
497598042@mail.fju.edu.tw, bai@ee.fju.edu.tw, 402216130@mail.fju.edu.tw

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

***Keywords*—tri-axis accelerometer; bluetooth; projectile motion; smartphone**

## I. Introduction

Traditional darts which just use a plastic dart head to reduce the risk of injury use the photoelectric switch or direct sensing of the dartboard to detect the location of the shot [1]. The home video game machine also has a similar design, but darts are replaced by a handheld remote control, and the use of infrared and Bluetooth are used to send the location information to determine the location of the darts which the user has shot.

G-Sensor, mostly used in the virtual world created by electronic games is also a three-axis gravity acceleration sensor which is an electronic device that can provide the information of both velocity and displacement [2, 3]. The principle is similar to the use of a vector to sense the existence of a motion state. The gravity axis (X, Y, Z) which is generated by the acceleration space (G force) neglects the air resistance, when an object flying in space has not been under the influence of an external force, so as to maintain a constant horizontal linear motion. As the vertical direction is affected by the vertical throwing motion gravity, we use a three-axis projectile motion formula to predict the course of a dart in space [4].

In this paper, we design a virtual electronic dart game with no physical dartboard. The players only need to use a virtual electronic dart, which communicates with a smartphone to begin a virtual electronic dart game. The advantage of this design is safety because as there are no physical darts, there will be any potential human injuries that need to be taken into consideration. The players simply directly download the application, and pair the virtual electronic dart with the smartphone 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 virtual electronic dart hardware architecture consists of two parts: a virtual electronic dart and virtual dartboard, as shown on Fig. 1. A virtual electronic dart consists of a microcontroller, a Bluetooth module, a tri-axis accelerometer, an LED and a reflective photoelectric switch (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.

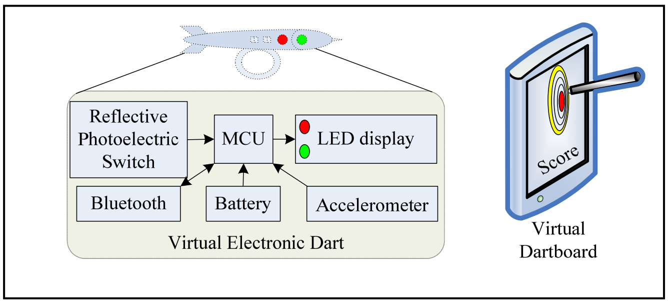


Fig. 1. The virtual electronic dart hardware architecture.

There are two functions of the micro controller unit (MCU). First, it reads the value of the accelerometer when the player swings the dart in the air which has a continuous acceleration value which the controller has read. Second, by determining whether the optical sensor element has been pressed or not, the MCU will send back the acceleration values to the smartphone. The virtual electronic dart always stays in the user's hand. We design a ring in the virtual electronic dart side to keep the dart from going out of the ring area thtat is being used. The LED is used to indicate the state of dart. A green light indicates the dart is ready to be thrown and a red light indicates the dart is ready to be set. The right side of Fig. 2 shows the virtual dartboard which is in a smartphone screen. This dartboard shows the score of the thrown dart in relation to its target location.

## III. APPLICATION SOFTWARE ARCHITECTURE

In the typical electronic dart game, the distance between the player and the target is defined as 2.37 meters, while the height from the center target bullet to the floor is 1.73 meters as shown in Fig. 2. We also can use a printed target paper attached to the wall as the dartboard which provides the player with an opportunity to judge the target location. The virtual electronic darts flying path can be computed by the (1).

$$\begin{Bmatrix} V_{xf} = V_{xi} + a_x t \\ S_{xf} = \frac{1}{2}\left(V_{xi} + V_{xf}\right)t \end{Bmatrix} \qquad (1)$$

Where $V_{xf}$ and $V_{xi}$ are the final and initial velocity along the x-axis, $a_x$ is the acceleration along the x-axis, $S_{xf}$ is the final distance along the x-axis and the value of $a$ acceleration on three axis can be obtained from the accelerometer module The system can calculate both the path and the hit location on the dartboard.

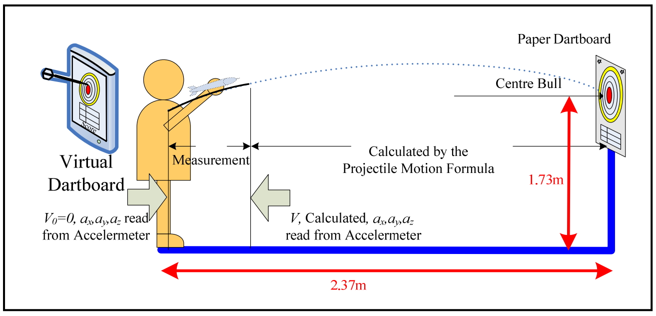


Fig. 2. The relative location and height of the dartboard.

Fig. 3 shows the flowchart and the application interface on the smartphone's screen. Players only need to press two switches: RPS1 and RSP2. The right side of Fig. 3 presents the scoring when a user is playing the electronic dart game.

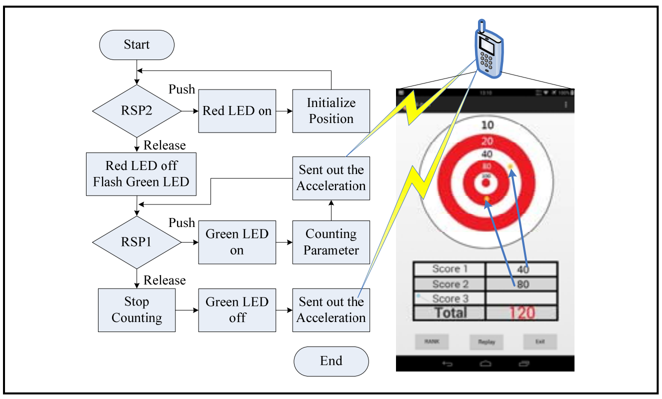


Fig. 3. The flow chart and the application interface of the smartphone

## IV. IMPLEMENTATION RESULTS

Table I is the power consumption of the virtual electronic dart. The standby power has only consumed 53.82 mW. The dartboard is a piece of common paper which does not really sense the dart. The hit location of the electronic dart is only displayed in the smartphone's screen. The hit location of the virtual dartboard and the hit location of the screen can be calibrated after several practices.

TABLE I. THE POWER CONSUMPTION OF EACH MODULE

| | *Accelerometer Module* | *Bluetooth Module* | *MCU* | *Total* |
|---|---|---|---|---|
| Stand By | 0.17 mW | 12.05 mW | 43.30 mW | 53.82 mW |
| Working | 0.56 mW | 107.61 mW | 51.58 mW | 160.12 mW |

a.

Table II is a comparison table with other designs. Design A is a traditional dart design, whereby a player uses a metal needle dart which is thrown to the wooden dartboard. Design B is an electronic dart game machine. The user throws a plastic needle dart to the plastic dartboard. The power consumption reference of this product's specification is around 7 Watts or more. With this design, as the user need not throw any object, therefore, our design is much safer than other designs.

TABLE II. COMPARISON WITH OTHER SYSTEMS

| | *Design A* | *Design B* | *Our Design* |
|---|---|---|---|
| Risk | High | High | Low |
| Power Consumption | None | High | Low |

## V. CONCLUSION

Virtual electronic darts provide a similar traditional form of dart entertainment and eliminate the risk of being stabbed by physical darts. Because this design uses a piece of paper as a dartboard for the player to target the location of the dartboard, the system does not require any complex dartboard sensor module; the smartphone performs the function of the virtual dartboard.

## REFERENCES


[1] J. Nakagawa, An Qi, Y. Ishikawa, H. Oka, K. Takakusaki, H. Yamakawa, A. Yamashita, and H. Asama, "Analysis of Joint Correlation between Arm and Lower Body in Dart Throwing Motion," 2013 IEEE International Conference on Systems, Man, and Cybernetics (SMC), pp. 1223-1228, Oct. 2013.

[2] M. Joselli, J. R. da Silva, M. Zamith, E. Clua, M. Pelegrino, E. Mendonca, and E. Soluri, "An architecture for game interaction using mobile," 2012 IEEE International Games Innovation Conference (IGIC), pp. 1-5. Sept. 2012.

[3] Shin Yoonyong and B. C. Wunsche, "A smartphone-based golf simulation exercise game for supporting arthritis patients," 2013 28th International Conference of Image and Vision Computing New Zealand (IVCNZ), pp. 459-464. Nov. 2013.

[4] Hyunju Cho, Sangchul Kim, Jinsuk Baek, and P. S. Fisher, "Motion recognition with smart phone embedded 3-axis accelerometer sensor," 2012 IEEE International Conference on Systems, Man, and Cybernetics (SMC), pp. 919-924, Oct. 2012.