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A NOVEL SCORING SYSTEM FOR THE GUN SHOOT OF EMULATED WAR GAMES

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Abstract. *The emulated war games are very popular sports for gun shoot players. Low cost, fair scoring and environmental friendly are critical factors for the emulated war games. This paper proposed and implemented a novel scoring system to meet these factors. The proposed system was successfully verified in the iterative experiments of airsoft shoots. The results showed that the hit-target signals were correctly caught and scoring count was accurately accumulated.*
Keywords: Emulated war game, Airsoft, Paintball, Scoring system

1. **Introduction.** The emulated war games were started and designed about 50 years ago. The initial motivations of the war games are to train the shoot skills of trainees with lower cost and to provide an indoor or outdoor recreation for people who love shoot sports.

Typically, there are two main categories of the war games. One is named as paintball [1], and the other one is airsoft [2]. The players in both types of games would carry replicated guns. In general, the guns are similarly powered by mechanical spring, electrical mechanism, or high pressure gas. However, the bullets or pellets are very dissimilar. An airsoft gun utilizes plastic BB (ball bullet) pellets to shoot the opposite side players. The BB pellet is usually solid and is made of plastic material [3]. It does not mark the target player. The target hit count is recorded and depends on self-evidence. On the other hand, the paintball usually applies the hollowed bullets which are filled with liquid or powder dyestuff. While the bullet hits the target, it would break and mark the target for hit proof.

According to the above description, the hit score for the BB pellet of airsoft is vague to count whereas the dyestuff in the bullet for paintball is unfriendly to players and environment. In addition, a dyestuff bullet costs much higher than a BB pellet. Therefore, Gilbreath and Gilbreath [4] proposed a target shooting system. The system detects a hit-target signal by piezoelectric sensors and transmits the hit data to the system processor via RF (radio frequency) for scoring. Thorne-Booth [5] invented a shooting system based on optical bullets and photo sensors over the target. In our invention, an accelerometer is proposed as the projectile sensor. This is a novel method for scoring system in comparison to that of piezoelectric sensors or the photo sensors. In addition, the advantages of a low cost pellet and precise hit count in a none-dyestuff paintball are adopted in our system, named as a novel scoring system for the gun shoot of emulated war games.

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The structure of this paper is organized as follows. Section 1 introduces the motivation and solving consideration of the novel scoring system for the gun shoot of emulated war games. Section 2 describes the system analysis and design together with related technologies. The details of the system implementation are explained in Section 3. Finally, the conclusions are given in Section 4.

2. **System Analysis and Design.** In order to fulfill the purpose of our invention, a novel scoring system for the gun shoot was designed and illustrated as Figure 1. In Figure 1, the power module converts 110V AC power to stable 5V DC power and supplies to all other modules. The hit detection of a pellet is sensed by an accelerometer. The detected signal is treated by a signal processing circuit and the result is connected to a microcontroller for further processing. The hit count, which is accumulated by the microcontroller, is shown on a display module. The player or shooter can reset the hit count through an infrared remote. Then, the reset command is received by the infrared receiver and is passed to the microcontroller for resetting the counter.

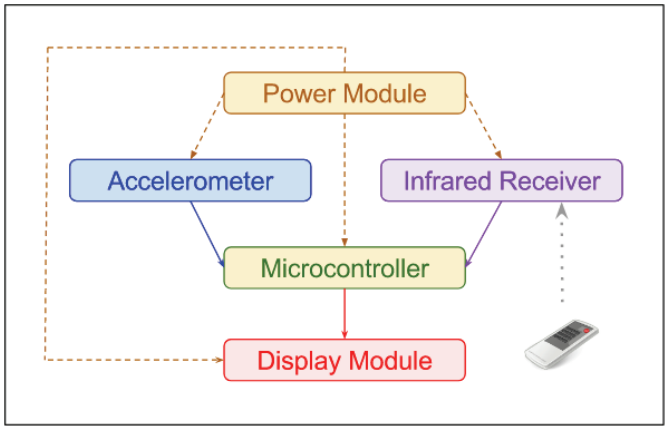

FIGURE 1. The schematic diagram of hit detection

With this design, a player can enjoy the shooting game and can get the correct score while hit the target. No need to use the expensive dyestuff bullets for shooting, the game is surely cheaper and it is environmental friendly. Furthermore, an infrared remote controller is utilized as the operation interface. It is convenient to reset the score and to restart a new shooting game.

The kernel function of this system is whether the judgement of a BB pellet hits the target correctly or not. For this requirement, a 3-axis accelerometer needs to be utilized as the detection sensor. The x-axis is allocated in horizontal direction on the front side of the vest of a player. The y-axis is allocated in vertical direction of the vest. The z-axis is perpendicular to the x-y plane. When a BB pellet hits the target vest. The z-axis signal sensed by the accelerometer would show that the vibration pulse has obviously higher amplitude and shorter pulse. These characteristics could be applied to identifying the hit signal from normal vibration signals. The z-axis signals of a static player were measured and shown in Figure 2.

The movement signals of the players were shown as Figure 3. They have typically hundreds of ms interval and majorly perform on x-axis and y-axis. Because of the shorter pulse width and greater amplitude characteristics of the hit target signal, even the movement signals superimposed on z-axis, the hit target signal has no difficulty in identifying from movement signals.

3. **System Implementation.** To collect the measured data from the 3-axis accelerometer, the Arduino NANO module is adopted as the microcontroller. As shown in Figure

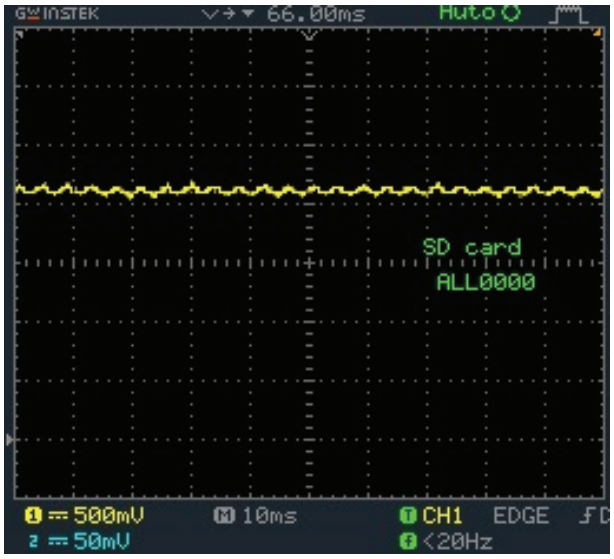

FIGURE 2. z-axis signal while static

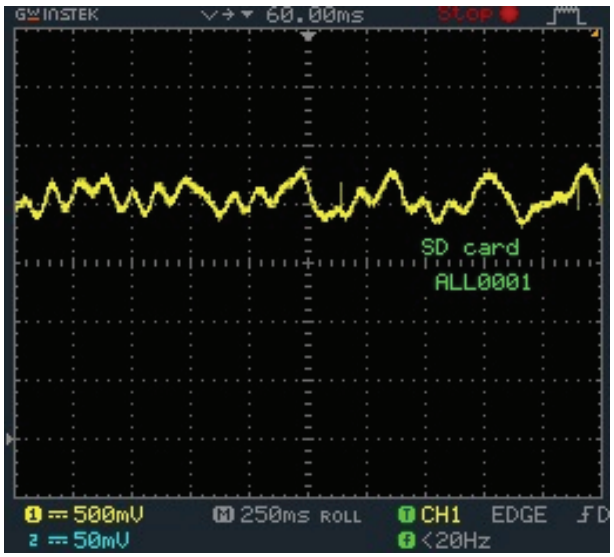

FIGURE 3. z-axis signal while moving

4, the accelerometer is located at the coordinates of column 2 and raw D of the hardware layout. The coordinates were abbreviated as $(2, \mathrm{D})$. The accelerometer is connected to signal pin A0 through a low-pass RC filter. The infrared receiver at $(4, \mathrm{D})$ is allocated to pin A5. D6∼D12 are connected to 7-segments digital display as A∼G respectively, whereas D2∼D5 are used as the digit selection for 4 decimal digits.

The implemented hardware module of the scoring system is shown in Figure 5. In Figure 5, only two 7-segments digital displays were utilized for showing the hit-target score. It is possible to extend the digits to 4 in future refined modules. The ADXL330 3-axis accelerometer was adopted for this prototype and is shown at the right-hand side of Figure 5. The Arduino NANO microcontroller was located at the central part of the module. The IRM-3638M infrared receiver was located at the left-hand side of the 2-digits display. A usual remote controller shown on the left-hand side of Figure 5 was utilized as the remote of the system. The CH (Channel) button on the top-middle of the remote panel was defined as the game control button. It is defined as a toggle switch. A player needs to press it once to start a game. Then, the game would be stopped when the player

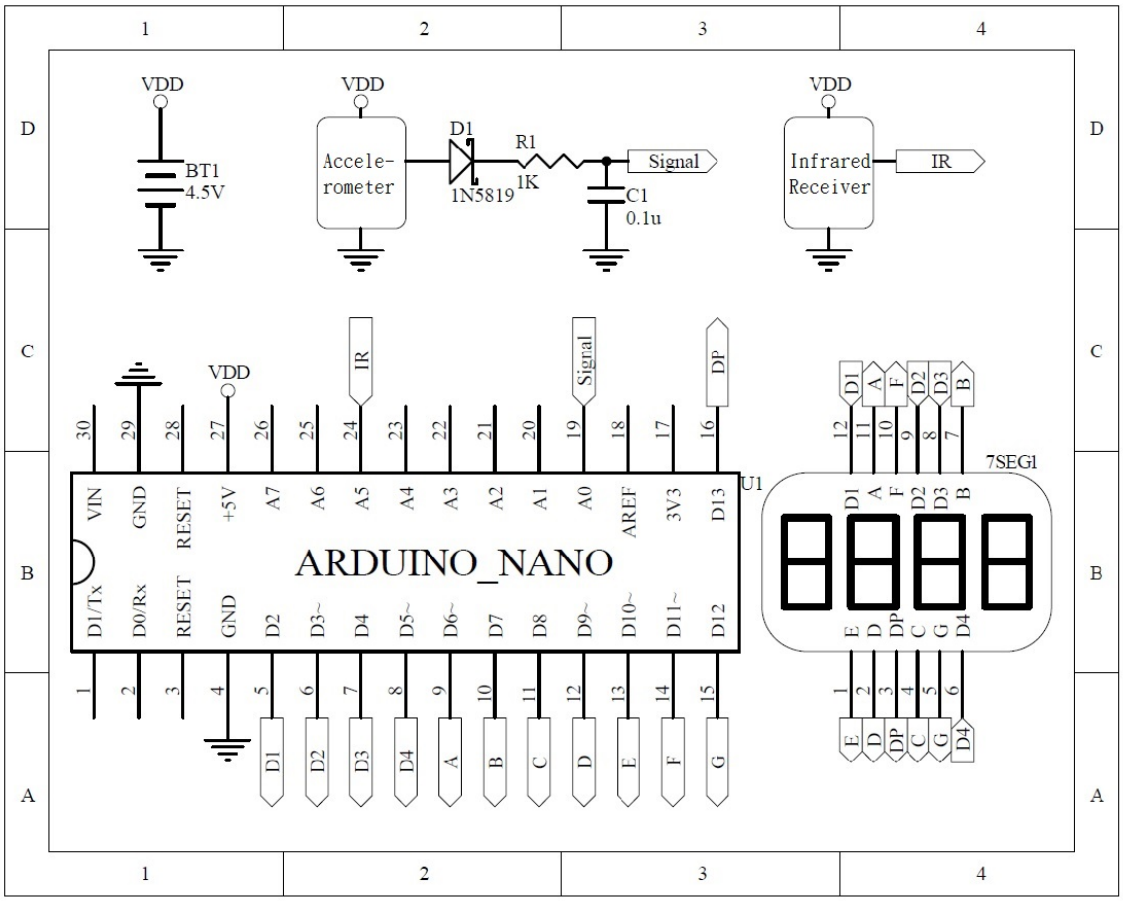

FIGURE 4. Hardware layout diagram

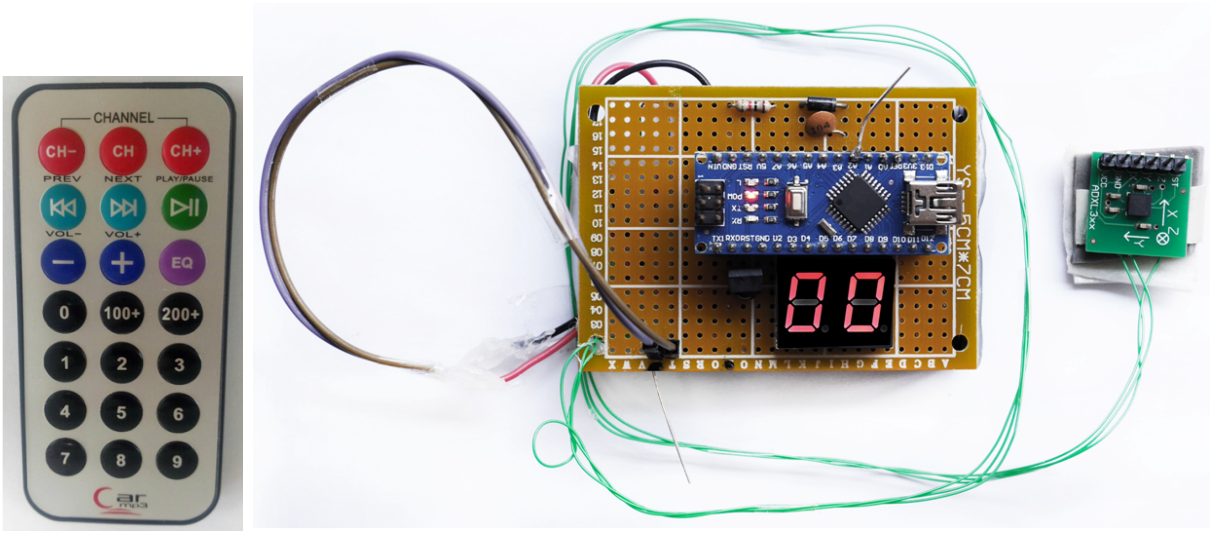

FIGURE 5. The implemented scoring system

presses it again. While the CH button is pressed again by another player, the scoring counter is forced to reset. Therefore, a new shooting game is started again.

The scoring program was developed in C language by the Arduino IDE. It was uploaded into the Arduino NANO microcontroller to be a scoring firmware via USB cord. The flowchart of the scoring firmware is illustrated in Figure 6. At the beginning of the firmware, the scoring counter is reset. Next, the firmware reads the z-axis signal from AI pin 0. The characteristics of the amplitude and pulse width of the z-axis signal are

extracted from the AI data by a char_extract() function. Then, if the amplitude is larger than a given threshold and the pulse width is less than a given interval, the result is deemed as a hit-target signal. Thus, it increases the score by 1. Otherwise, the result is considered as a miss-target signal. Next, the game continuing state is checked against the received result of the infrared receiver. The firmware is stopped while the stop command is true. Otherwise, it loops back to scan the z-axis signal again. In this way, a player can continue to shoot until the player presses the CH button on the top-middle of the handheld remote controller in Figure 5.

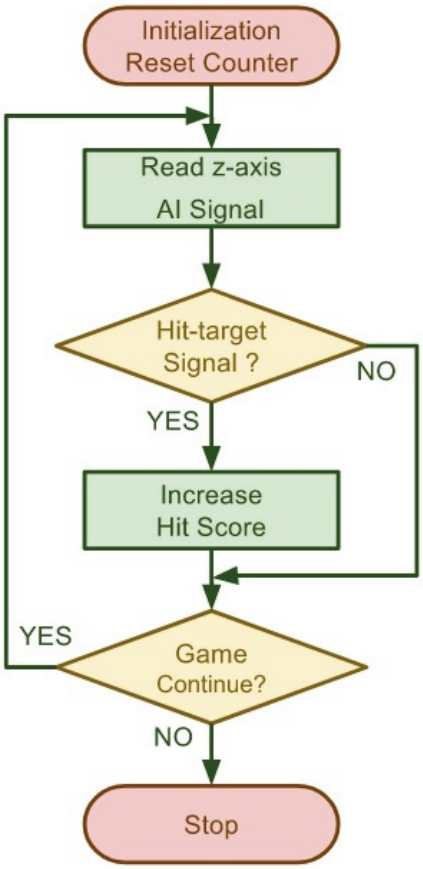

FIGURE 6. The flowchart of the scoring firmware

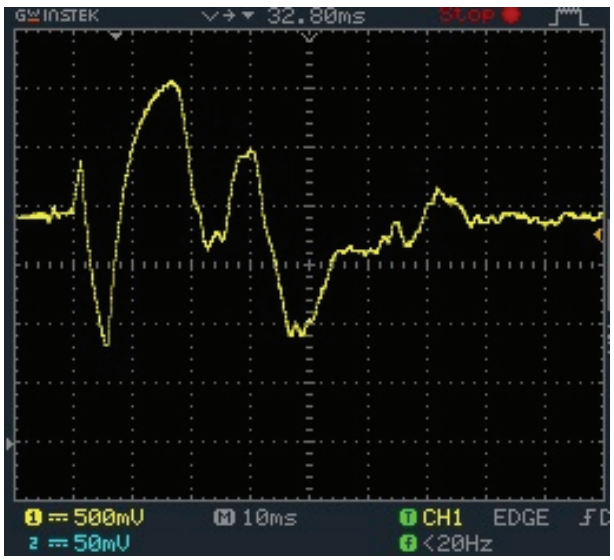

FIGURE 7. The hit-target signal of a BB pellet

The shooting experiment was conducted and the signal of the shooting result is measured and shown in Figure 7. The characteristics of Figure 7 are that the amplitude is obviously greater than that of a player's movement and the pulse width is merely several tens ms compared to hundreds ms of that of the player's movement. Therefore, the shoot scoring firmware identified that the signal is effective or not, by scanning and judging the amplitude of the signal, meanwhile by accumulating the persistence duration of it. This mechanism is effective for the area of about 20cm diameter with an accelerometer at the center. This implies that it is necessary to deploy several accelerometers around the surface for a wider target. This situation is similar to that of piezoelectric sensors or the photo sensors.

4. **Conclusions.** The features of the proposed scoring system for the gun shoot of emulated war game were introduced. The proposed system provides a low cost, environmental friendly and trustful counting mechanism for gun shoot players. The system was designed and implemented thoroughly. Iteratively shooting experiments were conducted to verify the scoring functionality. The results obviously showed that the shooting count was accurately increased while the hit-target signal caught by a 3-axis accelerometer was correctly analyzed to extract the characteristics of amplitude and the pulse width. Furthermore, the recycled pellets could be reused again for next shooting games. In future, the system has to downsize for wearable applications. In addition, an extended system has to facilitate multiple distributed shoot scoring devices and to centralize the scores of individuals for team players.

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