Development of Low-Cost Shooting Simulator (LCSS)

By

Aimal Khan Khalid

Abdul Wajid

Shahab Shah

Najam Ul Huda

Supervised by:

Major Sohaib Khan Niazi

Submitted to the faculty of Department of Electrical Engineering,
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in partial fulfillment for the requirements of B.E Degree in Electrical (Telecom) Engineering.

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In the name of ALLAH, the Most benevolent, the Most Courteous

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is carried out by

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under my supervision and that in my judgement, it is fully ample, in scope and excellence, for the degree of Bachelor of Electrical (Telecom.) Engineering in Military College of Signals, National University of Sciences and Technology (NUST), Islamabad.

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Department of EE, MCS

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DECLARATION OF ORIGINALITY

We certify that the work presented in this thesis has not been submitted elsewhere for credit toward a degree or certification.

ACKNOWLEDGEMENTS

Allah Subhan'Wa'Tala is the sole guidance in all domains.

Our parents, colleagues and most of all supervisor, Major Sohaib Khan Niazi without your guidance.

The group members, who through all adversities worked steadfastly.

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_____

Abdul Wajid

NUST Serial no 00000278759

_____

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_____

Najam Ul Huda

NUST Serial no 00000278747

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ABSTRACT

This proposed project deals with development and implementation of a simulator for shooting practice . In the proposed system, photodiode sensors are used to detect the laser pointer. Arrays of photodiode sensors are laid out in rows and columns around a central point, and a scanning method is used to check for the presence of a laser beam to keep costs down. A seven-segment display and an Arduino mega compute the shooting position, which is then transmitted to a mobile device. The software developed for use on mobile devices is also a potent tool for managing the production as a whole.

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Chapter 1: Introduction

Repeated and constant firing drills are standard procedure for the military. The traditional shooting range is commonly used in military training and consists of a plastic or paper target and a firearm with a bullet. Installation and ammunition costs are high, and there is a narrow window in which it can be used effectively to prevent injuries. The toxic waste produced by the weapon also needs to be taken into account. For this reason, a shooting simulator has replaced actual practise at the range. Conventional shooting simulators consist of a laser pointer mounted on the gun and a laser sensor mounted on the target. By far the most popular sensor for detecting the laser beam, the CCD sensor (camera) is used in everything from the simplest camera system to the most complex multimedia system. Commercial shooting simulators typically feature a camera projector system and a gun with a laser pointer. A laser pointer is used to hit a projected target screen, which is then photographed and analyzed by mobile software.

1.1 Problem Statement

Traditional military shooting ranges are expensive to set up and supply with ammunition, and they necessitate a dedicated training area free of hazards for trainees. When compared to the cost of a traditional shooting range, the above-mentioned camera-based shooting simulator is a more expensive but more effective alternative. There is a need for an accurate and low-priced shooting simulator, and we must create one.

1.2 Proposed Solution

The primary goal of the proposed system is to provide users with a low-cost shooting simulator. In order to improve the quality of the first stages of shooting instruction, a proposed progressive laser shooting practise system will be implemented and tested. To counter the presented system, we installed a photodiode sensor on the intended target, which is a replica gun with lasers instead of projectiles. This scanning method is used to alleviate pressure on the microcontroller's I/O port, which would otherwise be overburdened by the number of photodiodes required to cover the target. In addition, a mobile app is developed to act as the interface between humans and computers, recording data about where shots were taken and the final tally.

1.3 Objectives

- Design and develop a laser shooting simulator
- Use the microcontroller and photodiode sensors for detection of the laser beam
- Develop a mobile application for monitoring and analyzing the information

1.4 Deliverables

1.4.1 Hardware

- Laser Gun
- Photodiode based shooting target

1.4.2 Software

- Mobile Application

1.5 Relevant Sustainable Development Goals

Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation.

1.6 Organization of Thesis

Chapter 2: This chapter contains the literature review on which this thesis is based upon.

Chapter 3: This chapter contains the design and development of the project.

Chapter 4: This chapter include detailed evaluation and working of the project.

Chapter 5: This chapter include the conclusion leading to the of our project.

Chapter 6: The last chapter of the thesis throw light on all future aspect related to this work.

Chapter 2

2.1 Literature Review

A new product is launched by modifying and enhancing the features of previously launched similar products. Literature review is an important step for development of an idea to a new product. Likewise, for the development of a product, and for its replacement, related to shooting simulator, a detailed study regarding all similar projects is compulsory.

2.2 Conventional Shooting Range

To train, practise, and compete with firearms, one must go to a shooting range. Indoor and outdoor shooting ranges are both available. Additional ballistic, hazardous material, and security requirements may be needed in areas such as backstops, Control centres, target carrier systems, and firing positions are all components of a shooting range.

Numerous people regularly visit traditional shooting ranges where they use firearms to shoot at plastic or paper targets. It's costly to set up and supply bullets for, and it can only be used in a specific area to reduce injuries. The toxic waste produced by the weapon also needs to be taken into account.

Figure 1: Normal Shooting Range

2.3 Shooting simulators

Due to the high cost, inherent risk, and lack of statistical analysis of learner performance inherent in traditional shooting ranges, this shooting simulator has replaced them.

2.3.1 Camera-based shooting simulator

The shooter uses a laser pointer to aim at a target screen shown by a projector in this system. After the laser pointer's location on the target has been captured by the camera system, the data is processed by a computer to determine the player's score.

Figure 2: Camera Based Shooting Simulator

2.3.2 Kinect-based shooting simulator

By utilizing Microsoft Kinect, we are able to provide aiming data that is highly indicative of actual performance. The application used in this system uses the input from the embedded Kinect sensors to calculate the aiming point at the screen, recognizes the user's gestures and voice command inputs and matches those commands in simulation.

Figure 3: Kinect Based Shooting Simulator

2.4 Existing solutions drawbacks

The existing solution has some drawback which are discuss below

- Cost of installation is very high
- Require special area for its installation
- The current system is not user friendly

Chapter 3

Design and requirement

3.1 Project Hardware

The project utilizes following hardware components.

3.1.1 Arduino module

Arduino is cross-platform module (windows, mac OS, Linux) application based simple hardware and software. At mega 8266 microcontroller is used in target and Arduino NANO is used in gun .it is simple to use. It has 16 analog, Plus, there's a USB port, power jack, ICSP header, and 54 total digital I/O pins (of which 15 are PWM pins).

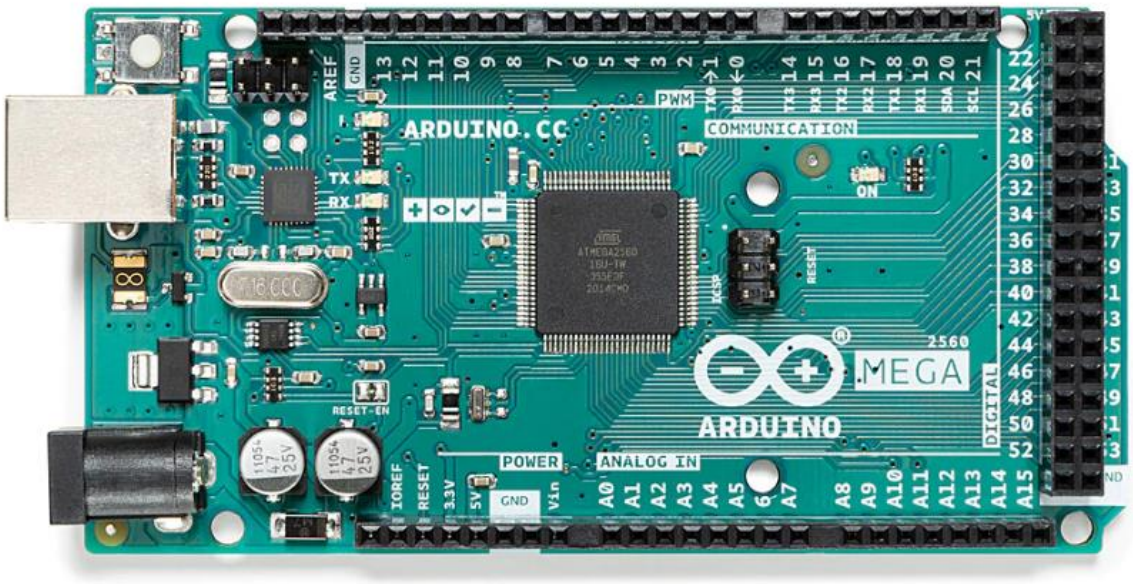

Figure 4: Arduino Module

3.1.2 Photodiode

A photodiode is an electrical sensor used to detect and convert light into an energy signal through the use of a photodetector. The photoelectric effect is used by photodiodes to create electrical current from light. Electrons are “knocked” out of place when photons of light strike the surface of a diode. A charge occurs when the electron is moved.it has 2 pins one is anode and other is cathode.

Figure 5: Photodiode

3.1.3 HC06 Bluetooth module

Bluetooth is short range wireless technology that can be used to communicate between two microcontrollers like Arduino, or any two Bluetooth-enabled devices like a phone or a computer. It uses the microcontroller's serial port to exchange data. This device uses the 2.45GHz frequency band.There is point to point or multi-point connection with a maximum range of 10 m. it has a 1 mbs data rate.so in this project we will use HC-06 Bluetooth module. Through it we will generate communication between Arduino and mobile application.

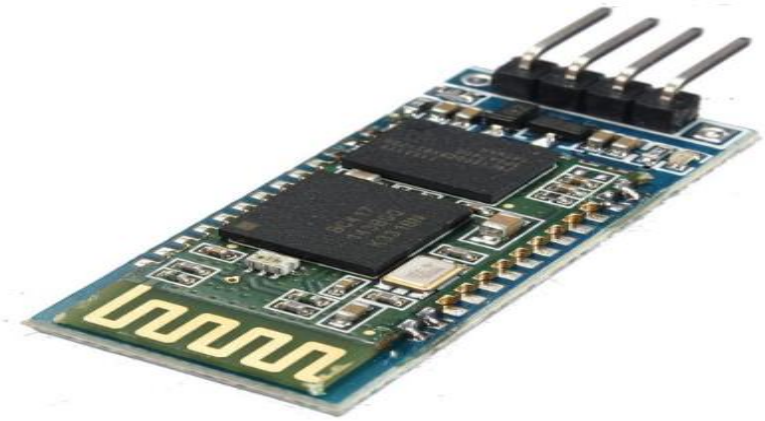

Figure 7: Bluetooth Module

3.1.4 9V seven segment display

It consists of seven segments, meaning it consists of seven LED's, which together can be used to form one complete digit on the display. Two 7 segment display will be fitted on the target for displaying score.

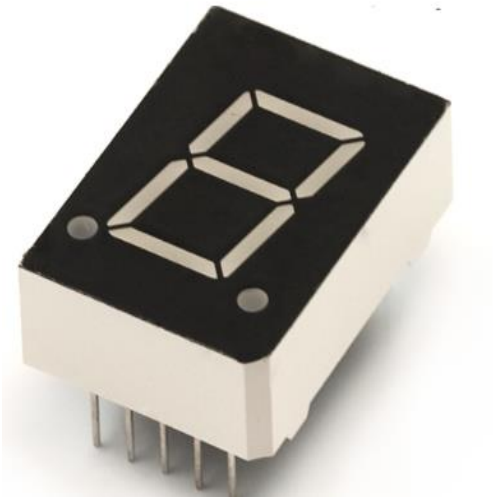

Figure 8: Seven Segment Display

3.1.5 12-volt adapter

It is a combination of transformers, diodes, and transistors is all that's needed to convert 120- or 240-volt AC input into 12-volt direct current (DC).

3.1.6 Buck booster converter 12V to 9V

Since a buck-boost converter is a DC-to-DC converter, its output voltage can be higher or lower than its input voltage.

3.1.7 Switch On/Off

Switch is used to start or stop a device powered.

3.1.9 Push button

It is placed under the trigger.

3.1.10 7805 Regulator

7805 voltage regulator whose output voltage is fixed at +5V regardless of the input voltage. It has three pins.

3.1.11 3906 PNP Transistor

2N3906 is PNP bipolar junction transistor intended low-power amplifying or switching applications.

3.1.10 Laser module

A laser module is a sensor that emits a constant, steady beam of laser light at one or more specific wavelengths. There is at least one laser diode and possibly more, along with the necessary optical and electronic components.

3.2 Project software

The project utilizes following software components.

3.2.1 Proteus

Electronic design automation is the primary application for the software tools included in the Proteus Design Suite.Schematics and electronic prints can be made with the help of this programme.for manufacturing printed circuit boards.

Figure 9: Proteus for circuit designing

3.2.2 Arduino IDE

Arduino software, or the Arduino Integrated Development Environment,allow user to build and upload programs. it typically supports C and C++ programing languages.it contains code editor, message area, text console, toolbar with button with common functions and menu system. The serial monitor can be used to display data loop that are continuously monitored.

Figure 10

3.2.3 MIT APP Inventor

MIT's App Inventor is a cross-platform app creation platform that can be accessed online. Users can quickly create executable code by dragging and dropping graphical building blocks. The Android platform.

Figure 11

3.2.4 Autodesk 360 fusion

For those involved in the creation of physical goods, Fusion 360 is a 3D modelling software platform. The exterior of the target is designed using this tool.

Figure 12

3.3 Target Design

Target design compromise of two parts.

3.3.1 Structure Design

The structure of target body is designed in Autodesk fusion 360 and it is made from polymer using 3d printer having length, width, and height. The front and back side of the body is made from acrylic sheets. From the front side in acrylic sheet, we made hole in a circular pattern, arranged in 10 circles.so total number of holes are 248. These holes will be used for placing 248 photodiodes in target i.e., 6 in 1st,10 in 2nd ,14 in 3rd ,19 in 4th ,24 in 5th ,29 in 6th ,35 in 7th ,41 in 8th,45 in 9th ,53 in 10th. The space between 2 photodiode 4mm. On the top of the front side, we place 2 seven segment LEDS display of score.

Figure 13: Structure & Design

3.3.2 Circuit Design

Target designs consist of the following components

Photodiode

Arduino 2560

HC- 06 Bluetooth

Switch Button

12V power Adapter

12V to 9V converter

Female connector

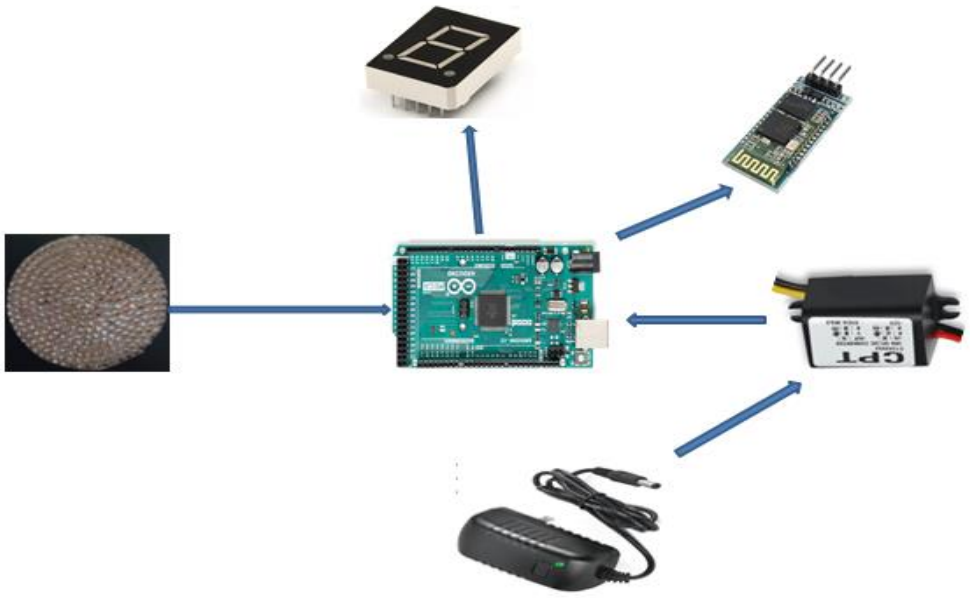

Figure 14: Circuit Diagram of Simulator

In target we use 248 5mm photodiodes which require to many interfaces for connection, to make our circuit simple we arrange 248 photodiodes into 31 rows and 8column.connect 31 rows of photodiodes with digital pins of Arduino ranges from pin 22 to pin 53 and 8 columns with analogue pins of Arduino ranges pin 14 to 21 pin.

To display score on a target we connect two 7 segment display on the target which connects with Arduino for transmitting the given data to the mobile software we use HC-06 Bluetooth module. Which is connect with Arduino pin 1 and 0. power is given to the Arduino through 12 v power adapter which connected with 12v to 9-volt dc to dc convertor.

3.4 Gun Design

Gun designs consist of the following components

- Arduino NANO
- 7805 regulators
- 3906 PNP transistor
- Diode laser module
- Push button
- Motor

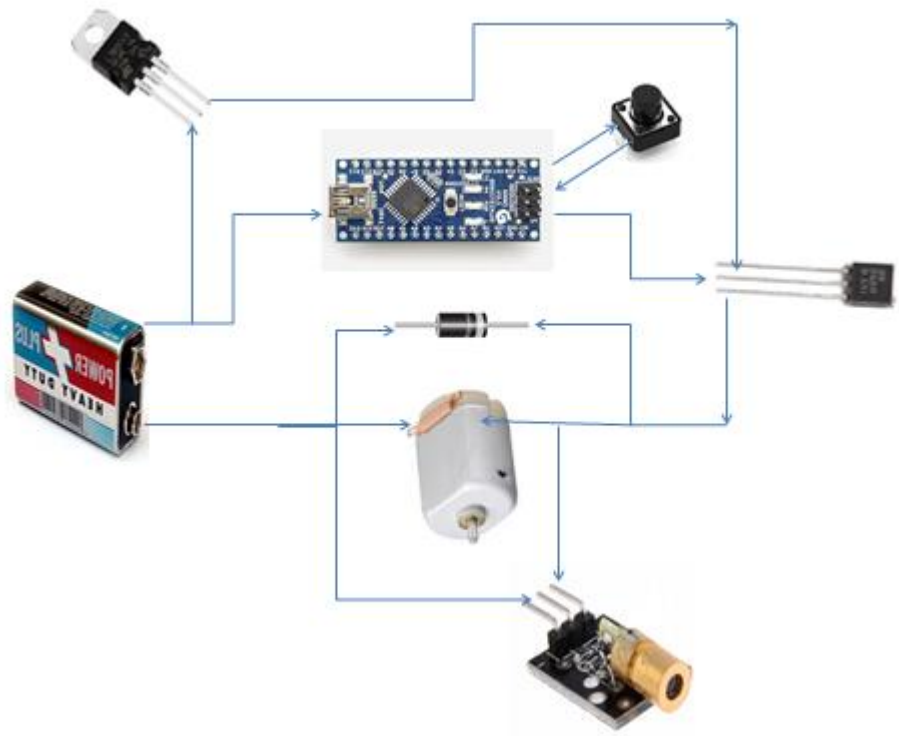

Figure 15: Gun Circuit Design

In laser gun we have Arduino NANO, which is power by 9-volt battery, same 9-volt battery is connected with 7805 regulator which will convert the 9 volts to 5 volts, and its output will be connected with 3095 PNP transistor. Center pin of transistor is connected with digital pin of Arduino, and 3rd pin is connected in parallel with dc motor and 1N4007 diode and with laser module, other side of these 3 components is connected with negative terminal of the battery, one push button which will be placed below trigger is also connected with digital pin of the Arduino NANO.

3.5 Mobile Application

An MIT spinoff called APP inventor is used to create the app.which will connect with target through HC-06.Bluetooth module for data communication, data received will be processed in application and will be compared with lookup table, score and position will be calculated, score will appeared in table against the each shot ,consist of 5 rounds, total score of round will be display at the top off the table ,and dot will be appear on a target chart in mobile application where laser beam hit on the target.

3.6 Block Diagram

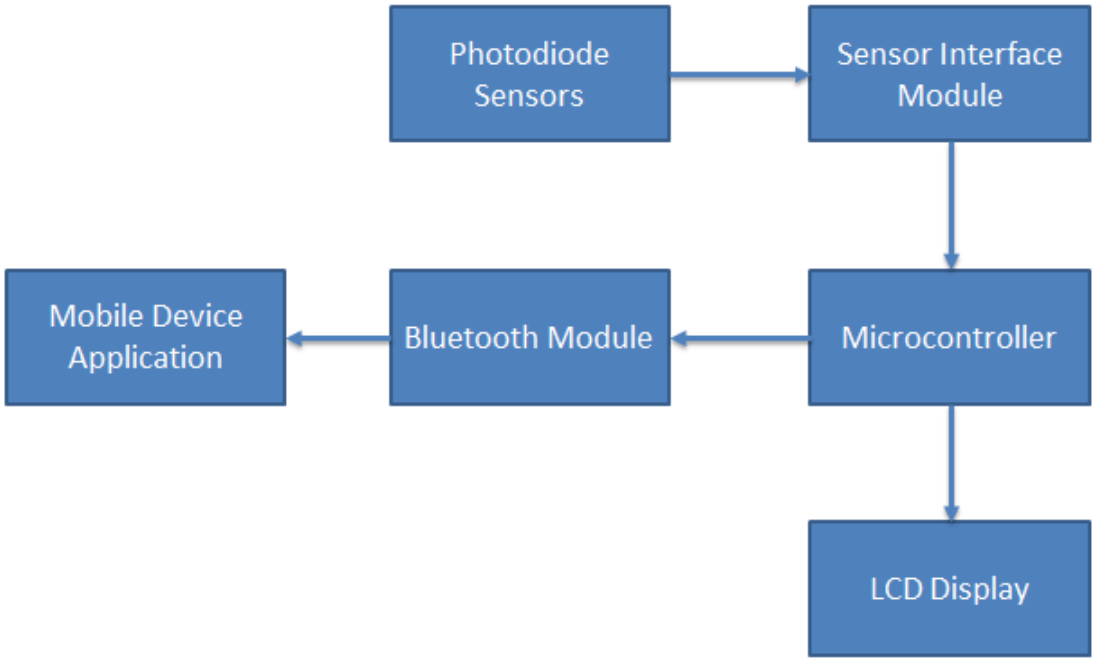

Figure 16: Block Diagram

Chapter 4

4.1 Working and Evaluation

The project is implemented in hardware and working is discuss below

Flow chart

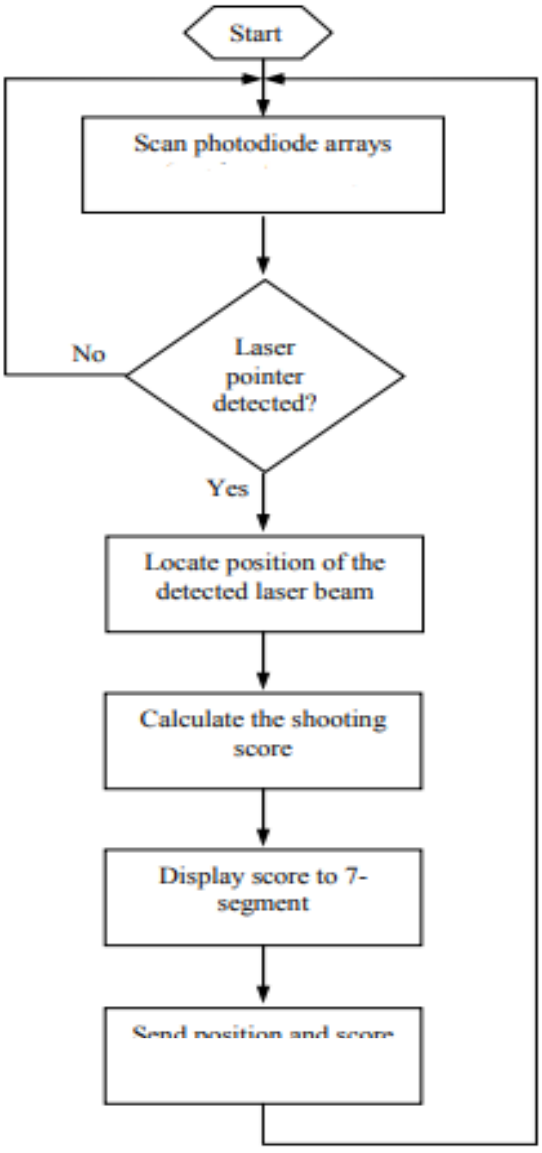

Figure 17: Working Structure

4.2 Laser shoot

Push button is installed below the trigger, which is connected with digital pin of Arduino nano, Arduino is powered by the 9-volt dc battery, that battery is also connected with the 7805 convertors, which will convert the given 9 volts to 5 volts.

The output 5 volt is connected with 3906 transistors, which is also connected with Arduino thought its middle pin and with motor, diode, laser module with 3rd pin,3906 transistor will be used as timer switch. DC motor will be for recoil purpose and laser module is fitted at barrel of gun, when trigger is pressed, the push button will also be pressed, through it signal will be detected through digital pins, and switch will be turned on 0.1, power will be transferred to the laser module for that instant and shoot will be generated for 0.1 sec.

4.3 Laser Detection

There are 8 Columns (Input) and 31 Rows (Output). Columns are declared OUTPUT and rows are declared is INPUTP_PULLUP. Scanning when laser array hit the target .it turn each column LOW at once and look for the any of row gives signal low because INPUTPULL command pull the pin to HIGH and it gives signal when it's low. Its working is same as Hex Keypad, but the difference is that the keypad is 4x4 and in this scenario the matrix is 31x8.It take the value from 31x8 matrix that is declared regarding the row column value that is picked.

4.3 Calculation of Score and Position

Row and column that is find during detection step is noted by Arduino, the noted row and column is then compare with lock up table of score and position. Through this we will calculate the score and position.

4.4 Score Display On 7 Segment Display

The target has two 7 segment display on top, on which the calculated score will be displayed.

4.5 Communication with Application

The calculated score will be communicated to mobile application through Bluetooth module, HC-06 will be used for this .it send it will send data up to 10 m distance.

4.6 Display of Score and Position in Mobile Application

Figure 18: Bull Eye View on Mobile App

Chapter 5

5.1 Conclusion

The laser pointer-based shooting simulator is a newly developed, low-cost option.The laser gun is used for shooting the target. 248 photodiodes are used. photodiode is arranged in row and column to form the circular target. The number of interfacing components can be kept to a minimum by scanning the sensor arrays' rows and columns. It is installed on real hardware and is monitored by dedicated software. The developed system has been shown to perform well under a wide range of illumination levels.

Chapter 6

6.1 Future work

Following improvement will be made in the future

- Increase the size of target
- Introduction of recoiled in gun
- Introduction of sound system in gun
- Updates for capturing multiple shot at instant

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APPENDIX A

Arduino Code

For detection

1. ////////////////////////HC-06//////////////////////

```
/*
 * HC-06 Tx --> 0(arduino Mega)
 *       Rx --> 1(arduino Mega)
*/
void printt(int l, int m);
////////////////////////// SSD PINS//////////////////
#define a1 2
#define b1 3
#define c1 4
#define d1 5
#define e1 6
#define f1 7
#define g1 8
#define a2 9
#define b2 10
#define c2 11
#define d2 12
#define e2 13
#define f2 A0
#define g2 A1
////////////////////////Score Board//////////////////////
int scoreboard[31][8]=   {{1,1,2,3,4,5,6,8},
                          {1,1,2,3,4,5,6,8},
                          {1,1,2,3,4,5,6,8},
                          {1,1,2,3,4,5,6,8},
                          {1,1,2,3,4,5,6,8},
                          {1,1,2,3,4,5,6,8},
                          {1,1,2,3,4,5,6,8},
                          {1,1,2,3,4,5,6,8},
                          {1,1,2,3,4,5,6,8},
                          {1,1,2,3,4,5,6,8},
                          {1,1,2,3,4,5,6,8},
                          {1,1,2,3,4,5,6,8},
                          {1,1,2,3,4,5,6,9},
                          {1,1,2,3,4,5,6,9},
                          {1,1,2,3,4,5,6,9},
                          {1,1,2,3,4,5,7,9},
                          {1,1,2,3,4,5,7,9},
                          {1,1,2,3,4,5,7,9},
                          {1,1,2,3,4,5,7,9},
                          {1,1,2,3,4,5,7,9},
                          {1,1,2,3,4,5,7,9},
                          {1,1,2,3,4,5,7,9},
                          {1,1,2,3,4,5,7,9},
```

```
                    {1,1,2,3,4,5,7,9},
                    {1,1,2,3,4,5,7,9},
                    {1,1,2,3,4,5,7,9},
                    {1,1,2,3,4,5,7,10},
                    {1,1,2,3,4,6,7,10},
                    {1,1,2,3,4,6,7,10},
                    {1,1,2,3,4,6,8,10},
                    {1,1,2,3,4,6,8,10}};
//////////Variales//////////
int scr = 0;
int shots = 0;
int runs = 0;
int col[] = {14, 15, 16, 17, 18, 19, 20, 21};
int row[] = {22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 47, 49,
50, 51, 52, 53};

int norow = 31;
int nocol = 8;
int i, j;
void setup() {
  // Initializing Serial communication
  Serial.begin(9600);
  //////Declaring SSD pins as output
  for (i = 2; i < 14; i++)
  {
    pinMode(i, OUTPUT);
  }
  pinMode(f2, OUTPUT);
  pinMode(g2, OUTPUT);
  //// Initializing columns as Input
  for (i = 0; i < nocol; i++)
  {
    pinMode(col[i], OUTPUT);
    digitalWrite(col[i],HIGH);
  }
  /// Initializing ROws as outPut
  for (i = 0; i < norow; i++)
  {
    pinMode(row[i], INPUT_PULLUP);

  }
}
void loop() {
  for ( i = 0; i < nocol; i++) {
    digitalWrite(col[i], LOW);
    for ( j = 0; j < norow; j++) {
      if (digitalRead(row[j]) == LOW) {
        printt(i, j);
        if(shots == 5){       ////////////////////////Number of shots in a round is 5
          shots=0;
          Serial.print(i);
          Serial.print(";");
          Serial.print(j);
          Serial.print(";");
         Serial.print(runs);
         runs=0;
```

```
        delay(2000);
         }else{
           shots++;
           runs=runs+scoreboard[j,i];    /////// It shows the score of complete round
         }

      }
    }
  digitalWrite(col[i],HIGH);
  }
}
```

FOR PRINTING

```
//////////////////////////// Print the score on SSD and Mobile App through Bluetooth
void printt(int i, int j) {
  scr=scoreboard[i][j];
Serial.print(i);
Serial.print(";");
Serial.print(j);
Serial.print(";");
Serial.print(scr);
  if (scr == 1) {
    zero(1);
    one(2);
    delay(500);
  }
  else if (scr == 2) {
    zero(1);
    two(2);
    delay(500);
  }
  else if (scr == 3) {
    zero(1);
    three(2);
    delay(500);
  }
  else if (scr == 4) {
    zero(1);
    four(2);
    delay(500);
  }
  else if (scr == 5) {
    zero(1);
    five(2);
    delay(500);
  }
  else if (scr == 6) {
    zero(1);
    six(2);
    delay(500);
  }
```

```
  else if (scr == 7) {
    zero(1);
    seven(2);
    delay(500);
  }
  else if (scr == 8) {
    zero(1);
    eight(2);
    delay(500);
  }
  else if (scr == 9) {
    zero(1);
    nine(2);
    delay(500);
  }
  else if (scr == 10){
    one(1);
    zero(2);
    delay(500);
  }
  else
  {
    zero(1);
    zero(2);
  }
//scr=scr+scoreboard[i][j];

}
```

Laser gun

```
#define btn 2
#define out 3
int x=0;
void setup() {
  // initialize digital pin LED_BUILTIN as an output.
  pinMode(out, OUTPUT);
  pinMode(btn,INPUT);
  digitalWrite(out,HIGH);
}

// the loop function runs over and over again forever
void loop() {
  if(x==0 & digitalRead(btn) == HIGH){
    digitalWrite(out, LOW);
    delay(100);
    digitalWrite(out, HIGH);
    x=1;
    while(digitalRead(btn)==HIGH){

    }
  } else
  digitalWrite(out, HIGH);    // turn the LED off by making the voltage LOW
  x=0;
}
```

Development of the low cost shooting simulator

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