Golf Ball Deflection System Conceptual Design

Adam Morrow | Allen Watson | Colby Drake | Jonah Burke | Tyler Kasuboski | James Jones
Electrical and Computer Engineering Department
Tennessee Technological University Cookeville,
TN
awmorrow42@tntech.edu, arwatson42@tntech.edu, cjdrake42@tntech.edu, jlburke42@tntech.edu,
tkasubosk42@tntech.edu, jtjones49@tntech.edu

I. Introduction

The Golf Ball interceptor project is expected to be a competition between two teams of engineers, and the goal of this competition is to intercept incoming projectiles in a manner that is safe to be done in a classroom. The safety requirements and competition process are provided by DEVCOM [1]. The design to complete this task is expected to be function effectively as well as being cost effective. In order to completing this task, we have divided the project into six modules that work together seamlessly. Within these modules we explain the minimum requirements each module must be capable of to properly complete our given task. All these requirements will be determined by our shall statements below. Finally, all requirements must be able to be completed by following all the relevant standards that are listed below.

II.

A. Formulated Problem

-This is where we state each shall statement and its origin. This can be a constraint given by customer as well as if a standards that impact this shall statements.

1) Create an interceptor capable of functioning on its own without outside interaction.
2) Create an interceptor capable of wirelessly communicating with the sensor array.
3) Create an interceptor capable of fitting inside a 1x1x1 foot box before powering on.
4) Create an interceptor that poses no danger to spectators.
5) Include a clearly marked power switch on the interceptor.
6) Include a clearly marked emergency stop option on the interceptor.
7) Design a sensor array that can detect approaching objects and relay their locations to the interceptor.
8) Design a sensor array that operates on battery power.
9) Design an interceptor that complies with the safety check list provided in the competition rules [1].
10) Design an interceptor that has lights.
11) Design an interceptor with decorations contributing to camouflaging of the device.
12) Design an interceptor which plays an alert noise before firing.
13) Design a network that has the capability to have up to six inputs to a master device.
14) Design a system with a maximum sensor input delay of 100ms.

    According to our calculation of how long a projectile will take to ~2.2 seconds to reach the interceptor with the worst-case scenario.

B. Background information

III.

A. Standards

In this section, the standards that will govern or affect the design of the Interceptor will be stated along with background pertaining to the standard.

IEEE Code of Ethics: This standard dictates how engineers should coincide together in a work environment. Following this standard will allow the team to work together in a professional manner. [2]

IEEE 802.11: This set of standards applies when using Wi-Fi as the method of wireless communication from the sensors in the competition field. This standard regulates the frequency of the radio band the data is transmitted by, as well as the speed of the data transfer rate. [3]

FCC Parts 15 and 18: These standards constrain the radiated emission limits of certain electronic devices (based on their operational frequency) to ensure that the electronics used in a project will not interfere with the other electronic devices around them. [4]

IPC J-STD: This standard will be applied when soldering connections during the construction phase of the project. This standard helps regulate high performance soldered connections and list the methods and materials used when soldering. [5]

NEC 310.15(B)(16): This standard table shows the ampacity limits of a wire based on the gauge and material of the wire, as well as the temperature rating of the conductor material. This standard will aid the team when deciding which wiring will be needed for the project during the design phase. [6]

NFPA 79-10: This standard sets the regulations for the color and shape of the emergency stop button and will aid the team in designing this feature of the Interceptor. [7]

ISO 8573: This standard identifies the type of contaminants found in compressed air. Also, this standard separate different air quality levels into 9 classes. This information will be helpful to guide the team to make informed decisions about compressed air during the design process. [8]

IEC 60529: This standard regulates the protection of electrical equipment and will be helpful to the team when designing the housing, or enclosure, for the interceptor. [9]

-- blue tooth standard

II. Ethical, Professional, and Standards Considerations

A. Ethical Considerations

B. Standards Considerations

C. Broader Impacts Considerations

IV. Block Diagram Modules

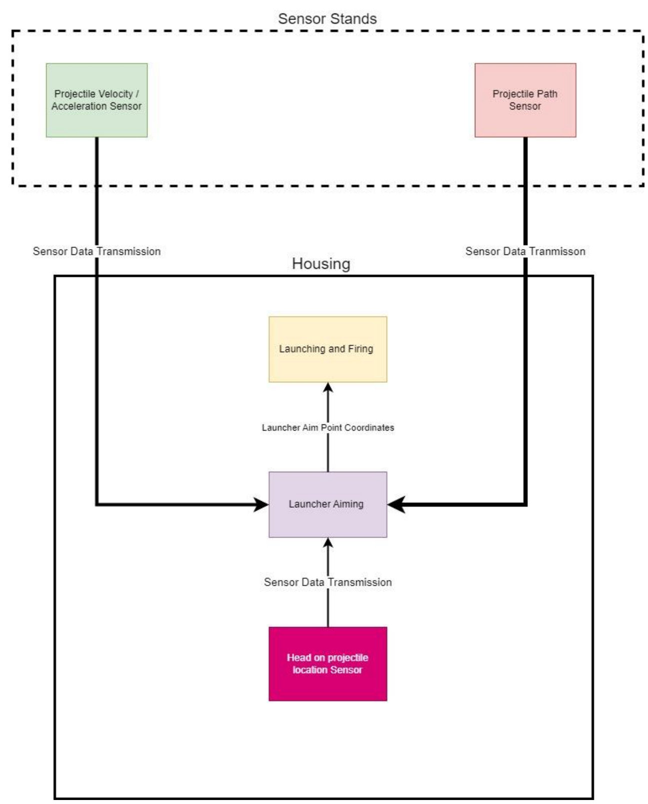


Figure 1. Over Arching Block Diagram

A. Launching and Firing

The Interceptor will be able to accurately fire an object toward the incoming projectile before the projectile reaches the Interceptor without interaction during the competition(C1). The projectile will remain compliant with the projectile guidelines given in the DEVCOM rulebook. (##SITE

HERE ##) This subsystem contains three smaller subsystems which are the DC Motor Driver, DC Motor, and the Firing Mechanism subsystems. This subsystem will physically located in the main housing within the single cubic foot of space allowed for the Interceptor body. A block diagram showing the launching and firing subsystem is shown in Fig. 2 below.

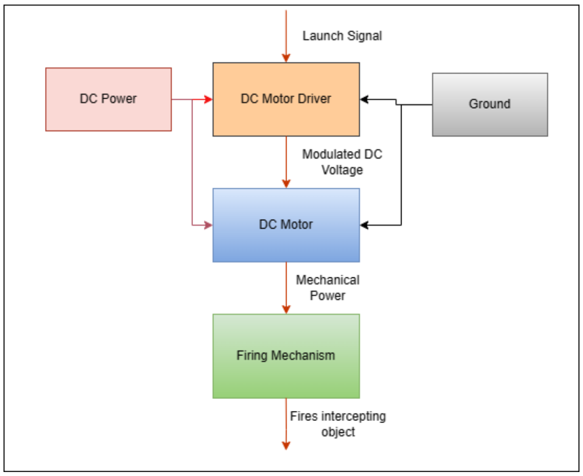


Fig. 2: Launching and Firing Block Diagram

1) DC Driver: The DC driver contained in the Launching and Firing Block Diagram will be able to send the proper voltage and current to the DC motor to allow this motor to work to its specifications when given the signal to fire from the aiming subsystem.

Inputs: Firing Signal, DC Voltage

Outputs: Modulated DC Voltage

Applicable Constraints: C1, C3, C9

Analytical Verification: The specific DC driver used will be selected as a result of the DC voltage that the DC motor will be running off of as well as the voltage and current requirements needed to allow the DC motor to supply mechanical power as needed for the firing mechanism.

2) DC Motor: The DC Motor contained in the Launching and Firing Block Diagram will activate and supply mechanical power to the firing mechanism when activated by the DC driver.

Inputs: Modulated DC Voltage

Outputs: Mechanical Power

Applicable Constraints: C1, C3, C9

Analytical Verification: The specific DC motor used will be selected as a result of the DC voltage available, mechanical power required for the firing mechanism, and the type of motor action needed to engage the firing mechanism.

3) Firing Mechanism: The firing mechanism will be built mainly by the mechanical engineers to safely fire the object towards the incoming projectile when prompted by the DC motor. The object shall be no more than 6 feet away from the Interceptor when the object comes to rest, as stated by the DEVCOM competition rule book. (##SITE HERE ##)

Inputs: DC Motor Mechanical Power

Outputs: Fires an object

Applicable Contraints : C1, C3, C4, C9

Analytical Verification: The firing mechanism will be built to comply with the safety and competition-rule constraints listed in the DEVCOM rulebook.

B. Housing

The main housing for the interceptor is crucial to the operation of the device. It serves as the platform from which the rest of the interceptor will be built from. This subsystem will contain three smaller subsystems.

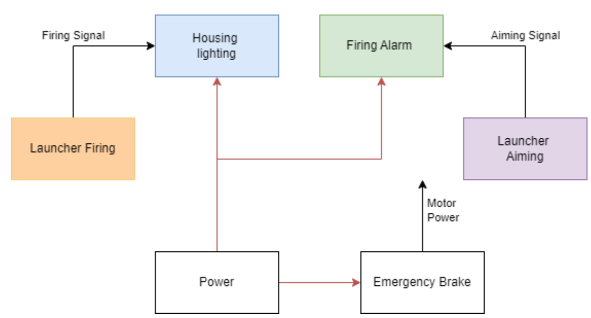


Figure 3. Housing Block Diagram

1) Emergency Break

Inputs: Emergency Brake button, power

Outputs: Motors

Applicable Constraints: C3, C4, C6

Analytical Verification: The interceptor must have a clearly labeled emergency break which will stop all mechanical function. This is to verify constraint six is met. When activated the emergency break will open all circuits connected to motors and other select components. This will prevent power flow therefore preventing motion of the interceptor.

2) Firing alarm speaker

Inputs: Aiming signal, power

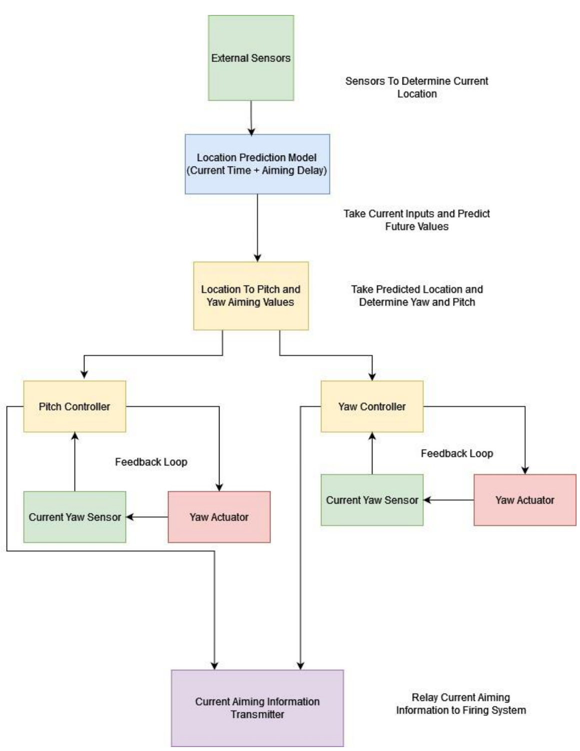
Outputs: Audible sound

Applicable Constraints: C3, C12

Analytical Verification: Before firing a projectile, the interceptor must play an audible sound. This to verify constraint twelve is met. A human being takes on average 140-160 ms to react to a sound. [9] To ensure spectators are aware that the interceptor is about to fire the interceptor will begin playing a sound at least 200 ms before firing.

4) Aiming

The purpose of the aiming subsystem is to keep the apparatus pointed in a safe direction and be able to follow the projectile to result in a reliable interception. The aiming system needs to be fast, in order to lock onto the projectile with the most up-to-date position data.



Inputs: Target Location, pitch sensor, yaw sensor

Outputs: Pitch actuator, yaw actuator, aiming transmitter

Applicable Constraints : C1 C2 C3 C9

3) Housing Lighting

Inputs: Firing signal, power

Outputs: always on lights, firing lights

Applicable Constraints: C3, C10, C11

Analytical Verification: The interceptor must have lights on it to both indicate that it is powered on and indicate that it has fired. The lights will also serve as part of the interceptor decorations. This is to verify that constraint ten and constraint eleven are met. The typical human eye can see lights with a wavelength of 380 to 700 nanometers. Therefore any lighting on the interceptor intended to be seen by the human eye will fall within this range.

C. Projectile Path Sensor

The projectile path sensor has the task of determining when a projectile is incoming and the path that the incoming projectile will take. According to the competition rule book [1] projectiles have

two different starting heights and 15 possible starting positions at each height. This means that there is a total of 30 possible starting positions. With these 30 starting locations we can estimate the trajectory.

This subsystem has four smaller subsystems within: a motion sensor, projectile location sensor, Subsystem Power, and a wireless transmission device.

1) Motion Sensor: The purpose of this sensor is to sense when a projectile is being prepared to be sent towards the interceptor. This will be the first signal that is sent to the interceptor, thus initializes the interception process.

Inputs: Movement at projectile starting location, Power

Outputs: Sensor raw data

Applicable Constraints: C2, C7, C8, C13, C14

Analytical Verification: Sensor power requirements must be properly researched to verify that it can properly be powered to meet constraint 8. The other verification is to verify in the data sheet of the sensor has the ability to detect motion at a minimum of 64 inches from the sensor in order to meet Constraint 7. Finally, this data must be transmitted to the interceptor in under 100ms to meet the rest of this subsystem's applicable constraints.

2) Projectile Location Sensor Array:

Inputs: Projectile X location, Projectile Y location, Power

Outputs: Raw sensor data

Applicable Contraints: C2, C7, C8, C13, C14

Analytical Verification: The sensor array must have an operating power that can be powered remotely. This is to verify constraint 8 is met. In order to properly measure the correct starting location of an incoming projectile the datasheet of the chosen sensor must have a distance accuracy of less than 4 inches. Finally, similar to the motion sensor this sensor's data must be transmitted to the interceptor in under 100ms.

Subsystem Power:

Inputs: N/A

Outputs: Motion Sensor Power, Projectile Location Sensor Power, Wireless Transmission Device Power

Applicable Constraints: C8

Analytical Verification: Proper research must be conducted to verify the chosen power supply must be able to power all subsystems in the projectile location sensor array. This will meet the requirements of constraint 8.

3) Wireless Transmission Device:

Inputs: Motion Sensor Data, Projectile Sensor Data, Power

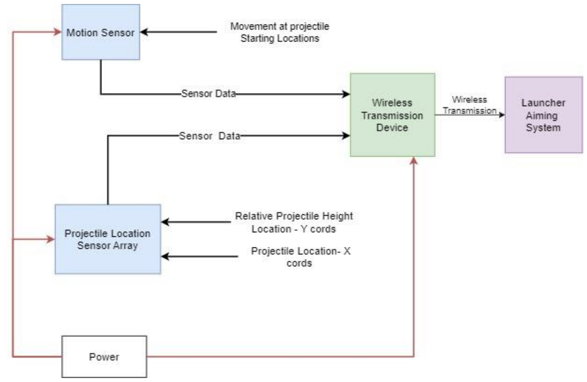


Figure 4. Projectile Path Sensor Block Diagram

Outputs: Wireless Sensor Data

Applicable Constraints: C2, C13, C14

Analytical Verification: The wireless signal transmission device must have the capability to have a wireless network with 6 devices sending signals. Also, the delay of transmitting these signals must be less than 100ms. Therefore, the device selected must have the capability to use a wireless data transferring technology that meets this requirement. Also, this technology must also be available to the interceptor.

D. Head On Projectile Location Sensing

The head on projectile location sensor is locating the head- on location of the projectile as it is heading toward the launcher. This sensor needs to be able to detect and track a projectile from a maximum distance of 72 inches away and be able to view a width of 60 inches and a maximum height of around 50 inches. These dimensions were obtained from the layout of the arena in the competition rule book. With the head-on position of the ball, the launcher can then adjust itself to intercept the ball. This subsystem has been divided into 4 different subsystems: projectile detection sensing, a controller, device power, and signal data processing.

1) Projectile Detection Sensing: This sensor array must detect a moving projectile from the view of the launcher.

Inputs: Projectile Motion, Power

Outputs: Raw Sensor Data

Applicable Constraints: C1, C3, C7

Analytical Verification: This sensor array must be able to detect a projectile at a maximum of 72 inches deep, 50 inches high, and 60 inches wide. The sensor also must be able to able to sense projectiles at a speed going up to 50 feet per second based on worst-case scenario calculations.

2) Controller: This device should be able to receive the data from the sensor and convert it into a digital signal that is usable for software.

Inputs: Raw Sensor Data, Power

Outputs: Digital Signal

Applicable Constraints: C1, C3, C7

Analytical Verification: The controller must be small enough to fit in the 1 cubic foot space and should leave ample space for the rest of the launching apparatus.

3) Subsystem Power:

Inputs: N/A

Outputs: Sensor power, controller power

Applicable Constraints: C1, C3, C7

Analytical Verification: Proper research must be required to ensure that the correct amount of power is supplied to the head-on sensing subsystem.

4) Signal Data Processing Algorithm: This module will get the sensor data and find the position of the projectile and transmit that information to the launcher.

Inputs: Digital Signal

Outputs: X and Y coordinates relative to the launcher

Applicable Contraints : C1, C3,C7,C14

Analytical Verification: The algorithm must be able to process the data fast enough to achieve C14 to get the launcher to intercept the projectile.

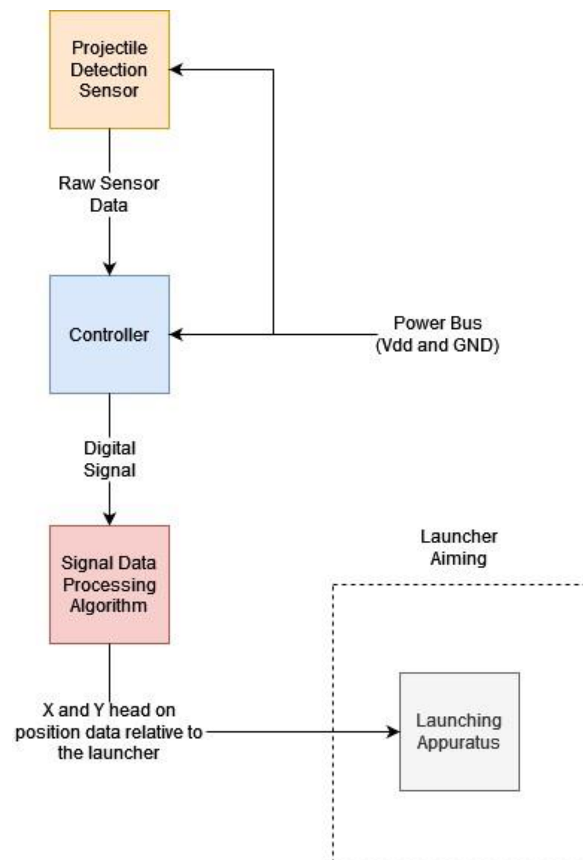


Fig 5: Block Diagram for Head On Projectile Sensing

E. Sensor Post Array

The Sensor Post array has the tasks of calculating an estimated path that the projectile has been released on, velocity of the incoming projectile, and acceleration of the projectile from the data it receives. The sensor Post will also communicate wirelessly with aiming system. The block diagram for the Sensor Post Array is seen in *Figure 6*.

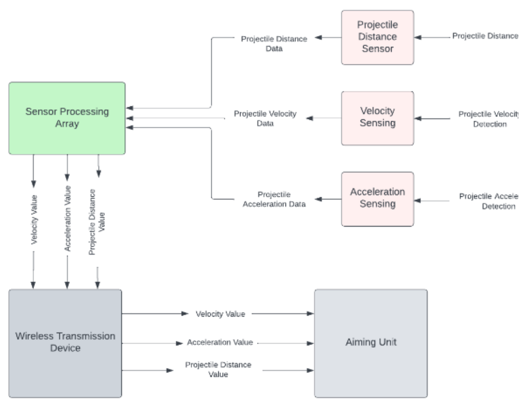


Figure 6: Block Diagram Sensor Post Array

1) Post Processing Array: This array must calculate the velocity, acceleration, and path that the projectile is traveling on from the data received then send the values to the wireless transmission device for wireless transmission.

   Inputs: Velocity data, Acceleration data, Estimated Path data

   Outputs: Velocity Value, Acceleration Value, Estimated Path

   Applicable Constraints: C2, C7, C8, C14

   Analytical Validation: This processing array must calculate and transmit the values calculated wirelessly within the 100ms time frame. Must also operate for a minimum of one hour before needing battery replacement.

2) Projectile Distance Sensing: This sensor must detect an estimation for how far the projectile is from the sensor.

   Inputs: Projectile Distance

   Outputs: Projectile Distance Data

   Applicable Constraints: C7, C8, C14

   Analytical Validation: This must detect the Projectile distance at a maximum of 64 inches and distance measurement must be accurate within 6 inches. Must operate for a minimum on one hour.

3) Velocity Sensing: Determine the velocity that the object is traveling at.

   Inputs: Projectile Velocity

   Outputs: Projectile Velocity data

   Applicable Constraints: C7, C8, C14

   Analytical Validation: This must detect the Projectile Velocity at a maximum distance of 64 inches and transmit data within 100ms.

4) Acceleration Sensing: Will determine the acceleration of the projectile as it passes by.

   Inputs: Projectile acceleration

   Outputs : Projectile acceleration data

   Applicable Contraints: C7, C8, C14

   Analytical Validation: This must detect the Projectile Velocity at a maximum distance of 64 inches, and transmit data within 100ms.

5) Wireless Transmission Device: Will communicate data wirelessly to another module.

   Inputs: Velocity, Acceleration, Estimated Path

   Outputs: Velocity, Acceleration, Estimated Path

   Applicable Constraints: C2, C8, C13, C14

   Analytical Validation: This device must reliably transmit all data at a minimum distance of 78 inches and within 100ms to follow standards. Further research needs to be done to find the bandwidth needed for data transferred.