Enhanced Golf Rangefinder Proposal

ECE 445: Senior Design Project

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Team 14

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Introduction

Problem:

Golf is an extremely difficult game that requires a great deal of precision. There are a multitude of factors that can affect a single golf shot such as distance, weather conditions, and club choice. Jowett and Phillips [1] show that even the most talented golfers will have shots and scores affected by adverse external conditions. Modern golf rangefinders gauge distance well, with some even able to show yardage adjustments for changes in elevation. However, rangefinders still lack many features that could help average or new golfers improve quickly. For example, if a golfer is using a normal rangefinder and measures a flagstick that is 150 yards away, they may think this distance should dictate the club they choose. However, what if there is a 15 mile-per-hour wind they are hitting into? What if that wind is at their back? What if the temperature and humidity are high enough where the density of the air is affected, ultimately affecting the flight of the golf ball? All these factors contribute to a change in the perceived distance, and whether it is a big change or a small change, it matters. Our proposed project will address this extremely common problem.

Solution:

The solution to the problem would be to create an enhanced rangefinder that adds several new features. The distance would be measured through a time-of-flight sensor, a commonly used component in rangefinders. To make our project unique, we would integrate several other components to help measure a more precise distance. This would consist of more sensors measuring factors such as wind speed, humidity, air pressure, and temperature. The adjusted distance due to these factors would be updated on the rangefinder and shown through an OLED display. Another component that would be utilized in our device would be a user interface where a proper club recommendation can be given based on the measured distance. All these components would be included within a 3D-printed enclosure that is both safe and easy to handle.

An explanation for a possible implementation would be as follows: The user would aim the device at the target and press a button. This button press would initialize the operation of the device, where the time-of-flight sensor emits a laser that strikes the object and reflects light back to measure the distance to the object. The wind sensor would measure the wind speed, while either one other sensor or multiple other sensors measure temperature, air pressure, and humidity. The exact number of sensors is to be determined as we continue to navigate the process of ordering parts, but the measurements listed are what we hope to achieve regardless. All the information obtained from these sensors would be passed to the microcontroller. Through programming of the microcontroller, we will implement thresholds for each external factor where the measured distance from the time-of-flight sensor can be altered accordingly to produce an adjusted distance. This adjusted distance would be shown on the OLED display for the user. Another part that would be programmed through the microcontroller is a UI feature where the user is provided with a club recommendation based on the adjusted distance. It is important to note that due to budget restrictions and the fact that our project is still in the very early stages of development, we will initially only be able to work with a time-of-flight sensor that measures up to 50 meters of distance. Pending early stages of design and testing, if our device can work with measuring 50 meters, we will move forward to expanding to a sensor with a larger range depending on faculty support and/or budget expansion.

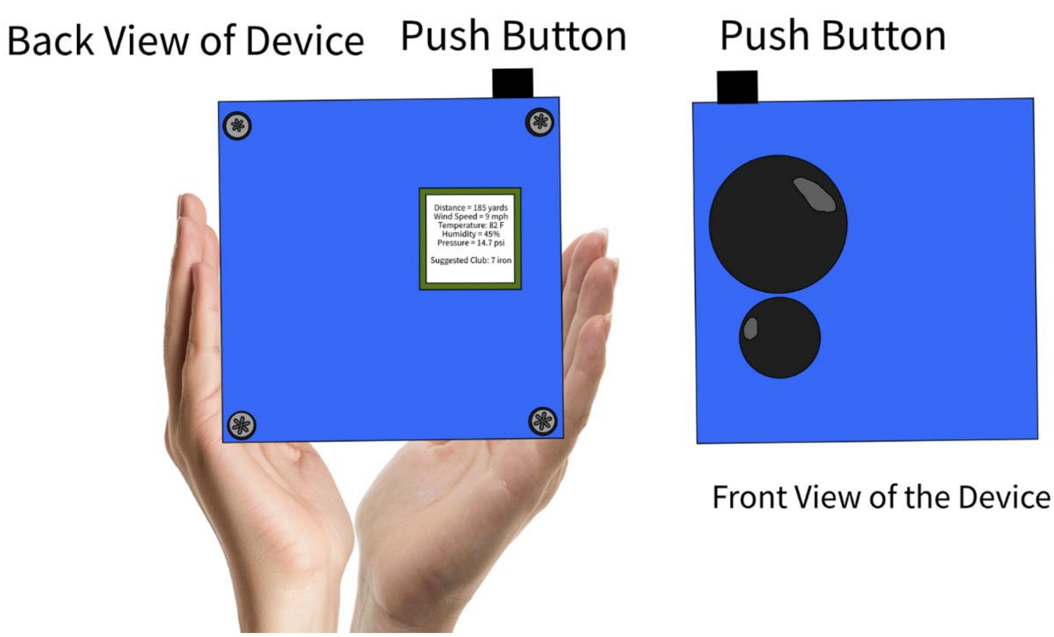
Goals:

- Create a device that measures distance accurately
- Implement functions that adjust the distance of a shot based on external conditions
- Device is as easy to use as a normal rangefinder

Benefits:

- Provides as precise a measurement as possible
- Helps golfers eliminate guesswork of the effect of weather conditions
- Gives golfers the opportunity to improve quicker by decreasing the chances of incorrect club choice leading to an off target shot

Visual Aid:



High Level Requirements:

- The rangefinder measures the correct distance from the user to the flag pin when the button is pressed. The distance should be constrained to the tolerance specified by our time-of-flight sensor's datasheet.
- When the button is pressed, the environmental sensors collect the correct data and provide the necessary adjustments accordingly.
- The user interface recommends a suitable club based on the measured distance. It is important to note that since we are starting with a limited range ToF sensor (50 meters), there would be scaling that takes place to meet this requirement. For example, if we measure 30 meters with the device but are scaling our results to reflect that of a 200-meter ToF, the simulated distance would be 120 meters, which would give a recommendation of a 9-iron for the average golfer.

Design

Block Diagram:

Figure 1 displays the block diagram for the Enhanced Golf Rangefinder. A legend for each connection type is displayed as well.

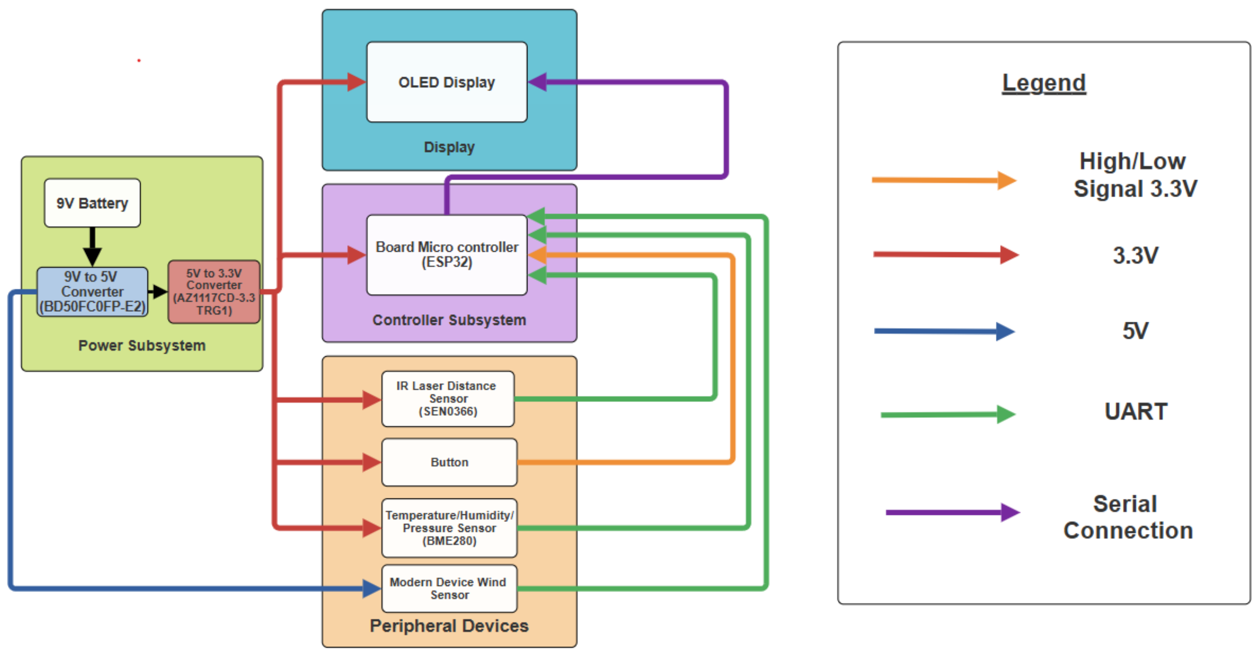


Figure 1: Block diagram for the Enhanced Golf Rangefinder

Block Descriptions:

Power Supply

The Power Supply Subsystem is responsible for supplying sufficient power to each of our electronic components within the Enhanced Rangefinder, which includes the Controller Subsystem and Peripheral Devices Subsystem. The Power Supply Subsystem contains three blocks: Our Power Supply, which is a 9V Battery, a 9V to 5V voltage converter, as well as a 5V to 3V voltage converter. These voltage converters will be linear voltage regulators. The 9V to 5V converter must be able to safely power our wind speed sensor, while the 5V to 3V converter must safely power our microcontroller, push button trigger, humidity, temperature, and air pressure sensor, and our time-of-flight laser distance sensor.

Requirements	Verification
• The battery must be able to supply a constant 9V DC supply	• Connect the 9V battery to the 9-5 converter • Utilize test points to verify that the correct voltage is being supplied
• The 9-5 converter must be able to successfully step down the DC voltage from 9 to 5 volts to be supplied to the wind sensor	• Utilize test points to verify that the voltage was converted from 9V to 5V • Utilize test points to verify that 5V is supplied to the wind sensor
• The 5-3 converter must be able to successfully step down the DC voltage from 5 to 3 volts to be supplied to the following components: 1. Button 2. Weather Sensor 3. Time-of-Flight Sensor 4. Microcontroller	• Utilize test points to verify that the voltage was converted from 5V to 3V • Utilize test points to verify that 3V is being supplied to items 1-4 listed under the requirements column
• Supply current does not exceed 500mA and disperses current effectively to all components	• Measure current from supply and current through all components
• Ensure that power ratings are met	• Measure voltage and current through components as applicable and calculate and verify that power meets the correct ratings

Controller

The controller subsystem is responsible for gathering the data from the peripheral sensors when the push button is triggered and sending the data to the user on an OLED display. Information from the IR laser distance sensor, wind sensor, and temperature, humidity, and pressure sensor will be transmitted through basic UART communication to a microcontroller. The microcontroller that we will use for this subsystem is the ESP32. The ESP32 includes 34 GPIO pins, PWM support, UART interface, and it supports Wi-Fi and Bluetooth v4.2 if those features are desirable in the future. The ESP32 requires a 3.3V input voltage and a 0.5A maximum current input, making this microcontroller favorable for high performance and low power consumption.

Requirements	Verification
• The microcontroller successfully receives data from the peripheral sensors upon push button triggering. Data will be received from: 1. Weather Sensors 2. Time-of-Flight Sensor	• Observe output data on serial monitor to confirm successful communication • Ensure data is received after push button is pressed
• The microcontroller successfully delivers information to the OLED display	• Ensure correct output is displayed by comparing output data from the serial monitor to the OLED display

Display

The purpose of the display is to show users the distance between the device and the target, temperature, humidity, pressure, and wind speed on an OLED. This is necessary for users to find this data without consulting with a serial monitor output on a computer. The dsiplay will be programmed from the the microcontroller to display all data listed in an organized fashion. The OLED will also display the suggested golf club to use based on the conditions given.

Requirements	Verification
• The OLED successfully displays the correct data from the microcontroller conveniently to the user	• Ensure correct output is displayed by comparing output data from the serial monitor to the OLED display • Ensure that the data is organized in a way the user can easily find information

Peripheral Devices

The peripheral devices are what collect and send the data needed for our Enhanced Golf Rangefinder to work. The sensors under this subsystem include the IR laser distance sensor (SEN0366), the Modern Wind Device sensor, and the temperature, humidity, and pressure sensor (BME 280). The IR laser distance sensor will be used to collect an accurate measurement of the distance between the device and the target. The sensor measures up to 50 meters using a visible Class II laser (620nm~690nm). The Modern Wind Device sensor will be used to measure the wind speed conditions while the device is triggered. This data will be used to provide an adjusted shot distance if necessary. The temperature, humidity, and pressure sensor will also be used to gather important data necessary for a potential shot adjustment. All data will be taken when the user triggers a push button. The sensor data will be sent to the microcontroller through UART communication while the push button will use a high/low signal at 3.3V.

Requirements	Verification
• The IR laser distance sensor is safely powered and accurately measures the distance between the sensor and the target	• Ensure the sensor receives the required 3.3V input rating through multimeter measurement • Validate distance measured by comparing a physical measurement between the device and target to the sensors reading on a serial output monitor
• The weather condition sensors function and output a realistic measurement of temperature, humidity, pressure, and wind speeds	• Ensure that each sensor receives correct input using multimeter measurements to ensure proper power is supplied • Compare data received and output on a serial monitor to actual weather conditions to ensure relative accuracy.

Tolerance Analysis

The most critical part of our design is the time-of-flight sensor. The SEN0366 sensor needs to be able to measure distance accurately for successful project completion. A crucial component that contributes to accurate measurements is timing. The sensor measures distance by sending a 620~690nm laser towards its target. Light is then reflected to the sensor. Since the speed of light is constant at 3 x 10^8 m/s, the sensor can convert the travel time into distance. If the time it takes for this process to occur is measured inaccurately, it will lead to an incorrect distance measurement. Per the datasheet of the SEN0366, the accuracy standard deviation is +/- 1mm which is the standard for the sensor's performance under ideal, factory-controlled conditions. However, when the sensor is used in real-life applications it is not functioning under ideal circumstances which can lead to small risk of error between distance measurements. This can be seen in the relationship between distance and speed of light:

$$d = \frac{1}{2} c\Delta t$$

Where d is the measured distance, c is the speed of light, and Δt is the round trip of the time of flight. Then looking at the relationship between distance uncertainty and timing uncertainty:

$$\sigma_d = \frac{1}{2} c\sigma_{\Delta t}$$

Solving for timing uncertainty by plugging in 3e8 m/s for c, and 1mm for distance uncertainty, we get a timing uncertainty of 6.7 ps.

Timing uncertainty can possibly be amplified due to extreme external conditions. If the operating temperature is too high or too low, there could be slight drift in the laser. However, the operating temperature of our sensor is -10 to 60 degrees C, so the sensor already compensates for this potential error and will not be affected by high or low temperature. In conclusion, there is an element of timing delay present that poses a slight risk to the operation of our ToF, however, with the specifications of our specific sensor, we feel it will operate successfully.

Safety and Ethics

The maximum power draw for the Enhanced Rangefinder is overall low; however, there are always possibilities for error and potential harm. One area involves our power supply which consists of an Alkaline battery, which will be stepped down using voltage regulators. Additionally, our project involves the use of lasers, and the overall design will be enclosed within a box structure. In doing this, there are several critical factors we need to consider:

- Do not short circuit the battery supply, avoid leaving conductive materials near the battery
- Avoid having liquids near the battery, keep the battery in a safe and stable environment (hot/cold temperatures)
- Do not overload the battery, always be sure of what is being loaded onto the battery and maintain routine checks using the ammeter
- Correctly size wires per the expected current when breadboard testing
- Linear Voltage Regulators can dissipate voltage as heat, always maintain routine thermal checks and accommodate for ventilation if needed within the enclosure
- Ensure the battery is installed with the correct polarity
- The laser inside the Time of Flight Sensor is a Class II laser, in normal conditions this is very safe and does not cause injury; however, ensure that the user does not directly stare into the beam and never point the laser at another person’s eye or any moving vehicle
- The project will be contained within a box enclosure, always make routine checks for live wires or exposed conductors to prevent shock

Additionally, all team members have completed the lab safety training prior to participating in any lab work. This includes electrical safety which provides knowledge of potential risks and methods of preventing such risks.

Our project will follow the IEEE Code of Ethics [2]:

[1] We will put the safety, health, and welfare of the first, act with honesty and integrity to avoid harm, provide clarity with risks, and minimize negative impacts on the environment by designing our system to prioritize safety, disclose known limitations, and document our testing

[2] We will work to deepen our own understanding of the technology while using it appropriately, remaining aware of the possible consequences

[3] We will be honest and realistic when describing the performance and expected outcomes of our project

[5] We will welcome any constructive feedback, acknowledge our mistakes, and give credit to others where it is due

[6] We will only take on risks for which we have proper training and fully state any limitations in our expertise

[9] We will avoid any actions that may cause harm to people, their property, reputations, or professional growth

[10] We will support our teammates and treat one another with respect as we grow in knowledge and encourage one another to uphold these ethical standards

References

[1] H. Jowett and I. D. Phillips, “The effect of weather conditions on scores at the United States Masters Golf Tournament,” *International Journal of Biometeorology*, vol. 67, no. 11, pp. 1897–1911, Sep. 2023.

[2] *IEEE Code of Ethics*, IEEE, 2020. [Online] Available: http://www.ieee.org/about/corporate/governance/p7-8.html