ECE 445 – Project Proposal

Waterski Tracker

Team #52
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Introduction

Problem:

Slalom skiing is one of the main events in competitive waterskiing. In this event, the competitor starts by passing through an entrance gate, skis through a course with 6 fixed buoys, and finishes by passing through an exit gate. The scoring for this event comes from a combination of speed and the length of ski rope used. In this case, a faster speed and shorter rope will lead to a higher score. If a skier misses either gate or does not clear even a single buoy, their run is over, and they cannot score any more points. This means that competitive skiers are very precise in their passes and require precise feedback in order to get to the 'next level'
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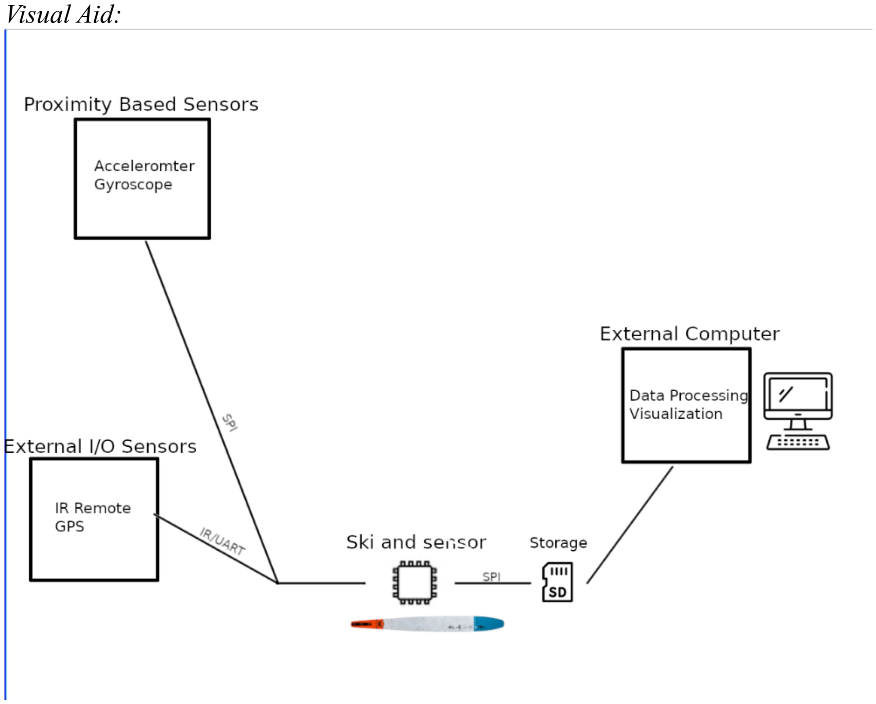
The main source of feedback for skiers is currently video playback and coaching advice. While videos are very easy to take with smartphones and accessible to almost anyone, video alone does not provide very detailed analysis of a skier's pass. A waterski coach is both expensive and difficult to find, so they are not accessible to everybody in the sport. This project aims to provide high-quality, precise feedback to slalom skiers in an affordable, accessible manner.

Solution:

Our solution involves a Printed Circuit Board that will house sensors to get data on ski runs. The main sensors are a GPS for positioning on the run, an accelerometer to get acceleration and speed data, and a Gyroscope for getting the tilt of the ski. We will be using a microcontroller to read and format this data and write it to an SD card. Also housed in the PCB will be a battery and battery management for power, some status LEDs for debugging and information while skiing, and an IR receiver for wireless control.

The second part of our product is data analysis. We figured that the data analysis required for this project is too processing-intensive to be done a micro controller, so we plan to save all sensor data to an SD Card. This SD card will be removed from the device after the skier has performed their runs and inserted into a computer program. The program will use Kalman Filtering, Google Maps API, and more data processing to convert the data into something that can be used by the skier for their information.

Visual Aid:

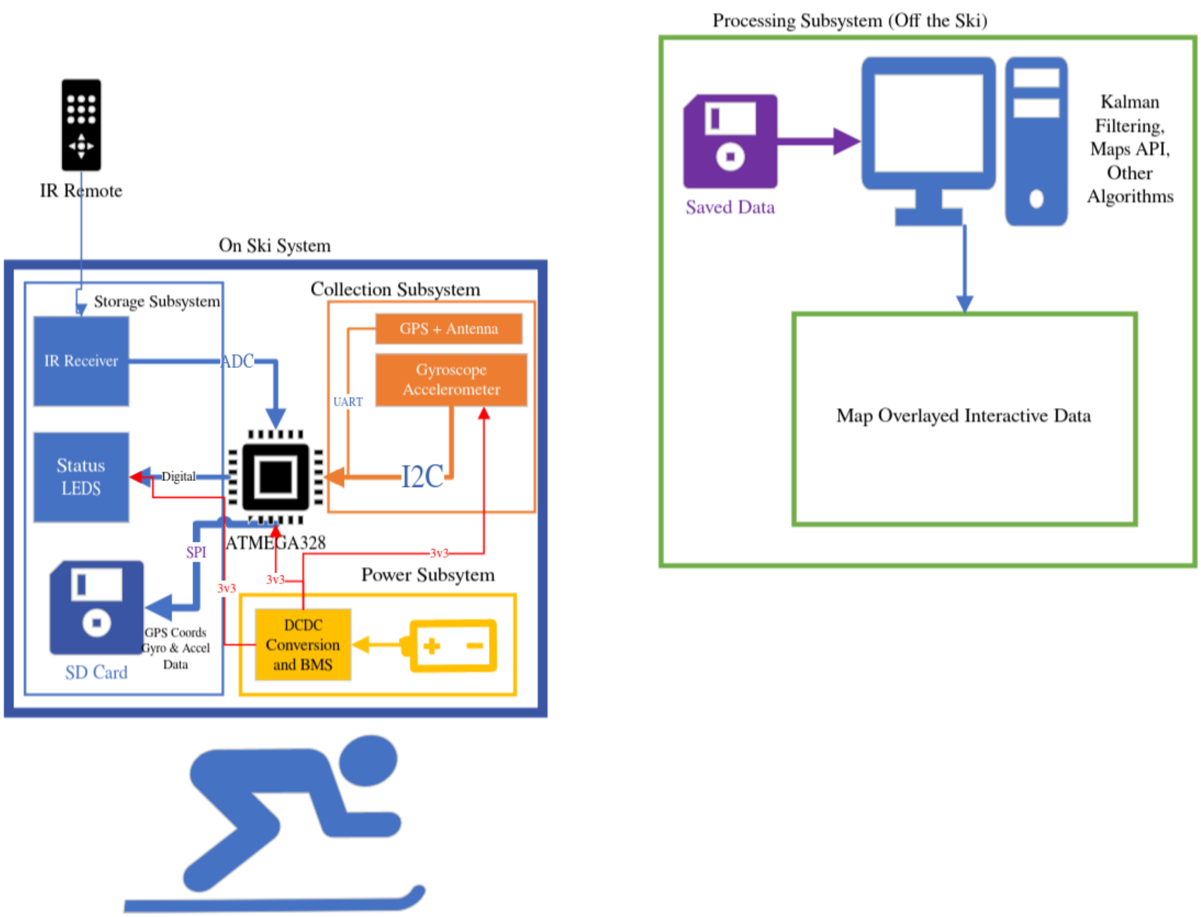


High-Level Requirements List:

1. Waterproofness and Efficacy for Skiing:
    a. We require that our device can be submerged at up to 10 feet for 3 minutes to test initial waterproofing. The next part is that the device must be successfully attached to the ski so that it does not fall off or get wet during a water-skiing run.
2. Accuracy:
    a. We want to make sure the data we collect is accurate. Our GPS should be accurate to within 3m. Our accelerometer should provide accurate acceleration and speed within 10%. Our gyroscope should also be able to provide tilt accuracy in all dimensions within 5%.
3. Multiple Passes:
    a. Since a skiing run includes more than one pass in a short amount of time, it is important that we can save multiple runs without opening and manually resetting the ski tracker. We will use an IR receiver and transmitter to start and end each run. This can be held by someone on the boat or even attached to the skier. We want to be able to house 10 passes before the SD card needs to be shifted out.

Design

Block Diagram:



Subsystem Overview:

<u>Collection</u>: The collection subsystem is the group of sensors that collects data before relaying it back to the storage subsystem to be processed on the external computer. The collection subsystem is home to the GPS,

Gyroscope, and Accelerometer sensors, which are the primary functioning of the device. They have various communication protocols but will be merged into a single bus when transmitting back to the storage subsystem.

Processing: The processing subsystem includes only the external processing computer that draws analysis from the data taken on the device. The processing subsystem can be any home computer and performs the Kalman Filtering, Maps API, and Data Smoothing before representing the data in a visualization.

Storage: The storage subsystem includes the microcontroller that facilitates the collection of data onto the SD card, and the SD card itself. The microcontroller will communicate with the SD card via SPI to write the sensor data onto cold storage for processing later, on the external device. No data processing is done on the microcontroller or storage subsystem.

Power: The power subsystem will be a compact system that provides power to the other subsystems both for data collection and storage. We will strike a balance between weight and capacity to ensure that the device can function for an extended period without needing to recharge the batteries.

Subsystem Requirements:

Collection: The collection subsystem is the primary functioning of the device. We need the sensors to be recording at minimum 10hz within their respective tolerances. This is +-10% on GPS positioning, +-5% on velocity measurement, and +-5% for pitch, yaw, and roll.

Processing: The processing subsystem will need the ability to read the SD card medium, as well as a functioning OS that can run Python3 code. To view the visualization the system will need a monitor.

Storage: The storage subsystem must be able to take data from the three sensors of the collection subsystem and store them in the SD Card. It must be able to hold multiple passes without running out of space. This subsystem also must be able to display different status messages on the debug LEDs. Finally, this subsystem must be able to use the IR receiver to control distinct functions of the processor, such as many passes and buoy location saving.

Power: For our power subsystem, we plan to use a LiPo battery to power our waterski tracker. We will allow the battery to be recharged from a port that is accessible without completely disassembling the device. We will also have a status LED that will tell us when our battery is at too low of a voltage. Finally, we will be able to use this device for 2 hours without recharging to allow ease of use while skiing.

Tolerance Analysis:

The most important tolerance in the project is the GPS accuracy, which is +-1.8m on each side. To improve this tolerance, we plan to implement Kalman Filtering / Sensor Fusion. As described in https://www.sciencedirect.com/science/article/pii/S1674984722000969 we can use RMSD to compare the actual results with the filtered ones. Results in the paper indicate that accuracy can be reduced to within 1.0m, with all data points falling into this category.

Ethics and Safety

Ethical Issues:

Since the data will be processed externally, location data will be available to potentially be misused. To avoid any potential misuse of this data, it will be saved on an SD card instead of being sent to the internet.

Safety Issues:

Outside of the safety risks associated with waterskiing, this device will not add any extra risk to the sport.

IEEE or ACM Code of Ethics Citations:

The ACM Code of Ethics section 1.6 discusses respecting privacy. Our product will make sure to store no information for outside parties to access. While we must store location information for usage by our processing algorithms, we will not access other users' data, and all data will be held locally.