ROBOTIC FOOTBALL

Low Level Design: First Design Review

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Overall System Requirements

The system that is being designed is an indoor-positioning system. It has the overall goal of being utilized by the Notre Dame Robotic Football team as a way to create a more autonomous and effective team. The basis of this system relies on a RF ranging chip called the DWM1000 which can be used to measure the distance between an initiator and responder module where the initiator is located on the Robot and the responder is located on one of the several stationary beacons seen in Figure 1. The distance to each of the four beacons is then available on Robot 1 and this information is passed via WiFi to an MQTT broker. Here a PC can then gather the data from the MQTT broker and evaluate the location of the Robot. From this location, the PC can make relevant autonomous decisions such as driving a robot or throwing the football.

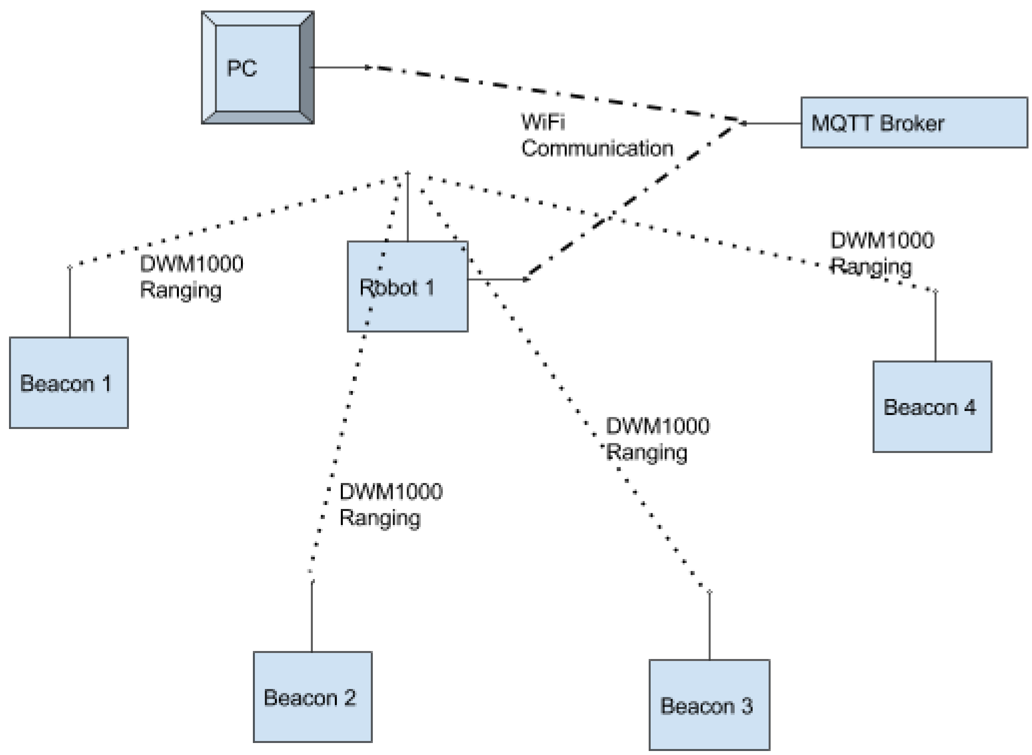

Figure 1: High Level Overview of Indoor Positioning System

For this to be implemented, a system must be created to integrate the various components for communication, ranging, and orientation. The proposed solution is a single control board that will contain all relevant systems for operation. This board then will execute different control code based on its role in the system.

Subsystem Description & Requirements

- Ranging: DecaWave DWM1000

  This subsystem implements the distance measurements between robots and beacons necessary for position calculations. The DecaWave DWM1000 ranging module was chosen for this project. It is a wireless transceiver module that operates in the 3.5-6.5 GHz range and enables the location of objects in real time location systems (RTLS) to a precision of 10 cm indoors using time of flight (TOF). It interfaces with the main microcontroller via serial SPI. In the ranging setup there will be an initiator module placed on one robot that initiates a ranging transaction with the beacons. The initiator will end up with the distance measurements after the transaction and then send that data to the PIC via serial communication. Frame filtering will be used to distinguish between each beacon distance measurement on the initiator side.

  Requirements:
  - Be able to measure distance to within an approximately 10-15 cm accuracy
  - Have an operating range of at least the length of the football field (approximately 30 m)
  - Operate in a frequency range that will not have excessive noise interference
  - Be able to communicate to the PIC microprocessor via a serial interface
  - Allow frame filtering to distinguish between distance measurements

- Microcontroller: PIC32MX795F512H

  The PIC32MX795F512H will be the main microcontroller for this project. It will receive distance data from the ranging module via SPI and then send the data to the WiFi module via UART. It will also communicate with the robot's microcontroller via UART and have a serial I2C interface with the magnetometer.

  Requirements:
  - Be able to support two UART ports, one I2C port, and one SPI port for serial communications with the subsystems and the robot's microcontroller
  - Be able to operate on rechargeable battery power or the robot's power supply
  - A dip switch will be used to configure the PIC for the initiator and beacons

- WiFi Communication: ESP8266 & MQTT

  The ESP8266 WiFi Module is a self-contained SOC with integrated TCP/IP protocol stack that gives our microcontroller access to the WiFi network we will be using. The MQTT protocol will be used for the WiFi communication. This protocol allows the ESP8266 module to publish and subscribe to different topics. The measurements from each beacon will be published to their own topic. A computer will then be used to grab the data and do the necessary location calculations.

  Requirements:
  - Compatibility between ESP8266 and MQTT protocol
  - ESP8266 UART connection to PIC

- Magnetometer

  In order to successfully make a pass, it is not enough to know only the positions of the robot. The orientation of the robot is also needed. The magnetometer allows for precise orientation measurements. The NXP Xtrinsic MAG3110 Three-Axis, Digital Magnetometer will be used for this portion of the project. It will exchange data with the primary PIC microcontroller via an I2C connection.

  Requirements:
  - I2C or SPI connection to PIC microcontroller

Subsystems Diagram

All subsystems have been integrated into the board schematic for this system.