Senior Design Project Proposal

Robot Football
Team Members: Eddie Hunckler, Matthew King, Stephen McAndrew, and Kate Sanders

1 Introduction

This project proposal's goal is to outline the desired project goals for the Robotic Football senior design group which is to design a robust system to locate and report the position of the quarterback robot and the wide receiver robots. This will allow the quarterback robot to be able to accurately throw the football. We will explore the various technologies that are available to complete this task and evaluate them based on building a reliable, robust, and long-lasting system. The goal of this project is to create a robust, easily repairable, and well documented positioning system for robot football that can be easily used for more than one season.

2 Problem Description

Robotic Football is an intercollegiate engineering challenge. It consists of an 8-on-8 game played by robots that are individually controlled by a unique driver. The rules of this competition are written to encourage gameplay to be as similar to what people are used to watching with NCAA football as possible. As with any football competition, one of the most important players is the player in the quarterback position. Robotic football is no exception to this assessment as a reliable, quick, and accurate quarterback is necessary for playing competitively.

The single most difficult problem with the quarterback is completing a quick and accurate pass to one of the wide receivers. There are several elements to completing a pass that need to be addressed in the context of robotic football. These are the target must be selected, the distance to the target must be determined, and the ball must be launched with the proper speed and rotation to hit the target.

During the past several years, the Notre Dame quarterback has designed and redesigned mechanically with less design going onto the electrical side of the operation. The primary problem with the most recent setup is that the quarterback cannot quickly and accurately determine the location of the wide receivers. This functionality is necessary for an effective quarterback and essential for a winning team. The current solution relied on a PixyCamera. This is a camera with image processing on board that allowed us to track colored objects. This performs ideally within a small distance and in a properly lit room, but in practice, the camera has to deal with non-ideal lighting and longer distances.

The problem for this design proposal is to develop a positioning system for the quarterback and wide receivers that operates independently of the other systems onboard the robots but can interface with them for data transfer purposes.

3 Proposed Solution

There are a number of different technologies that could be implemented in the design of our indoor positioning system including various optical, radio, Wi-Fi, and acoustic technologies. Preliminary tests should be conducted to evaluate the merit of each technology. Three possible solutions will be considered in this proposal. However, it is possible that other available technologies will be discovered as we conduct further research into this topic. It is also possible that we find a combination of technologies will be best to implemented in our final design.

Ultrasonic Positioning

Ultrasonic positioning systems are based off of measuring the travel time of sound waves between transmitters with a known location and receivers with an unknown location. In this solution, a minimum of three beacons would need to be placed outside of the playing field. A signal would be sent to each beacon as well as the robot indicating that an ultrasonic signal from the beacon should be initiated. The robot would then start counting until it received the signal from the beacon. From this time delay, the distance from the beacon to the robot could be calculated. With the use of multiple beacons, the position of the robot on the playing field could be determined by trilateration. This approach is similar to what the robotic football team has tried to implement in the past. There is definitely ample opportunity for improvement by redesigning this current system including extending the distance and angular range of the system as well as overall accuracy.

Another possibility might be to measure the intensity of a ultrasonic signal sent from a beacon in a known location. Given the intensity of the signal directly next to the beacon and information about how the signal attenuates with distance, the robot could measure the intensity of the signal at its location and calculate its distance from the beacon.

Wi-Fi Positioning

Typically wi-fi positioning system are based on measuring the intensity of a received signal from wi-fi access points with known locations. A number of different wi-fi access point would need to be set up outside the playing field. The robot could then measure the intensity of the signals from each wi-fi access point, and given information about how the signal attenuates with distance, calculate its distance from that point. Trilateration could then be used to find the robot's position. Another option would be to measure the angle of the arriving signal. With this approach, we would need specialized directional antennas of antenna arrays that could measure the angle of an incident signal. With known distances and angles between the wi-fi access points and the robot, triangulation could be used to find the position of the robot. This approach would give us more accurate positioning then knowing the distance alone.

Positioning Using Inertial Measurements

In this approach, the robots would be equipped with some kind of inertial measurement unit containing an accelerometer and gyroscope that would report the robots specific forces and angular rates. The robot would start off in a known position and then its

current position would be calculated by advancing its initial known position based off the inertial measurements. It is doubtful that this method alone would be sufficient to accurately determine position as it is subject to accumulation error. It might be useful, however, to use this system, known as dead reckoning, in combination with another system.

4 Demonstrated Features

When completed, our main demonstrated feature is determining the distance between and position of 5 robots on the field. To demonstrate that this is working properly, some sort of GUI or interface will be needed to show where our system thinks the robots are, which should be able to be verified by examining the field. Each robot should be able to work independent of each other, except when communicating data to each other or to a centralized location. In addition to this, our system will need to be able to communicate with the existing systems on the robots in order to be properly integrated into the existing robot setups.

5 Available Technologies

The technologies we will need will vary based on the method we decide to use to determine the position of each robot. For the ultrasonic method, we will need transmitters and receivers in both the robots and in the beacons. For the Wi-Fi method we would need to equip the beacons and robots with Wi-Fi capabilities, and for the dead reckoning method we would need accelerometers and gyroscopes. A microcontroller with ways to interface with each of the systems would be sufficient to run the calculations needed and output pertinent data to a computer to verify the accuracy of the data.

6 Engineering Content

To achieve our goals, we will need to characterize the components that we choose to use to fully understand how they operate and to use them in conjunction with each other and the microcontroller. Analog circuits will need to be designed to drive any receivers/transmitters for the ultrasonic method, the Wi-Fi chips and related technology for the Wi-Fi method, and the accelerometers and gyroscopes for the dead reckoning method. A system of wireless communication will need to be designed between devices regardless of which positioning method we use, with minimum response time determining the resolution of our positioning system. All used devices will need to be able to interface with the microcontroller, and must be able to communicate with and be used with old systems already in place with robot football. This may include combining multiple sensor data sources in order to achieve the best results possible.

7 Conclusions

This project proposal's goal is to outline the desired project goals for the Robotic Football senior design group. We aim to design a robust system to locate and report the position of the quarterback robot and the wide receiver robots in relation to the field so that the quarterback robot will be able to accurately throw the football. We will explore the various technologies that are available to complete this task and evaluate them based on building a reliable, robust, and long-lasting system.