Functional Specification Document

ECEN 490 Robot Soccer

Team Botnet

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Table of Contents

Introduction

This document describes the functional specifications for The Robot Soccer Project for team Botnet. It will address the high-level implementation details of the project, the customer needs, and how they fit together. It will also analyze the level of completion expected, along with the critical assumptions and product metrics that entail this product.

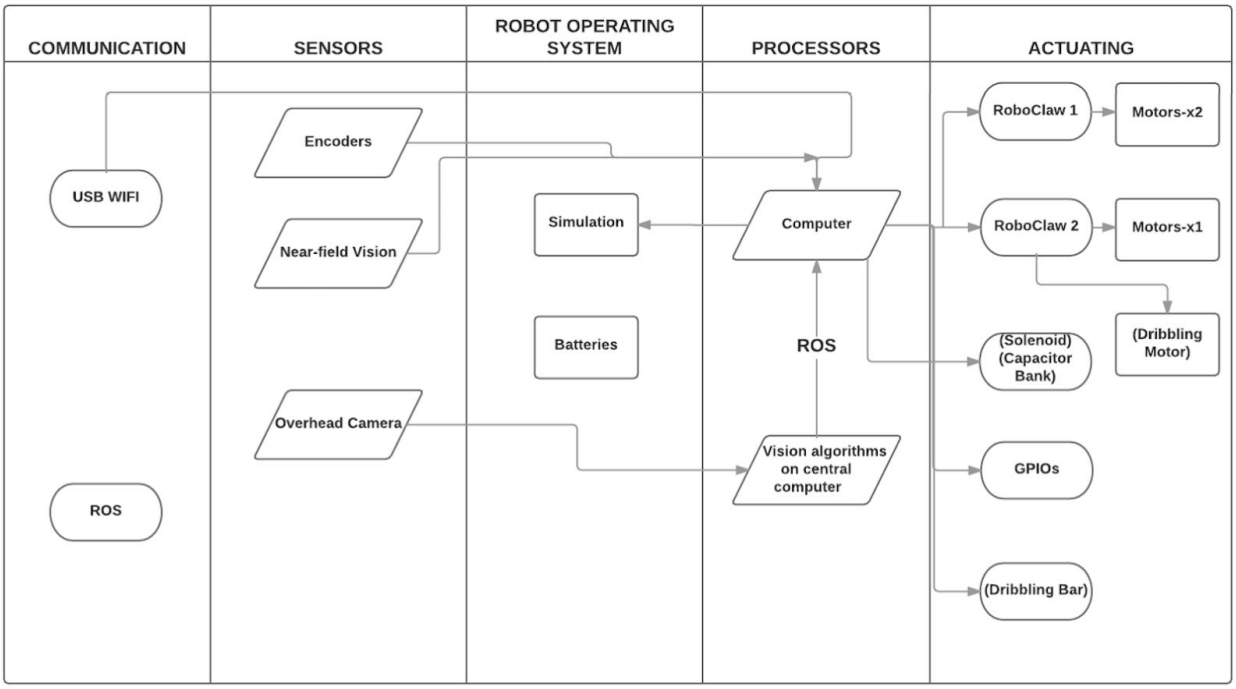
Project Description and Background

The notion of Robot Soccer started in 1997. An annual international competition “RoboCup” is held to promote robotics and AI research. Teams from all over the world participate in this competition and it has gained incredible public attention so far.

Following with the trend, Brigham Young University hosts annual Robot Soccer Competitions where teams of students participate in a two-on-two Robotic Soccer challenge. This project serves as the perfect capstone for the Electrical and Computer Engineering department where students must integrate a wireless communication system, Robotic vision, motion control, and artificial intelligence strategies in a fully autonomous system.

The system operates as follows: A single overhead camera is used to transmit crucial information to an onboard chip that processes the input and comes up with actions that the robot must perform. The onboard-chip is an ODROID running an Ubuntu linux operating system. The input to the system is the robots and ball positions. Then this information is put into an algorithm that assesses the situation using several artificial intelligence strategies and sends commands to the various motors that get the robot to move in the appropriate direction and angle.

Naturally, a lot of parts go into such a system. Here is a high-level block diagram depicting the various components that go into this system:



Project Requirements

Game Rules

- Robots must fit in a can with an 8-inch diameter and 10-inch height. All robots must be fully autonomous using on-board resources: other than start and stop directives, no information can be sent to the robots during play from human operators or from the team's base station computer.
- The ball is a standard golf ball, with the color to be determined by majority vote. We can choose from any currently available ball. (The ball will not be painted or modified.)
- The field will be five feet wide by 10 feet long. The goals will be two feet wide and specially marked with a unique color. The sides of the field will be angled so that the ball cannot get stuck against the sides or in the corner. There will be six markers at the four corners and at centerfield. The markers will be three feet high, with three one-foot color sections. The colors will be arranged so that each marker is unique.
- Each team will be assigned one of two fixed colors for each game. All players on that team must be able to wear the assigned color, and that color must be clearly visible from all angles at player height. All players on each team will be marked in the same way, so there will be no designated goalkeeper.
- Robots must be designed and operated in such a way that they do not damage other robots, the field, or human spectators. Kickers are not allowed to shoot the ball so hard

that it damages other players. Robots are to avoid collisions. Any contact with a defender while in the defense area will be deemed a violation. Outside the defense area, causing substantial contact with an opposing robot will be deemed a violation. (Contact is considered substantial if it noticeably changes a player's orientation, position, or motion.) If the responsibility for contact is not obvious play may be allowed to continue.

- The offside rule will not apply.
- It will be deemed a violation if a robot drops parts on the field.
- Robots are not allowed to fix the ball to their body, or encompass the ball in any way that prevents access by other players. 80% of the area of the ball must be outside the convex hull of the robot, when viewed from the side at a perpendicular angle.
- No robot can use adhesives such as glue or tape for purposes of controlling the ball or constructing a dribbler. It is a violation to leave residue on the ball or the field. Dribbling devices that exert backspin on the ball (to maintain contact with the robot) are permitted, provided that the spin on the ball is perpendicular to the plane of the field.

Critical Assumptions

- Additional hardware costs within budget
- All hardware will be able to communicate - WiFi, ODRIOD, camera, RoboClaw
- The battery will be able to provide the needed power/current
- Simulations will roughly approximate real life
- Processor will be able to run all of the needed software
- OpenCV will have the needed performance
- All provided hardware will function according to specs
- The motors will be able to handle the weight of the robot
- We will be able to estimate the state of the game in real time from the camera
- Controls feedback loop will run in real time

Product Requirements

Customer Needs

#	Customer Need	Priority	Requirement	Ideal Val
1	robot is big enough to fit all the parts, but small enough to follow the size rule	high	Diameter - Robot fits into 8 inch cylinder	8in
2	robot can move quickly in many directions	med	Time to change directions	< .8s
			Top Speed	> 1m/s

3	robots can respond to environment	high	Time until robot begins to react to state change of game	< .5s
4	robot prevents ball from going into own goal	high	Time to move in front of ball rolling towards goal (<.5 sec to respond + .5 sec to move)	< 1s
5	robot able score goals on opposing goal	high	Move ball towards open goal accuracy	100 %
6	multiple robots work cooperatively	med	robots behave differently to fulfill offensive/defensive roles	
7	robots move efficiently	low	Turn and drive at the same time	
8	robots implement strategy	high	Group movements into objectives	
9	robot can kick the ball	low	Some sort of pneumonic kicker on “front” of robot	
10	battery powered	high	2x7 V batteries in series to achieve 14 V	> 20 min
11	autonomous	high	Functionality determined by state of field as seen by overhead camera	
12	look cool	high	Lots of robot parts showing - Flare* LEDs Flamethrowers	
13	affordable	low	costs are not excessive	<$80

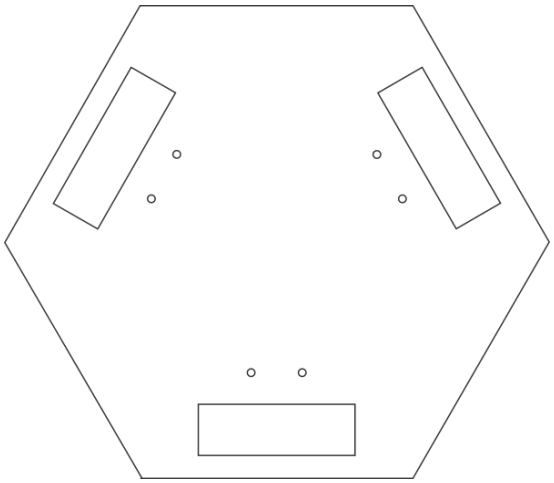
Design Specifications

Materials List

1. 3 sq. ft. acrylic plastic for body
2. 2 roboclaw boards

3. 1 ODroid board
4. 3 DC motors with encoders
5. 3 voltage dividers
6. 3 multidirectional wheels
7. 2 7.2V batteries
8. Jumper wires, solder
9. Screws

Body Diagram



Design Metrics and Need Correlation

The following table shows the linking of project requirements and specifications:

#	Metric	Min/Max	Ideal	Customer Need Addressed
1	Cost - beyond additional parts	< $80	$50	13
2	Size	<= 8”	8”	1
3	Precision of Robot Movement	< 0.5 “	0.1”	2 - 9
4	Precision of Camera detecting positions	< 1 “	0.1”	2 - 9
5	Robot movement delay	< 0.5 s	0.1 s	2

6	Camera Delay	< 0.3 s	0.05 s	2 - 9, 11
7	Response time to game state change	< 1 s	0.3 s	3 - 9, 11
8	Time to cross goal in response to ball being shot	< 0.2 s	0.1 s	4
9	Battery able to power robots for duration of time	> 20 min	30 min	10
10	Motors turn quickly with payload	> 150 RPM	200 RPM	2,4,7
11	Leaves a sparkle in Brother Clifford's eye	> one sparkle	two sparkles	12

Metric Reasoning

1: Allowance given by program is 80 US Dollars

2: Competition rules require maximum size compliance

3: Ability to move robot to desired potion heavily influences robot performance

4: Camera provides information of ball, opposing robot, and form position feedback for team robots

5: Time between occurrence of conditions that trigger robot action and action being performed lead to game altering advantages

6: Reliability of camera information determines reliability value of feedback

7: Time between game state change and response time is affected by complexity of code and other systems leading to robot action, and need monitoring

8: Combined response and agility measurement specific to critical defensive maneuver

9: Battery duration is necessary for game play during the entire match

10: Directly determines the speed the robot may achieve

11: The only true way of measuring beauty

Summary

For this project we will have to successfully build two robots that can play soccer and win using several offensive and defensive strategies. Our main concern is to be able to meet all our customer needs in a timely and efficient manner. In addition priorities have been assigned to different needs for more efficient resource management. In order meet the customer needs, there are certain requirements that must first be reached. Some of these needs include areas such as: limitations relative to cost, space, software capabilities, and hardware compliance and other needs listed as metrics in product specifications. We are also hopeful that we will improve on the quality level of last year's robots and have a more enjoyable tournament.