PROPOSAL FOR ROBOT RACE DESIGN

Prepared by

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Abstract

In the Robot Race project, the best robot will finish ten laps on a figure-eight track with the shortest time. Successful robots will be capable of detecting and avoiding obstacles up front and also able to identify the destinated path. In response to the project requirements, our proposed solution is a robotic car built with mainly image processing functions to detect obstacles and to identify clear path. The decision-making logic will also depend on distance detection from the Infrared Sensors. To identify the correct direction the robot should move, a digital compass will be used. This approach will result in accurate autonomous navigation.

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1. Introduction

The Robot Race project is initiated to expose students to the engineering experience with building autonomous robotic systems. The purpose of structuring the project as a team competition is to promote innovative engineering ideas, to accelerate students' software and hardware engineering skills and team building skills. The maximum time for the project is thirteen weeks. The maximum reimbursable budget for each team is $650. The project background and a more detailed description of our design are outlined below. In addition, details regarding cost and team organization are provided, and a Gantt chart of the project timeline is included.

2. Design Requirements, Goals and Proposed Approach

2.1.Mechanical Design

2.1.1. Chassis

Our robot will have an all aluminum space frame chassis. The chassis is going to be assembled with 2D flat pieces of water jet cut aluminum plates and brazed together to form a 3D structure. The design is still in progress.
We will carefully design our wheel and hubs with Ackerman's steering geometry, where the inner wheel will turn more than the outer wheel in a turn to minimize wheel slip(see figure.1)

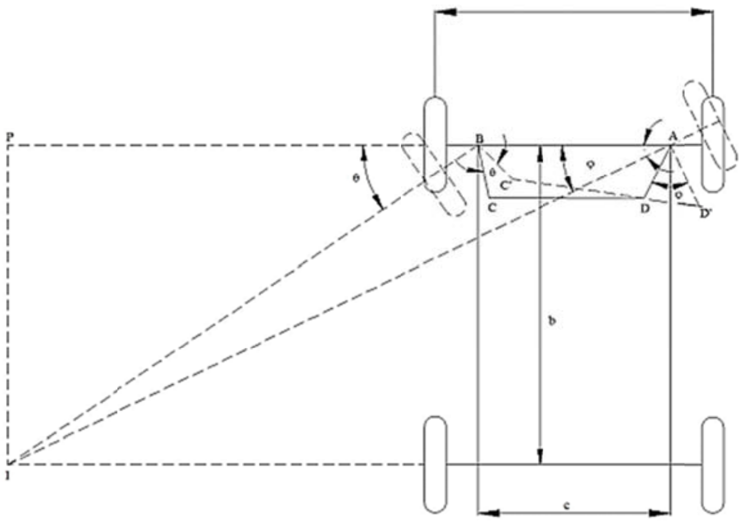


Figure 1: Ackerman's steering geometry

2.1.2. Battery

Since our robot is a racing vehicle, speed is a big design goal. To gain speed, we need power, and to supply enough power for a long period of time, we need lots of energy. This means we need the most energy dense battery available on the market. At 180Wh/kg, the Lithium Polymer battery takes the crown as the ideal battery for our applications. However, a challenge with using such battery is that they can explode if mishandled, which means we will have onboard battery monitoring hardware and software to make sure these batteries are in good shape.

2.1.3. Motor

As for the power train, we are using a high-end 1/10 scale RC car brushless DC motor and programmable controller. These motors are high in power density and have high continuous power rating to propel our robot through the racetrack. We will also use the motor as the brakes to slow down the robot.

3. Microcontroller

The Arduino Fio is selected as our microcontroller for the robot (Figure 2). It runs at 3.3V and 8 MHz and has 14 digital I/O pins, 6 of which can be used as PWM outputs for the motors. It contains a Lithium Polymer battery connection and an XBee wireless module for communication with the main computer which is used for image processing. We chose this microcontroller mainly because it’s designed for wireless applications. XBee is a cheater, more accurate and lower power consumption wireless solution compare with WiFi and Bluetooth.

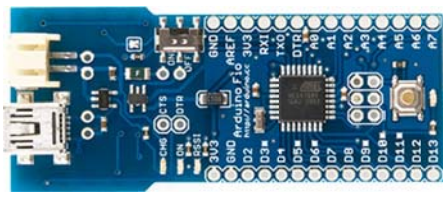


Figure 2: Arduino Fio

4. Navigation

The main sensor for our robot will be a wireless webcam. A laser pointer will be placed in front of the car and shoots out a horizontal line (Figure 3). The laser beam is projected on the track wall and other robots (Figure 4). The webcam will capture the image, and send the wireless signal to our computer via radio wave. The computer will process the image to get a clear shot of the laser line. From the image, places without laser lines are considered as open spaces. If the open space is wider than our robot width, the computer will send a direction command signal to the controller.

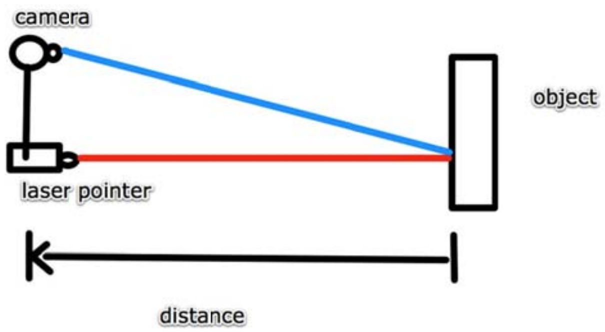


Figure 3: Triangulation

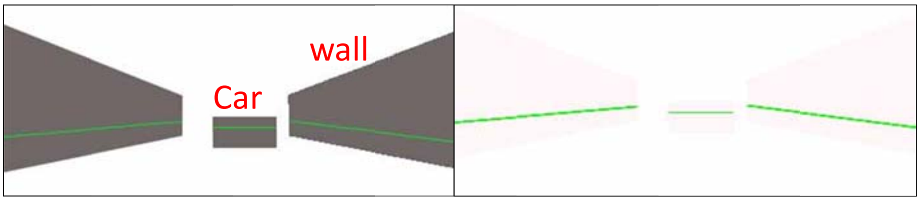


Figure 4: Before and After Image Processing

We will put a digital compass on our robot. During the race, the digital compass will be constantly read, and the data will be stored in registers. The image signal will be our main detection for direction. However, if our robot got hit or had a sudden change in direction, the microcontroller will use the previous direction data as reference and adjust the direction.

Since a black tape will be placed as the finishing line. A colour sensor will be placed on the bottom of the car to detect the black tape. In our program, there will be a loop count variable. When there is a positive reading from the colour sensor, the loop count will add up by 1.After finishing the required number of loops, the robot will stop automatically.

We will place two IR sensors on the side of the robot as a blind spot checker. If the distance with other objects too short, we will send an interrupt to our main program.

5. Algorithm

The video signal is transmitted from the camera to an AM radio receiver which is connected to a frame grabber that converts the camera analog signal to digital at 30fps. The video is then processed in MATLAB on the main computer. The control signal then is sent back to the robot via Xbee on the Arduino microprocessor. The flow chart is shown in Figure 5.

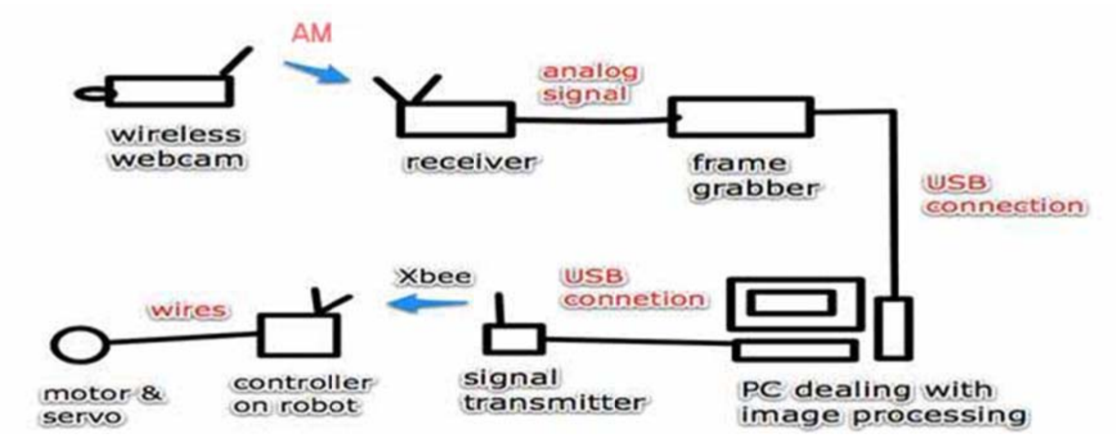


Figure 5: System Algorithm

The software algorithm follows the logic shown in Figure 6. The servo and DC motors are controlled according to the image processing signals.

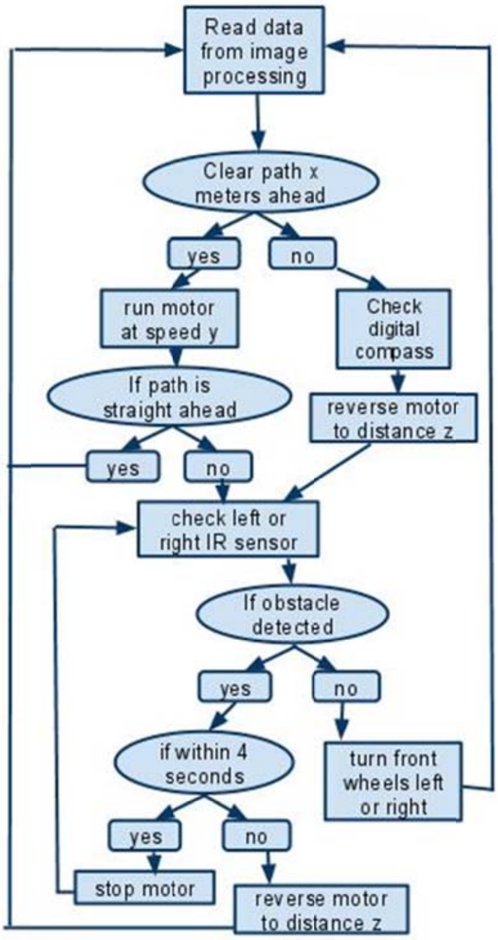


Figure 6: Software Algorithm

6. Cost

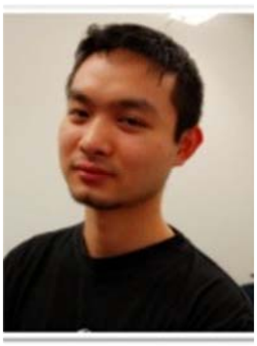
The budget analysis is outlined in the chart below.

Item	Quantity	Price	Total
Microcontroller	1	$25.00	$25.00
IR rangefinder	3	$15.00	$45.00
IR reflection sensor	1	$4.00	$4.00
Lithium Polymer battery	2	$30.00	$60.00
Wireless camera	1	$40.00	$40.00
Laser pointer	2	$15.00	$30.00
ServoMotor	1	$15.00	$15.00
DC brushless Motor	1	$80.00	$80.00
Rotary encoder	2	$4.00	$8.00
Xbee wireless	1	$60.00	$60.00
		Total	$367.00

7. Team Organization

Our team consists of three third-year students and one fourth-year student in the electrical and computer engineering program: Ricky Gu, James Li, Tony Lin, Allister MacLean. To ensure concise communication, our team meets every Tuesday and Friday. During each meeting, an oral progress update is given by each member. This is followed by an open discussion of the overall standing of the project. All the concerns are brought up and addressed, and the team schedule is reviewed and revised. Between meetings, research documents are often sent via email.

Each member is responsible for researching and building one component of the project. Other responsibilities and tasks were discussed and agreed upon based on each member's interests and strengths. Here is a tentative list of individual responsibilities that have been assigned to each of the four team members:

- Ricky Gu, the team leader, is in charge of making sure that all the deadlines are met and all the members are doing their share of work. He will also address any concerns from other members in the team. In addition, he is responsible for researching and building the mechanical component of the robot.

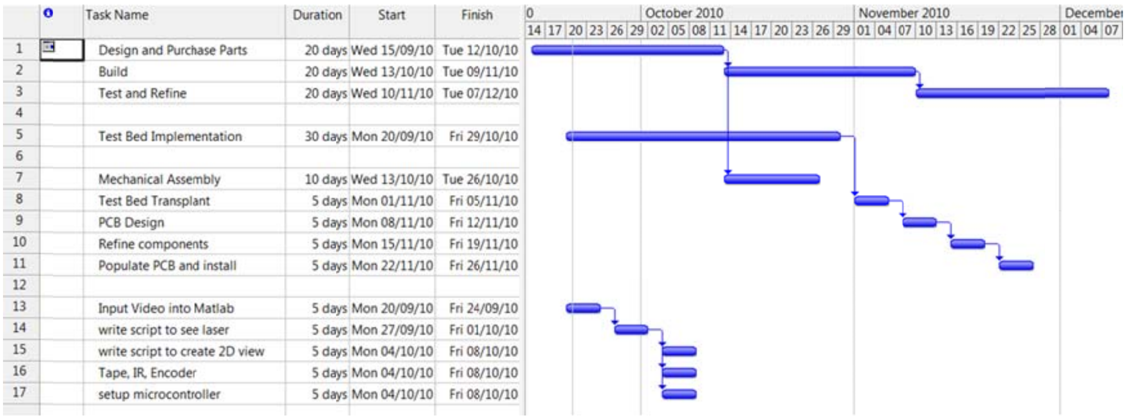
- James Li is in charge of researching and writing the robot control software and image processing.

- Tony Lin is in charge of researching and implementing the Infrared sensors and image processing.

- Allister MacLean is responsible for related work with the microcontroller and the color sensor.

8. Gantt Chart

Figure 7 is Gantt chart that illustrates the tasks and the expected completion dates for our project.



	Task Name	Duration	Start	Finish
1	Design and Purchase Parts	20 days	Wed 15/09/10	Tue 12/10/10
2	Build	20 days	Wed 13/10/10	Tue 09/11/10
3	Test and Refine	20 days	Wed 10/11/10	Tue 07/12/10
4				
5	Test Bed Implementation	30 days	Mon 20/09/10	Fri 29/10/10
6				
7	Mechanical Assembly	10 days	Wed 13/10/10	Tue 26/10/10
8	Test Bed Transplant	5 days	Mon 01/11/10	Fri 05/11/10
9	PCB Design	5 days	Mon 08/11/10	Fri 12/11/10
10	Refine components	5 days	Mon 15/11/10	Fri 19/11/10
11	Populate PCB and install	5 days	Mon 22/11/10	Fri 26/11/10
12				
13	Input Video into Matlab	5 days	Mon 20/09/10	Fri 24/09/10
14	write script to see laser	5 days	Mon 27/09/10	Fri 01/10/10
15	write script to create 2D view	5 days	Mon 04/10/10	Fri 08/10/10
16	Tape, IR, Encoder	5 days	Mon 04/10/10	Fri 08/10/10
17	setup microcontroller	5 days	Mon 04/10/10	Fri 08/10/10

Figure 7: Gantt Chart

9. Conclusion

We believe the Robot Race project is a valuable learning experience. Our proposed solution is capable of generating more accurate data than using only Infrared sensors and ultrasonic sensors. Using a digital compass to track the correct direction eliminates the need to identify the symbol on the track.