Butter Passing Robot

ECE 445 Project Proposal -- Spring 2018

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1. Introduction

1.1. Objective

We are trying to implement a butter passing robot, which will be able to find the butter on the table and bring it back to a fixed position on the table. This task can be mainly divided into two subtasks: the first one would be to implement an autonomous vehicle which can move by itself on the table; the second subtask would be to implement certain sort of algorithms to help the vehicle detect the target location and direct itself accordingly.

For the first subtask, we will build a tiny vehicle using two motors and a plastic chassis from Sparkfun. We plan to use Pulse Width Modulation to change the duty cycle of the signal going to the motors, so that we can change the speed of each motor respectively. To make the vehicle safe, we will program a microcontroller so that it can halt the vehicle when the motor gets too hot or gets stuck. For the second subtask, we will add a camera to the vehicle. The camera will take photos of the environments at certain speed. We will write a software program to analyze the contents of the image, so that we can get the relative location of the vehicle and the target. The challenge would be to implement a software that can run fast as well as accurately.

1.2. Background

This project idea was inspired by the famous sitcom Rick and Morty. In one of the episodes, Rick built a tiny robot which keeps asking “What’s my purpose?”. Rick then tells the robot to fetch the butter, and the robot successfully achieves that.

We searched “butter passing robot” on Google and found two similar projects. However, they both utilized manufactured toy robots as the vehicle. Our project, if completed, will provide similar functionality at a much lower cost. Also, our project can be easily transformed to accomplish other functionals.

1.3. High-Level Requirement List

- The vehicle can move by itself on a regular-sized(2m*1m) table.
- The vehicle can detect the target(butter) and the start point and direct itself accordingly.
- The total cost of the project should be less than $100.

2. Design

2.1. Block Diagram

To be successful in operating, the butter passing robot requires three sections: a power supply, a control module and a robotic platform. The power supply consists of one Lithium battery as power source. It also contains a voltage regulator so that all the electronic devices can operate under acceptable voltage range. The control module consists of a microcontroller as well as a Raspberry Pi. Connected with a camera, the Raspberry Pi will be used solely to analyze the input image. The microcontroller will be used to read inputs from the thermal sensor, infra sensor and the Raspberry Pi. It will then output appropriate signals to both motors. We plan to incorporate the microcontroller, the thermal sensor and the infra sensor on a PCB. The robotic platform consists of two motors, two small tires and one chassis.

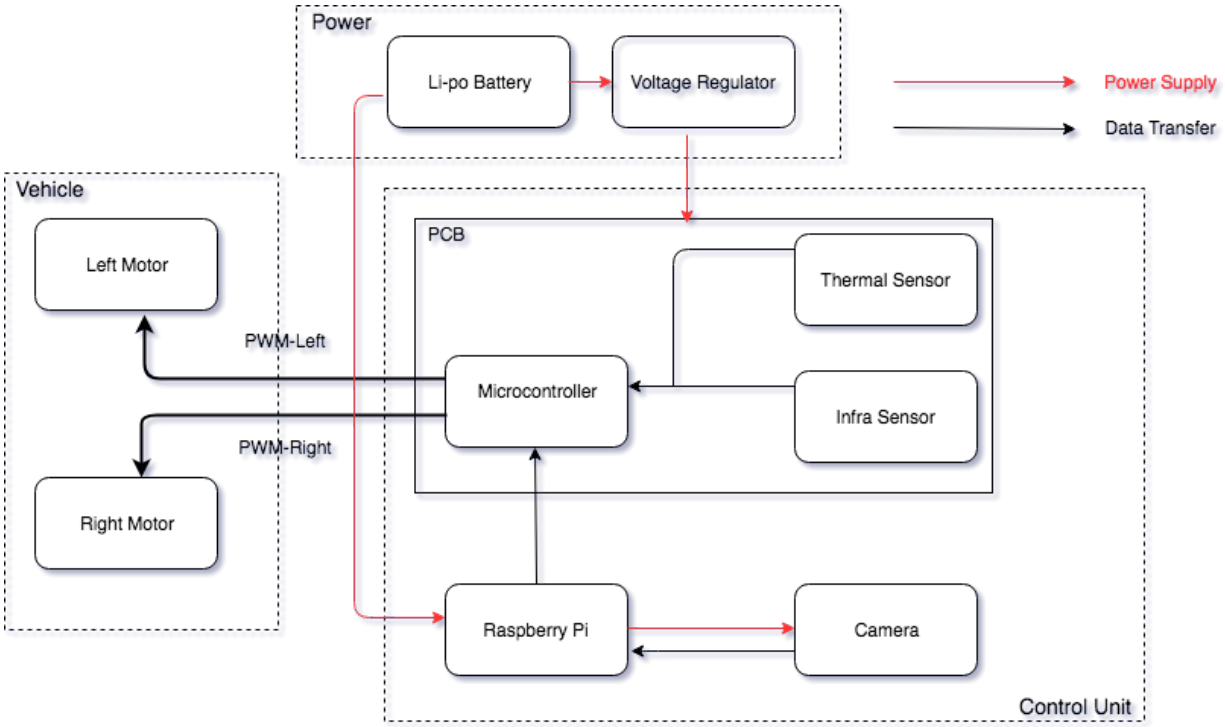

Fig 1. Block Diagram

2.2. Functional Overview and Block Requirements

2.2.1. Power Supply

The power supply module is required to keep the butter passing robot running continually. It will be connected to the PCB and Raspberry Pi.

2.2.1.1. Lithium Battery

The lithium battery must be able to keep the butter passing robot up continually.

Requirement: the battery must store enough charge to provide at least 2.5A at 5.75~6.25V for 10 minutes before recharging.

2.2.1.2. Voltage Regulator

Since the onboard hardware devices require a relatively low voltage to work, we need a voltage regulator to make sure all sensors and microcontrollers are operating under acceptable voltage range. The voltage regulator be connected to the lithium battery, the microcontroller, both sensors and the Raspberry Pi.

Requirement 1: the voltage regulator must provide 4.5V +/- 5%
Requirement 2: Must maintain thermal stability below 125°C[]

2.2.2. Control Module

The control module gathers information about the environment. Then it uses those information to lead the vehicle to the target state. It is powered by the power supply module and it controls the vehicle.

2.2.2.1. Microcontroller

The microcontroller receives input from the Infrared Sensor, the Temperature Sensor and the Raspberry Pi. It will be programmed to give appropriate output to the motors based on its inputs.

Requirement 1: the microcontroller must be able to communicate with the Infrared Sensor, the Temperature Sensor and the Raspberry Pi board at the same time
Requirement 2: the microcontroller must be able to work properly under the voltage from regulator(4.5V +/- 5%)

2.2.2.2. Infrared Sensor

The Infrared Sensor is used to detect the obstacles around the vehicle, so that the vehicle can avoid collision/falling off the table while moving toward the target. The Infrared Sensor reading will be input into the microcontroller.

Requirement: the Infrared Sensor should work properly under the voltage from regulator(4.5V +/- 5%)

2.2.2.3. Temperature Sensor

The Temperature Sensor is used to detect the temperature of the motor so that the robot can halt before the motor overheats. The Temperature Sensor reading will be input into the microcontroller.

Requirement: the Temperature Sensor should work properly under the voltage from regulator(4.5V +/- 5%)

2.2.2.4. Raspberry Pi

The Raspberry Pi will solely be used to run Python scripts for image analysis. It will find the target within the image and input that information to the microcontroller.

Requirement 1: the Raspberry Pi must work properly under 5V@2.5A
Requirement 2: the Raspberry Pi should be able to analyze an image within 0.25s+/-10%

2.2.2.5. Raspberry Pi Camera

The Raspberry Pi camera will be placed on the front of the vehicle. It will be powered directly by the Raspberry Pi. It should be able to take photos periodically so that the control module can gain up-to-date information about the environment.

Requirement : the Raspberry Pi must be able to take at least 4 photos per second

2.2.3. Robotic Platform (Vehicle)

The robotic platform of this project will be a small vehicle, consisting of two motors, two rubber tires and one chassis. The motors' spinning speed can change based on the modulated signals from the microprocessor.

2.2.3.1. Motor

We plan to use the hobby motor from Sparkfun. The motors should operate within the acceptable voltage range and acceptable temperature range.

Requirement 1: the motor should halt if the current through the motor exceeds 0.8A
Requirement 2: the motor should operate under voltage of 1V~3V
Requirement 3: the motor should halt if the temperature of the motor exceeds 80℃

2.3. Risk Analysis

The software program we wrote to analyze the image is a significant risk to our project. The algorithm we use must be capable of finding the target in the image accurately and efficiently. If the software program has a time complexity or space complexity that's too big, the Raspberry Pi will likely spend more time and power running it. Since the vehicle will not stop once it starts moving, the vehicle will most likely move toward a wrong direction if the microcontroller gives out-of-date instructions. Thus, the speed of the vehicle should also be designed to match the worst-case running time of our algorithm.

The advantage of Raspberry Pi is that it has relatively powerful computing unit and it is extremely portable. Initially we planned to use a wi-fi module and a remote laptop to transmit analyze the image. Although the computing power of a laptop is definitely sufficient for our purposes, the delay due to slow wireless transmission will be lethal to this project. The Raspberry Pi, on the other hand, can communicate with the camera using wired connection. After weighing those pros and cons, we made our decision on Raspberry Pi.

3. Ethics and Safety

The major safety concern within our project is the use of a lithium battery. Failure in performance can be caused by poor execution of a design, or an unanticipated use or abuse of a project. Risks include the thermal stability of active materials within the battery at high temperatures. Lithium-ion battery fires and explosions come down to a problem of short circuiting. We need to check our circuit design in order to prevent it. Also, we should always place our battery in a safe position in order to prevent it from violent collisions, since the violent collisions will damage the separator and cause the electrodes to touch. If the battery be pierced(either by accident or deliberately), then short circuit will happen.

Another safety concern of our project is the motors. In order to prevent the motors from overheat, we add some thermal sensors which can detect the temperature of motors. As long as the temperature is over the value that the motors can hold, power will be cut down and the whole project will halt. We also want to look out for scenarios in which the motors get stuck. To detect stuck motor, we will place a resistor in series with it. Once

the motor gets stuck, the current through it will increase significantly. And we can measure the voltage across the resistor and input that into the microcontroller.

References

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