Formal Written Report

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Towing Robot (Towbot)

EEL 4665C: Intelligent Machines Design Laboratory

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Abstract

In the frenzy of technological advancements, there has been a strong movement towards automation of tasks with the main goal of improving our conditions of living. With this in mind, the goal of our autonomous towing machine, is to be able to detect and actuate when an automotive has fail and needs a towing service; this task is to be perform autonomously. The application of this idea is to be extended to full-scale automotive and, to accomplish the vision in mind, we begin advancing this idea on small scale robots.

At this point, the project consists of having two autonomous robots. Robot A will mimic a daily automotive that would drive around until it 'breaks down.' Once it breaks down, Robot A would send a signal to Robot B signaling its need of towing service. When Robot B receives such signal, he would then proceed to Robot's A location for assistance. Upon arrival, Robot B would tow Robot A to a specified destination. In recognizing the location of Robot A, there are various ways to accomplish it. There are two alternatives that will be researched before selecting the best choice: 1) a god-camera that would recognize the environment and communicate with Robot B Robot's A location so that Robot B could then travel to the specified location for towing with a second camera on board, and 2) a camera onboard Robot B that would scan the environment looking for Robot A and towing it once located. Another function, and point of discussion, of the towing machine would be the mechanism for hooking or grabbing the broken-down robot. This could be accomplish using a claw of some sort, a magnetic attraction, Velcro, or some other possible solutions. Also, thought must be given to the communication between robots. Solutions include Wi-Fi, Bluetooth, or radio frequencies.

Introduction

In the real world, cars can be both a gain and a pain. They are used for transportation and can they have taken humans to places that were unthinkable. On the other hand, they are machines that break down. This break down could be because of mechanical car failure, road car accidents, or new car needing transportation. When one of this instance happens, there is a need for a towing truck, a truck driver, and the available time. Some of the challenges that arises when towing are communication failure in remote or busy locations, time delays from towing companies and truck drivers, and prompted unavailability. The towing process can be very inefficient. Therefore, a solution to increase efficiency is searched for. Although we cannot, nor do we want to, eliminate the towing truck, we could automate this process to make it more effective.

The proposed solution is to create an autonomous towing robots. Their purpose is to autonomously locate and aid cars that need towing. On a large scale, the goal would be to create an automated towing robots network that would aid broken cars as needed depending on the location of the broken car. Is this way, the autonomous towing robot closes to the broken car can readily aid it. On a small scale, the goal is to design and implement a robot and develop communication system in which robots can communicate. The project is divided into two phases: Phase I: Obstacle avoidance, motor control and Phase II: Image processing, communication.

Integrated Systems

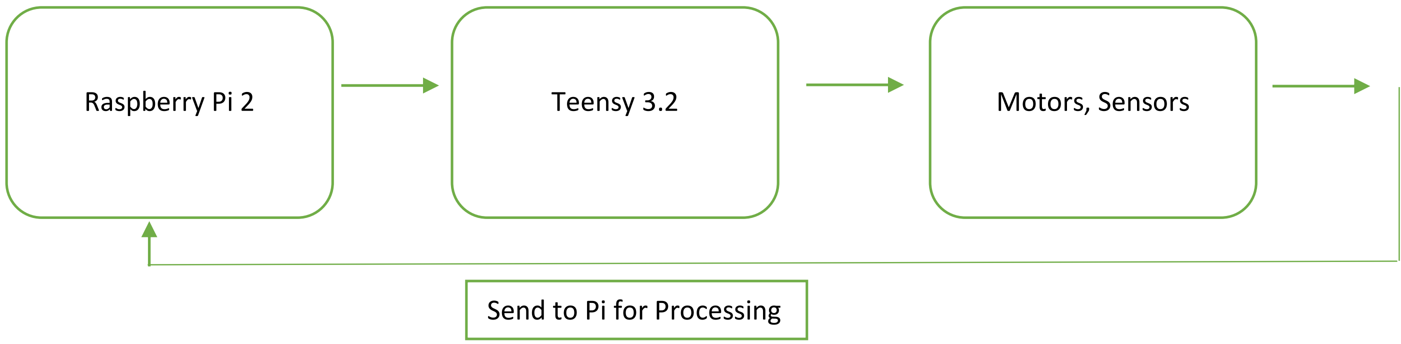
For the project, a Raspberry Pi 2 will be used as the main microprocessor. The Raspberry will be in charge of image processing from the on camera on Robot B. The second camera, the god-camera could be controlled from a laptop or also from a secondary Raspberry Pi 2. When Phase II is implemented, the decision will be made. Also used, will be a Teensy 3.2, this will be in charge of controlling the motors and sensors. Below are the specification of both the Teensy 3.2 and the Raspberry Pi 2, and a rudimentary flow chart of robots basic data flow.

Teensy:

- 32 bit processor at 72 MHz
- 34 I/O pins
- 12 PWM
- 21 ADC
- 256 KB of memory
- 3.3 V logic, supports 5 V logic

Raspberry Pi 2:

- Quad-core processor at 900 MHz
- 40 GPIO pins
- 4 USB ports
- Micro SD card needed



Mobile Platform

Platforms for the project have not been considered in depth. Here are many pre-made platforms only that range from $5-30. To save money, the platform will be designed and fabricated in house based on the parts that need to be hold.

Actuation

As previously described, there will be two independent robots that will be moving autonomously. Because the robot has not been built yet, the robots' weight has been estimated to be approximately 10 lbs. The necessary torque was estimated based on previous year's robots weight. These motors will be used to drive the wheels and carry the weight of the entire robots. Their objective is to move the robots to the desired location effectively without overloading the motors.

TABLE I

Specifications of chosen gear motors

Gear Motor	Nominal Voltage (V)	Free RPM (rpm)	Stall Torque (oz-in)	Stall Current (mA)	Reduction	Dimensions Motor (inches)	Weight Motor (oz)
Micro Metal	6	100	90	1600	298:1	1.42x0.39x0.47	0.35 (10g)
Motor + Encoder	6	110	72	1100	34:1	3.03x0.98x0.65	-

In Table I there are the specification for the motor that were selected. The motors were selected on the following criteria:

- Voltage lower than 6 V
- Available torque from 50-100 oz-in

- Cost effective
- With encoders or encoders compatible
- Stall current no higher than 3000 mA

Because we are going to use a Teensy 3.2 to power and control the chosen motors, there is a need for a motor controller that can supply the necessary voltage and current that the motor demands. In choosing the proper motor controller, the following criteria was adopted and used from *RobotShop.com*:

- Must support motor's nominal voltage
- Must have a continuous current of at least 1000 mA
- Communication: PWM, I^2C, and/or Serial
- Must be a Dual motor driver

TABLE II
Motor Drivers chosen to power and control the motors

Motor Driver	**Continuous Current (mA)**	**Voltage Range (V)**	**Max. Output Current (mA)**	**Built-in Thermal Shutdown**	**Max. PWM Frequency (kHz)**
TB6612FNG	1000	4.5-13.5	3000	YES	100
RP-Spa-368	1200	2.7-15	3200	YES	100

Also ordered were two magnetic encoder pair kit for micro metal gear motors with a 12 CPR, a voltage range of 2.7-18 V, and HPCB compatible. Lastly, two Pololu Wheel 40 x 7 mm Pairs were ordered. With this components the robot will begin taking form.

These motors and motor drivers will be controlled by the Teensy 3.2 and the Raspberry PI 2. The software code for controlling methods have not been yet designed but implementation of encoders readings will be used to achieve the goals project.

Sensors

As previously stated, the project will be divided into two phases: Phase I-Obstacle avoidance, motor control and Phase II- Image processing, communication. With this in mind, only the sensors needed for Phase I have been researched. With this, the following sensors have been purchased from Amazon and are waiting on arrival:

- PlayStation Eye Camera (x2)
- Ultrasonic Module (x10)

The purpose of the cameras are to act as location sensors. One camera will be used as a god-camera that will locate the broken robot and it will send its location to Robot B. There is going to be the need for coordinate transformation between the camera pixel coordinates and the map coordinates. Some of the method to accomplish this that have been used in previous projects are bilinear transformation or homography transfor mation.

Behaviors

As previously discussed the robots' behaviors are below.

- Robot A (Broken-down robot)
  - Able to move and avoid obstacles through an environment
  - Able to send a signal to Robot B (Towing robot) when it needs towing
  - Future: Able to receive a signal from Robot B when it arrives to towing dock
  - Future: Able to follow a path given by the god-camera
- Robot B (Towing robot)
  - Able to identify the position or receive the pixel location from the god-camera of Robot A
  - Able to move and avoid obstacle through an environment
  - Able to 'tow', attached to Robot A in order to tow to desired location
  - Future: Able to find the best path/ route to reach Robot A based on object recognition from the god-camera

Conclusion

As stated before, the goal of the project is to design two autonomous robots with different goals. One with the task of alerting when it was been broken down, and the other with the task to retrieve. Important factors that will need time and energy are imagine processing, coordinate transformation, and latching mechanism. Some of the future work is to implement A Star routing tool to develop an optimized path the towing robot should take based on detected obstacles.

It was previously mentioned that the project is divided into two phases: Phase I: Obstacle avoidance, motor control and Phase II: Image processing, communication. This will allow the project to develop in evolution stages, allowing the projects scope and focus to be narrow down.

Appendix

Projects	**Comments**	**January**	**February**	**March**	**April**
IMDL Robot					
Hardware Research Phase I	Sensors: Visual, Tactile, Movement,	11th -25th			
Budget Analysis	Estimate Cost of Final Robots	22th			
Buy Equipment Phase I	Equipment for Phase I	22th			
Software Implementation Phase I	Obstacle Avoidance, Motor Actuation	25th -	8th		
Hardware Research Phase II	Sensors: Special Sensor, Visual, Networking		1st-8th		
Buy Equipment Phase II	Final Purchase		8th		
Hardware Implementation Phase I	Obstacle Avoidance, Motor Actuation, Body		1st -15th		
Testing I	Obstacle, Motors' Performance		15th-22nd		
Software Implementation Phase II	Visual Recognition, Communication, Path		29th-	14th	
Hardware Implementation Phase I	Effective Components Location			14th -21st	
Testing II	Location of Object, Possible Path Recognition			21st-	11th
Re-assess the course of the project.	Assessment, Objective Met				11th -25th