Robotics Engineering  
Summer Workshop 2016

Design of an Autonomous Robot with the Raspberry PI platform

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Introduction to the Raspberry Pi

The Raspberry Pi is a low cost, credit-card sized computer that plugs into a computer monitor or TV, and uses a standard keyboard and mouse. It does everything a desktop computer does as well as everything a microcontroller (like the popular Arduino) does.

Students will be introduced to the Raspberry Pi platform and its programming environment. They will become familiar with simple LINUX commands, C programming, and simple web scripting with PHP.

Interface the Raspberry Pi with sensors

Students will learn how to interface a camera, GPS and IMU to the Raspberry Pi. They will learn common communication protocols including UART, I2C, and SPI. They will also learn basic bread boarding and component interfacing skills.
Build the Robot Chassis and Interface the Raspberry Pi with Motors

Students will gain hands-on experience with assembling a robot chassis. They will learn how to interface their Raspberry Pis with the robot’s motor controllers to successfully drive the robot.

Build a waypoint guidance system for the robot to autonomously navigate

Students will be introduced to common autonomous navigation algorithms and will implement them on the Raspberry Pi. They will build a web-based front-end allowing them to program GPS waypoints over the internet. They will also learn how to use IMU data in conjunction with GPS data to accurately pinpoint the robot’s position. Advanced students will have the option of using the Open CV library and the Raspberry Pi camera module to perform some obstacle avoidance.
Autonomous Mobile Robotics using Embedded Systems

Summer 2016

Dr. Bridget Benson, Dr. Andrew Danowitz and Professor Jeremy Edmonds

Day 1: Students are introduced to the course and course goals. Lectures include introduction to the Raspberry PI single board computer, the Linux operating system, and programming within the platform. Lab activity will involve hands on experience with the Raspberry PI.

Day 2: Students will learn how to configure a web server on the Raspberry PI and create a web interface using HTML and PHP. Lab activity will include a task involving the transfer of data between a C++ program and a PHP script in the web server.

Day 3: Students will be introduced to hardware interface via SPI, I^2C, UART, and the camera interface. Lab activity will consist of hands on experience retrieving images from the camera module.

Day 4: Students will learn the principles of how IMU’s work, what information IMU sensors provide, and how to properly reference documentation and data-sheets for using them in designs. Lab activity will involve a data-sheet reading scavenger hunt to identify key information needed in interfacing with the IMU.

Day 5: Students will build on their knowledge of hardware interfacing, and learn how to communicate with the IMU sensors that will be used in the class robot. Lab activity will involve writing and configuring code to retrieve sensor data from the actual IMU sensor.

Day 6: Students will learn the principles of how GPS works and what information GPS sensors provide. Lab activity will involve a data-sheet reading scavenger hunt to identify key information needed in interfacing with the GPS.

Day 7: Students will learn how to use their knowledge of hardware interfacing to retrieve data from the GPS sensor. Lab activity will involve writing and configuring code to retrieve sensor data from the actual GPS sensor.

Day 8: Students will be introduced to motors and motor control concepts such as H-Bridge circuits and PWM. Lab activity will involve a data-sheet reading scavenger hunt to identify key information needed in understanding the robot motors, properly wiring the motor drivers to the motors, and how to interface with the motor drive hardware.

Day 9: Students will learn how to use their knowledge of hardware interfacing to communicate with the robot motor controller. Lab activity will involve writing and configuring code to control motor speed and direction for the robot wheels.
Day10: Students will prepare for the physical build of the class robotic platform. Lab safety topics will be discussed, and students will be required to follow lab safety policies going forward. Lab activity will involve hands on experience with soldering, and safely using equipment commonly used in electronics manufacturing and laboratories.

Day11: Students will be introduced to mobile robotic kinematics and feedback control concepts. Students will be split into two lab groups to begin assembly of the robotic platforms used in class.

Day12: Students will be introduced to the robotic concepts of using sensors for perception, and how perception can be used in allowing the robot to make decisions to act on its environment. Students will continue the task of assembling the mobile robotic platforms.

Day13: Students will be introduced to the robotic topics of localization and path planning. Several useful robotic algorithms will be discussed with examples and at a conceptual level. Students will be split into several teams and the class competition task will be revealed. Lab will consist of teams discussing strategy for meeting the task requirement, and teams will delegate responsibilities among themselves.

Day14: Students will work hands-on in teams to develop their solution to the competitive task in a guided lab environment.

Day 15: Students will continue to work hands-on in teams to develop their solution to the competitive task in a guided lab environment.

Day 16:
Students will work hands-on in teams to develop their solution to the competitive task in a guided lab environment. Each team will finalize their solution.

Day 17:
Students will meet for the last time to compete in teams and demonstrate their solution to the autonomous robotic task.
Summer Robotics – Mobile Robotics using the Raspberry Pi

Useful Reference Materials for the beginning of this course:

Documentation for the single board computer -

Information page for the IMU used in this course -
https://www.adafruit.com/product/2472

Information page for the GPS module used in this course -
https://www.adafruit.com/products/746

A reference manual for GPS NMEA formatted data -

Some good reading on calculating distance, heading, and more between two GPS coordinates -
http://www.movable-type.co.uk/scripts/latlong.html

Easy reference for the Google Maps API -
http://www.w3schools.com/googleapi/default.asp

Easy tutorial for PHP, a programming language used in this course -
http://www.w3schools.com/php/default.asp

Helpful topics for later in the course:

A nice introduction to differential drive kinematics -

An easy to understand introduction to Kalman Filters -

A nice video demonstrating particle filters -
https://www.youtube.com/watch?v=H0G1v5lM5rc

Some reading on a popular path planning algorithm -
https://en.wikipedia.org/wiki/A*_search_algorithm

OpenCV computer vision tutorials - https://opencv-python-tutorials.readthedocs.io