FAMU/FSU College of Engineering

Department of Electrical and Computer Engineering

Updated Design Report

Team 315

Control Module/Interface for Service Robots

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Date: 3/23/22

Introduction

Team 315 will design a control module for a motorized system. This system will follow a user as they move around in a safe manner. This control module will also provide the user with a smooth transfer between semi-autonomous mode and manual mode. The requirements are the following: design a control module, integrates into a pre-built existing robot, dynamic and allow usage with multiple robots, detect obstacles, interact with different types of cameras, follow user via mobile app, powered by battery

Selected Concept

Camera: Digital camera - Intel® RealSense™ Depth Camera SR300

> The camera will receive power from the lead acid battery, and send its data to the control module for processing

Control module platform: Intel NUC 7 Business Computer

> Receives data from the camera and smartphone app, will use this data for pathfinding and object avoidance algorithms

Power Supply: Lead Acid Battery – 2 12V Deep Charge Cycle Batteries

> Delivers power to all components except the smartphone

Display: Smartphone - User's smart phone

> Control module will pass on necessary messages to the user through the smartphone

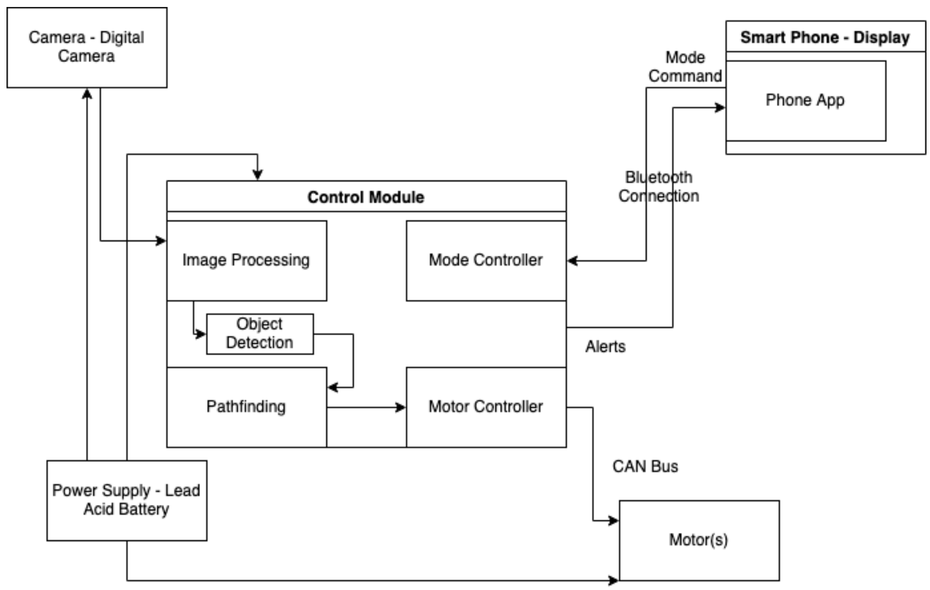
User Interface: Smartphone application

> Users can change between semi-autonomous and manual mode, as well as view messages from the control module.

Connectivity: Bluetooth

> This will be the communication method between the control module and smartphone as well as the means of finding/tracking the user

Design Concept



Service Robot Block Diagram

Camera – Digital Camera

The camera will capture images of its environment and transfer this information to the control module for processing.

Module	Input/Output
Power Supply	Input
Control Module	Output

Power Supply – Lead Acid Battery

The power supply will utilize a lead acid battery that is rechargeable. This will power all components of the design.

Module	Input/Output
Camera	Output
Control Module	Output
Motors	Output

Smart Phone – Display

The display will show the user the mobile application so they can see any alerts coming from the control module and the available modes and status of the service robot.

Module	**Input/Output**
Control Module	Input
Mode Controller	Output

Motor(s)

The motors will move the robot.

Module	**Input/Output**
Power Supply	Input
Motor Controller	Input

Control Module

The module will process the images coming from the camera to detect objects and determine the path to continue following the user unless it receives different input from the mobile app. The module will then drive the motors in the appropriate path.

Module	**Input/Output**
Power Supply	Input
Phone App	Output

i. Image Processing

Based on the input received from the camera, this module will use an algorithm (possibly YOLO) to distinguish objects from people.

Module	**Input/Output**
Camera	Input
Object Detection	Output

ii. Object Detection

Utilizing the input received from image processing, the object detection module will develop a route to avoid obstacles (i.e., people, shelves).

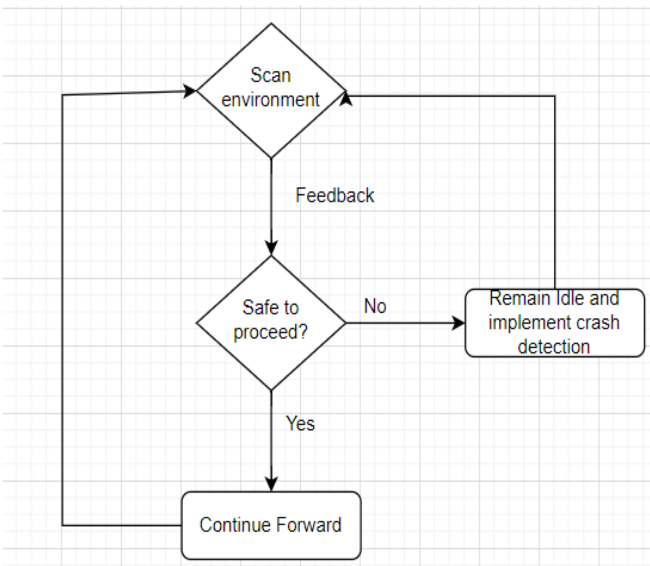
Module	**Input/Output**
Image Processing	Input
Pathfinding	Output

iii. Pathfinding

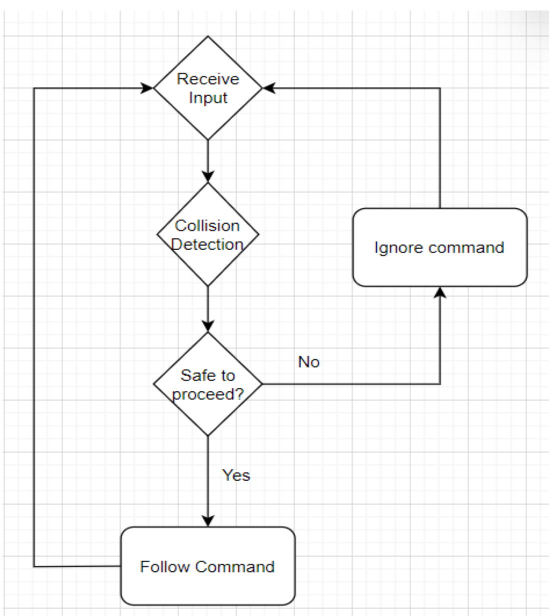
For this module, we use a flow chart to describe how we intend for the robot to move in its environment and what to do in the event there is an obstacle in its course.

Module	Input/Output
Object Detection	Input
Motor Controller	Output

Semi-Autonomous Mode



Manual Mode



iv. Mode Controller

This component sends the mode selected by the user from the mobile application to the control module.

Module	**Input/Output**
Phone App	Input
Motor Controller	Output

v. Motor Controller

The motor controller will drive the motors so they can move at the appropriate speed and direction on the path.

Module	**Input/Output**
Pathfinding	Input
Motor(s)	Output

Functional Decomposition

There have been no additional changes to the functional decomposition.

Codes and Standards

Codes

Ensure power components are turned off before connecting devices to them

Workspace is clear of items to ensure no one operating on robot trips or falls

Emergency stop implementation within code to not run into an object or person

Components and battery are disconnected when not in use and when no one is inside the lab facility.

Ensure product is charged overnight

Standards

Universal Serial Bus (Peripheral standard AKA USB) – The camera connects to the control module via USB connection. The control module connects to the NUC through a USB connection. The NUC has 3 USB 3.0 and 2 USB 2.0 inputs. These will be used to send data from the camera to the pathfinding algorithm.

IEEE 802.15.1 (Bluetooth standard) – The user’s smart phone connects to the control module via Bluetooth connection. This is used to directly connect to the user’s phone rather than establishing a connection to a router. Furthermore, the control module does not produce its own Wi-Fi signal. This standard ensures that the short-range radio frequency-based connections between the user's phone and the control module are implemented between a 2.4 and 2.485 GHz frequency.

Controller Area Network (CAN) Bus 2.0B (Communication standard) – CAN Bus was selected because RNET is a protocol based on CAN Bus that many wheelchairs use to have their joysticks communicate with the motors. Since our control module will be emulating the movements of a joystick and our wheelchair's communication system is based on CAN Bus, the CAN Bus standard must be implemented in our design to allow it to send joystick directions to the wheelchair. This is a communication protocol that allows devices to transmit data to each other across a single communication bus. This communication bus is incorporated in the design using an Arduino Mega with a CAN Transceiver attached. The CAN Transceiver handles the data that the control module and motorized system will send to each other. The control module can send CAN messages to the Arduino and send it across the bus. The motorized system will also send CAN messages to the bus, where the control module will receive the messages that the Arduino receives.

Serial Communication Standard – The control module communicates with the Arduino using this standard. Serial communication is used to transfer bytes of data across the serial port on the Arduino Mega to the USB port on the control module so the data can be communicated. The control module currently sends the joystick direction as X and Y coordinates in binary across the serial port to the Arduino. The Arduino can then use these values to send to the motorized system for controlling its direction. The Arduino sends back the received X and Y coordinates in binary to the control module to test correct operation of serial communication on the serial port.

X-Latching-Resilient 5 (Electrical Connection standard AKA XLR5) – Ensures steady delivery of DC power to charge the wheelchair. The wheelchair charges from a connection under one of the arm rests. We purchased an XLR connector head to be able to charge the wheelchair rather than the batteries directly.

Public Safety and Other Factors

A vital safety component of our design is safety for the user and the people around them. This involves implementing an emergency stop on our robot if necessary to not hit any person or run into an object which could potentially be knocked over into someone. All wiring will be secured to the chassis or covered to ensure they do not detach and become an electrical hazard. The response time of the robot will be under half a second so that our robot does not hit anyone while trying to process data and moving. The service robot control modules implementation will not cause any problems with any global, cultural, or social factors. The control modules materials are few and materials are obtained through legal avenues and does not present any harm to the environment. The control module will befit the economy by presenting a new product for multiple applications (stores, golf courses, hospitals, warehouses, etc.).

Summary

The sensor that was chosen from the concept selection was the digital camera which only requires power as an input and outputs a constant data steam of images to the microprocessor in the module. The Intel® RealSense™ Depth Camera D415 was chosen for this as they are already available to us from the school. The microprocessor chosen to be made responsible for image processing, pathfinding, and motor control was the Intel NUC 7 Business Kit. The Intel NUC 7 was provided by the department and provides more than enough power for all components connected. The NUC requires four inputs: power from the battery, image data from the camera, user application data received by the Bluetooth module (mode controller input), and motor encoder data so the NUC knows what the motors are doing.

The other modules are less complex and mostly exist so the system can operate. For example, the power supply block was chosen to be a lead acid battery because they are rechargeable and can provide enough power to the system for extended periods of time. The mode controller block is just a Bluetooth receiver that connects to the user's phone using a Bluetooth connection through an application that receives input data and sends it to the NUC to be processed. Then the motors are connected to the NUC using the CAN Bus communication method, which the type of motors depend on the customer. Finally, the application will be downloaded onto the user's phone and is the method for connecting to the module and providing input data to control the mode of operation for the module.