Preliminary Detailed Design

Project: Robotics & IMU

Team number: 307

Introduction

The Charles Stark Draper Laboratory, Inc otherwise known as Draper is interested in the field of autonomously navigating unmodified human environments. The main objective for this project is to build a robot that will get from start to finish, without any collisions, where it will scan a QR code. A couple of assumptions made include the following: the operating space will be unmodified, and the robot will not have to climb steps. The identified engineering requirements are the following: the robot will autonomously navigate an office environment without bumping into objects and people. In doing so, it will not receive GPS input, meaning it cannot receive location data from external resources. It will scan a QR code that is at an unknown location. As it travels it will limit its speed to average human walking pace which was found to be around 2.5 to 4 miles per hour. It will navigate multiple terrains, meaning typical office floors such as tile, carpet, and wood. It will fit in a 2 ft^3 space and will weigh around 20 pounds. Lastly, it will have an easily accessible cut-off switch.

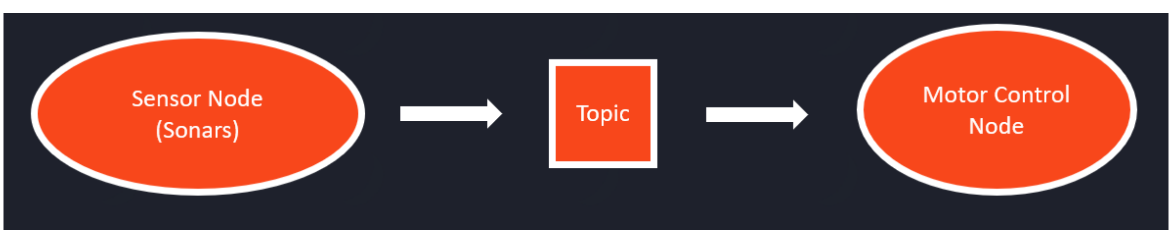
Preliminary Design

To meet our final goal, we broke the project down into smaller milestones.

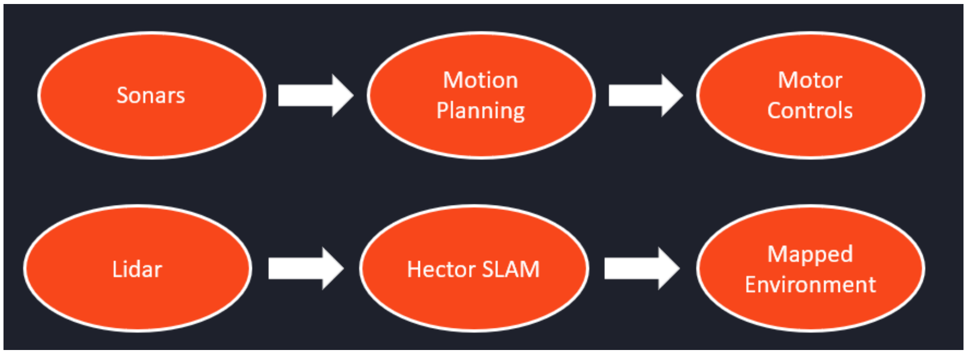
1. Have a robot that can move forward and stop if it detects obstacle in front of it.
2. Use a wall following algorithm that will traverse and map the environment without any obstacles.
3. Scanning a QR code.
4. The same as number 2, but it now includes obstacles.
5. By this step the robot will be able to autonomously navigate from point a to point b while avoiding obstacles and can scan QR code.

Shown below are the block diagrams for each of these milestones. The concept of node and topics relates to how ROS accomplishes communication. Nodes are executables that can send and receive messages to topics, messages contain the data that the executable needs to share.

1



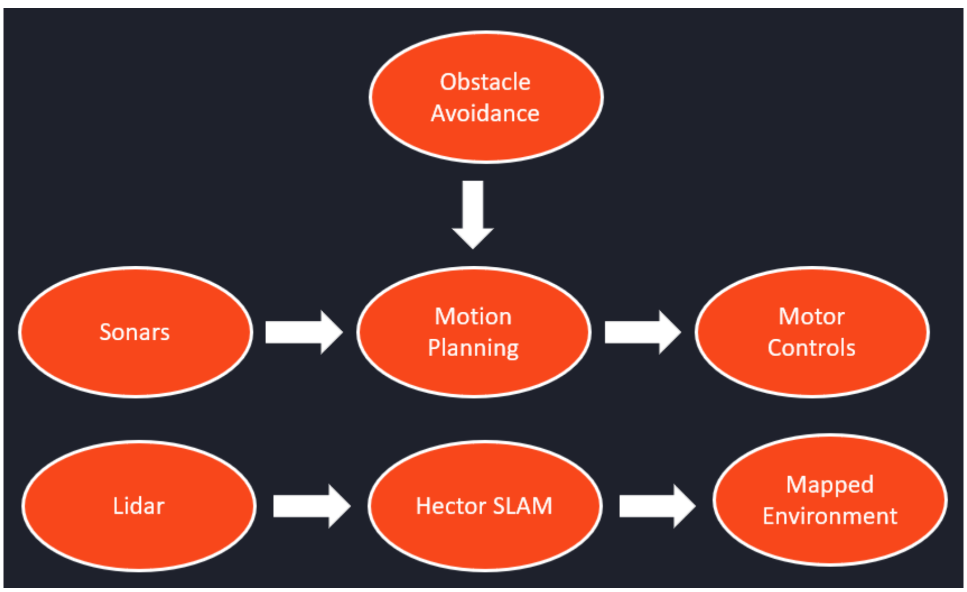
2


Sonars
Motion Planning
Motor Controls
Lidar
Hector SLAM
Mapped Environment

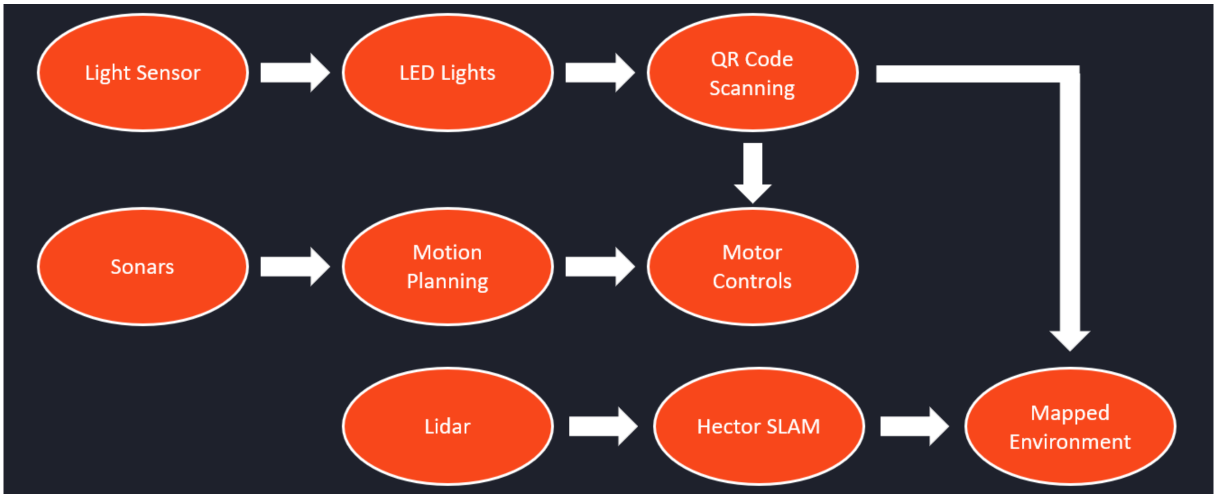
3


Light Sensor
LED Lights
QR Code Scanning

4


Obstacle Avoidance
Sonars
Motion Planning
Motor Controls
Lidar
Hector SLAM
Mapped Environment

5



Components

- Power: NiMH 12V Battery

- Reasoning Hardware: Raspberry Pi 4, Arduino Mega 2560

-Software: Robot Operating System (ROS), Arduino IDE

- Sensor Suite:

    - Slamtec RPLIDAR A1M8

    - Ultrasonic Sensor HC-SR04

    - Raspberry Pi Camera Module V2

    - IMU MPU-6050

    - LM393 Light Sensor

- Locomotion: Strafer™ Chassis Kit V5

    -Mecanum Wheels

    -Brushed DC Motors

- Frame: Plastic

- Enabling/Disabling: Momentary Push Button Switch

Codes and Standards

- (IEC 60825-1:2014) standard
- Universal Serial Bus (USB)
- IEEE 802.11

- XT30
- CSA C22.2 No. 127
- IPC-2221A
- AWG
- ISO 2400:2012
- IPC-2222 (Power distribution board)
- 96/216533 DC (Sealed nickel-metal hydride)
  UL 8750
- RIA TR R15.606-2016 (“TR 606”), Collaborative Robot Safety.

Public Health and other Factors

- We are implementing an obstacle avoidance algorithm, meaning we are avoiding hitting people or objects.
- We chose NiMH batteries over Lipo batteries because Lipo batteries can overcharge, over-discharge, over-temperature, short circuit, crush and nail penetration can all result in thermal run away and catastrophic failure leading to explosion and fire. So, we wanted to take into consideration the safety of the public. (96/216533 DC)
- We chose to stick to lower voltage to avoid getting injured while working with the robot’s components.
- We chose the Raspberry pi SBC because of its high performance-per-watt which is more energy efficient than competing solutions.
- We chose LED lights for low light conditions because of their highly energy-efficient lighting technology, Improved Environmental Performance, No Heat or UV Emissions and Low Voltage Operation. (UL 8750)
- We chose to use the Rplidar A1M8 because LiDAR products are manufactured following the Class 1 eye-safe, which ensures eye safety.
- We chose to use HC-SR04 because there are no known instances of harm or adverse sensation caused by imaging sonar. (ISO 2400:2012)
- We chose the XT30 connector type because it is a very firm connection between the plug and the female, safe and reliable to use. (XT30)
- We used USB for communication between devices. (USB)
- We used WLAN for headless communication with the raspberry pi. (IEEE 802.11)
- We chose the light sensor because it is safe to operate continuously.
- We used a PCB board because it is more reliable than using basic jumper wires, this will ensure that all of the safety procedures mentioned above. (IPC-2222 and IPC-2221A)
- In the creation of the robot, we are following proper working conditions and standards. (RIA TR R15.406-2014 and RIA TR R15.606-2016)
- We used AWG-16 to ensure safer transfer of voltage, due to the amount of voltage we are delivering. (AWG)
- We used bullet wires for connection between the motors and motor controllers to ensure that all of the safety procedures mentioned above. (CSA C22.2 No. 127)

- We used a power distribution board because it would safely distribute voltage to multiple components without using a manually created parallel circuit with tape. (IPC-2222 and IPC-2221A)