Comprehensive Design Review

Team 16
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Mapper

Kelvin Nguyen  
ME

Marcus Le  
EE

Bryan Martel  
CSE

Derek Sun  
CSE

Department of Electrical and Computer Engineering  
Advisor: Professor Ganz
Background and Motivation

- In 2017, homeowners found their new houses through:
  - Internet - 51%
  - Real Estate Agents - 30%
  - Yard/Open House signs - 7%
  - Other - 12%

Goal

- Provide homeowners or real estate agents with the ability to post an updated model of the interior of their house
- Potential integration with virtual reality tours
  - Similar to an open house
  - Cater toward the younger, more technologically adept generation that will inevitably dominate the future real estate market
Method of Resolution

- A robot that utilizes LIDAR sensors to remotely navigate around the surrounding environment and produce a 3D layout of an indoor area
- A camera mounted on the robot will allow for live video feed to assist in user navigation
Requirements Analysis: Specifications

- Speed of up to 3mph
- Effective detection range of 15ft
- Approximately 12 pounds
- Approximately 2 hours of battery life
- Durable enough to withstand minor collisions
Requirements Analysis: Inputs and Outputs

- **Input**
  - LIDAR sensor data
  - Inertial measurement unit data
  - Camera data
  - User navigation control

- **Output**
  - Live video feed
  - Map data
System Overview

![Diagram showing the system overview with various components connected.]

- Computer
- ESP Development Board
- L298N H-Bridge
- Roomba Wheels
- Camera
- Micro Maestro Servos Controller
- HS-422 Servos
- RP LIDAR A2 + IMU
Proposed CDR Deliverables and Responsibilities

- 3D SLAM
  - Simultaneous LIDAR and IMU data input
  - Pan & tilt calibration and integration
- Functional robot
  - Mount motors to our custom robot
  - Integrate custom PCB
- Wi-Fi connectivity between robot and PC
  - Able to send navigation input to robot through Wi-Fi

Responsibilities
- Kelvin (ME)
  - Ensure functional robot, mount SLAM components, pan & tilt system
- Marcus (EE)
  - Create PCB, ensure functional robot, pan & tilt system, Wi-Fi data transfer
- Derek (CSE) & Bryan (CSE)
  - Programming 2D SLAM → 3D SLAM, Wi-Fi data transfer
Design Changes

Custom Arduino PCB → H-Bridge PCB

- Originally, Arduino PCB would handle Wi-Fi signals from the ESP8266 and send signals to the H-bridge accordingly
- It turns out that the ESP8266 has a development board that can do this exact thing
  - Eliminates the need for an Arduino
  - Creates a more compact design by reducing redundant and unnecessary hardware

Will now use a custom PCB as an H-Bridge to control signals sent to motor
Actual CDR Deliverables and Responsibilities

- **3D SLAM**
  - Simultaneous LIDAR and IMU data input
  - Pan & tilt calibration and integration

- **Functional robot**
  - Mount motors to our custom robot

- **Wi-Fi connectivity between robot and PC**
  - Able to send navigation input to robot through Wi-Fi

**Responsibilities**

- Kelvin (ME)
  - Ensure functional robot, mount SLAM components, pan & tilt system

- Marcus (EE)
  - Create PCB, ensure functional robot, pan & tilt system, Wi-Fi data transfer

- Derek (CSE) & Bryan (CSE)
  - Programming 2D SLAM → 3D SLAM, Wi-Fi data transfer
CDR Deliverable (Robot)

- Chassis
  - Contains motors, circuit and battery to navigate Mapper
- 3D mounts
  - Servos mount custom-made to house servos motor
  - LIDAR mount custom-made to house IMU and LIDAR
- Lid
  - Servos system with 3D mounts installed on top
  - Holds LIDAR in place
Block Diagram

Mapper

Camera

Power Supply

Power

LIDAR System

Maestro Controller

Servos

IMU

LIDAR Sensor

ESP8266 Dev Board

Microcontroller

Wi-Fi module

Navigation

PCB

Motors

External Laptop

Display

Layout view

SLAM Algorithm

Sensor data

Communication Application

Sensor data

Video feed

Sensor readings

Direction input

Controls

Powers

Powers

Powers

Controls

Powers

Video feed

Camera

Microcontroller

Wi-Fi module

PCB

Motors

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Powers

Powers

Powers
CDR Deliverable (Wi-Fi Connectivity)

- Configure a network
- ESP chip, auto connects to the network on startup
- Computer connects to the same network
- PC Application can then communicate through the network to ESP8266
- Able to send robot movement controls through PC application to ESP8266
- Accepts WASD keyboard input
  - W = Forwards
  - A = Rotate left
  - S = Backwards
  - D = Rotate right
CDR Deliverable (Wi-Fi Connectivity)

- On startup the ESP8266 searches for the network pre configured within the RC_Mapper file and establishes a connection.
- PC client sends UDP messages to the IP defined in the UI through port 4320.
- Robot movement speeds can be changed using the drive and turn speed parameters.
CDR Deliverable (Wi-Fi Connectivity)

- Wi-Fi connectivity between robot and PC
- Able to send navigation input to robot through Wi-Fi

Next steps:
- Send LIDAR and IMU data through ESP8266 development board to PC
- Transition from Arduino libraries to C
Block Diagram

Mapper

Camera

Power Supply

Powers

Powers

Internals

ESP8266 Dev Board

Microcontroller

Wi-Fi module

Navigation

PCB

Motors

Controls

Controls

Sensor readings

Communications

Video feed

Direction input

Power Supply

LIDAR System

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Video feed

Video feed
CDR Deliverable (3D SLAM)

RPLIDAR A2 → rplidar ROS package
- read RPLIDAR raw scan result using RPLIDAR's SDK
- convert to ROS /scan messages
- record /scan messages to a rosbag

SparkFun 9DoF Razor IMU → razor_imu_9dof ROS package
- read IMU sensor data
- convert to ROS /imu messages
- record /imu messages to a rosbag
CDR Deliverable (3D SLAM)

ROS /scan and /imu messages → Google Cartographer node
- node processes data with Cartographer SLAM algorithm
- scan matching and IMU data to generate local submaps
- local submaps merged to global map
- 2D SLAM while gathering points in all directions for 3D map

Output
- Rviz
  - Live point cloud
  - Local and global map
- Meshlab
  - Full point cloud
  - Generated mesh
CDR Deliverable (3D SLAM)

Open Source
- Cartographer libraries
- ROS packages/nodes
- RPLIDAR A2 SDK

Our contributions
- LIDAR ROS integration
- IMU calibration and ROS integration
- LIDAR and IMU compatibility with ROS Cartographer package
- ROS configurations
Demo
What we plan to bring to FPR

Mapper completed

- Wireless maneuverability of robot
  - User controls sent through Wi-Fi to Mapper
  - LIDAR and IMU sensor data relayed back to PC
  - Camera feed sent back to PC
- 3D SLAM
  - 2D map generated and viewable in Rviz
  - Point cloud viewable in Meshlab
  - Mesh generated from point cloud
- Component integration
  - Functional PCB integrated into Mapper
  - All hardware and circuitry fits neatly in Mapper
What we plan to bring to Demo Day

- Completed Mapper on display
- Video that shows Mapper fabricating 3D model of a room
  - Perspective of robot
  - Current map that is being created
  - Marker that shows where the robot is relative to the room
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Department of Electrical and Computer Engineering
Questions?