SAR (Search and Rescue Robot)

Team E2 - Keshav Sangam, Jai Madisetty, Raymond Xiao

Motivation

No autonomous robots in SAR field with sensors specifically designed for fire/smoke

Firefighters can deploy these robots to assist with dangerous situations

Robots can scout ahead and provide valuable real time information

Use Case/Our Robot

- Robot that can accurately detect human presence in a smoke-filled room
    - Running under the assumption that humans always have their phones on them/nearby
- Robot can quickly navigate unexplored rooms and relay human presence to third party in real time
- Facilitates searching empty rooms/floors

ECE Areas:

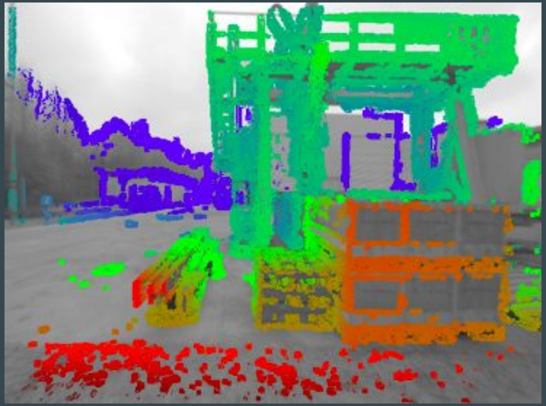
- Software (Planning and movement algorithms)
- Signals (Integrating sensor data from LIDAR, radar, Bluetooth, etc)
- Hardware (Robot itself)

Use Case Requirements

- Completely autonomous robot under varying environment
  - SLAM + Path Planning
- Process LIDAR/mmWave data at speeds higher than 20Hz
- Be able to reach Bluetooth beacon per room in under 45 seconds
- 100% Bluetooth localization accuracy

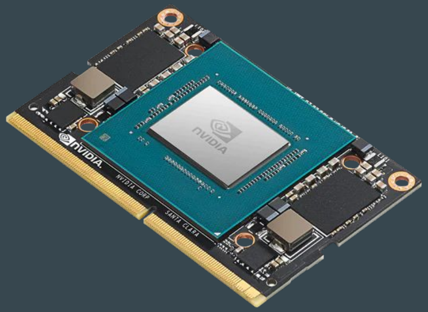
Technical Challenges

- Developing a SLAM technique that is robust to airborne particulates
  - mmWave techniques provide low-density point-cloud data.
  - LIDAR provides high-density point-cloud data
  - RGB-D comparable to LIDAR
- Testing path planning algorithms for movement around an enclosed environment
  - A* vs. Djikstra
- Accurate target localization
  - Bluetooth based localization



Solution Approach - Robotics System

- Robotics Platform
  - iRobot base
- Processor for compute
  - Nvidia Jetson Xavier
- Interface
  - UART between Xavier and iRobot, mmWave, and LIDAR
- Power
  - Xavier - Portable battery pack

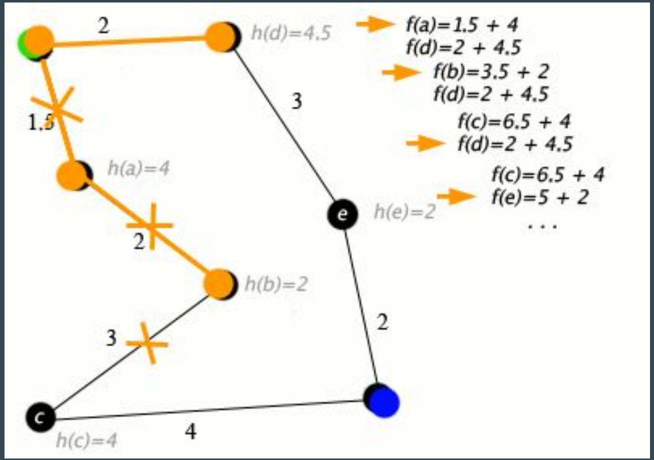


Solution Approach - Sensors

- Sensors and Data Acquisition
  - mmWave radar board
    - TI AWR1443BOOST
  - LIDAR sensor
    - Slamtec RPLIDAR
  - Potential additional sensors:
    - IMU
    - Odometer
- Bluetooth Beacon

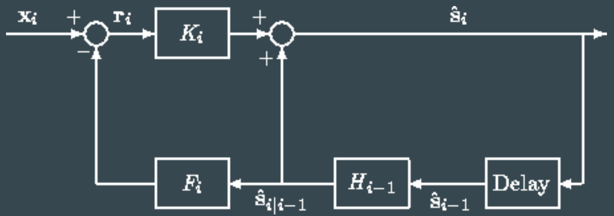
Solution Approach - Software

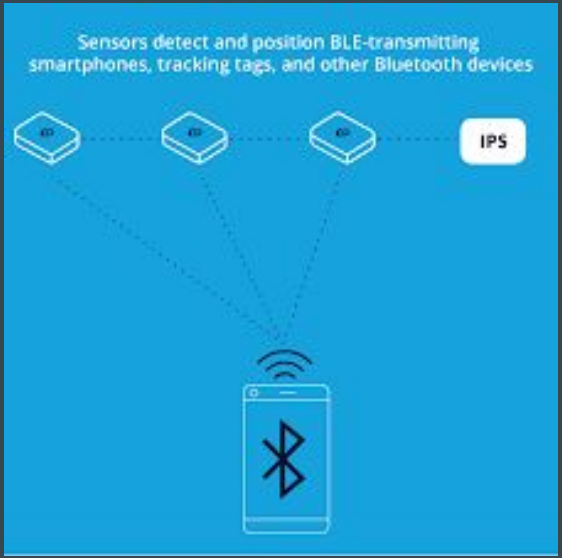
- Software Platform
  - ROS for SLAM, path planning, and controls
- Path Planning
  - A* algorithm
  - Heuristic determined via bluetooth signals



Solution Approach - Signals

- Sensor Filtering
  - milliMap: https://arxiv.org/pdf/1911.00398.pdf
  - Extended Kalman Filtering
- Bluetooth Localization
  - Use existing BLE beacon technologies to provide off-the-shelf localization.





Testing & Verification

Requirements	Testing	Metrics
Autonomously navigate and plan path through environment	Record time it takes for robot to visit each room	One room per 60 seconds
Lightweight and portable	Weigh robot on scale	Weight is less than 15 pounds
SLAM accuracy under varying conditions	Test robot's ability to map an environment under fog	Compare ground-truth LIDAR map to experimental map found with mmWave
Minimize false endpoint detection	Place varying number of BLE beacons in environment	100% accuracy in counting true number of beacons
Battery life	Exhaust robot resources	Able to visit every room on battery power

Tasks and Division of Labor

Team Member	Specialization	Tasks
Keshav Sangam	Signals	LIDAR and mmWave interfacing, bluetooth localization, Kalman filtering, SLAM
Jai Madisetty	Software	SLAM, A* path planning, learning ROS, learning CUDA
Raymond Xiao	Hardware	Programming Roomba, interfacing with Jetson Xavier, learning ROS

Gantt Chart

Teammates:
- Keshav Sangam
- Jai Madisetty
- Raymond Xiao
- Everyone

January: 18, 21, 24, 27, 30 | February: 2, 5, 8, 11, 14, 17, 20, 23, 26 | March: 1, 4, 7, 10, 13, 16, 19, 22, 25, 28 | April: 3, 6, 9, 12, 15, 18, 21, 24

	Tasks	Start	End	Team Member	Status
Part 1	**Proposal and Planning**				
	Brainstorm different projects	1/18	1/25	Everyone	Done
	Project abstract	1/26	1/26	Everyone	Done
	Proposal presentation	2/7	2/9	Everyone	Done
	Finalize parts required	2/5		Everyone	In progress
	Brainstorm algorithms/implementation	2/5		Everyone	In progress
Part 2	**Implementation and Design**				
	Milestone 1: Proof of concept				
	Order necessary components			Everyone	In progress
	Planning and movement algorithms			Jai Madisetty	
	Interfacing with all sensors			Keshav Sangam	
	Learn to program ROS			Raymond Xiao	
	Benchmark algorithm performance			Everyone	
	Milestone 2: Integration				
	Implement basic SLAM			Keshav Sangam	
	Receive data from mmWave			Keshav Sangam	
	Receive data from LIDAR			Keshav Sangam	
	Integrate components with ROS			Raymond Xiao	
	Interface with Jetson Xavier			Raymond Xiao	
	Set up testing environment			Everyone	
	Improve SW algorithms			Jai Madisetty	
	Milestone 3: Final Design				
	Finalize path planning			Everyone	
	Systems integration check			Everyone	
Part 3	**Verification and Optimization**				
	Rigorous testing in different scenarios			Everyone	
	Tweak design parameters (accuracy, speed, etc.)			Everyone	
	Test/improve robot's battery life			Everyone	
	Test/improve robot's speed			Everyone	
Part 4	**Finalize and Present**				
	Record video explaining project			Everyone	
	Edit and finish video			Everyone	
	Final presentation			Everyone	