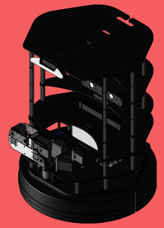
SAR

Team E2 - Keshav Sangam, Jai Madisetty, Raymond Xiao

Motivation

A building is on fire, and the firefighters need to find where humans are. How is it possible to find humans without going in yourself?



Use Case

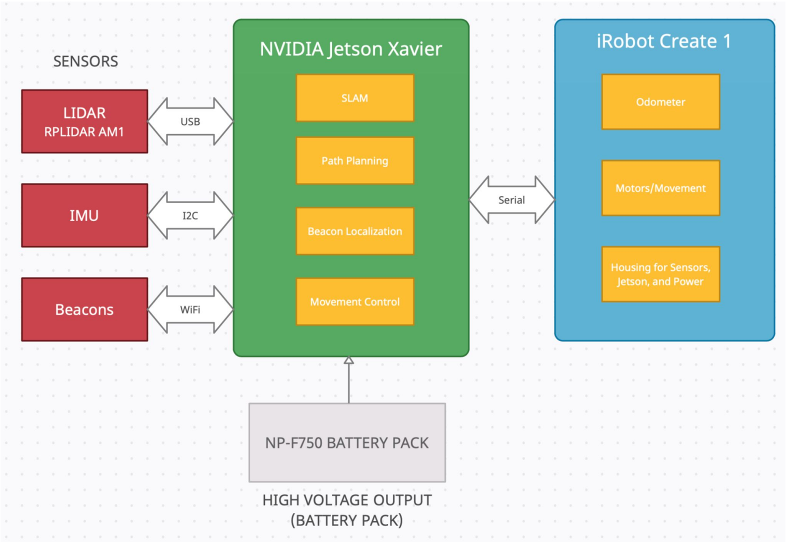
Enter SAR: Search and () Robot. An autonomous way of traversing a building and finding rooms where humans are likely to be.

Use-case Requirements

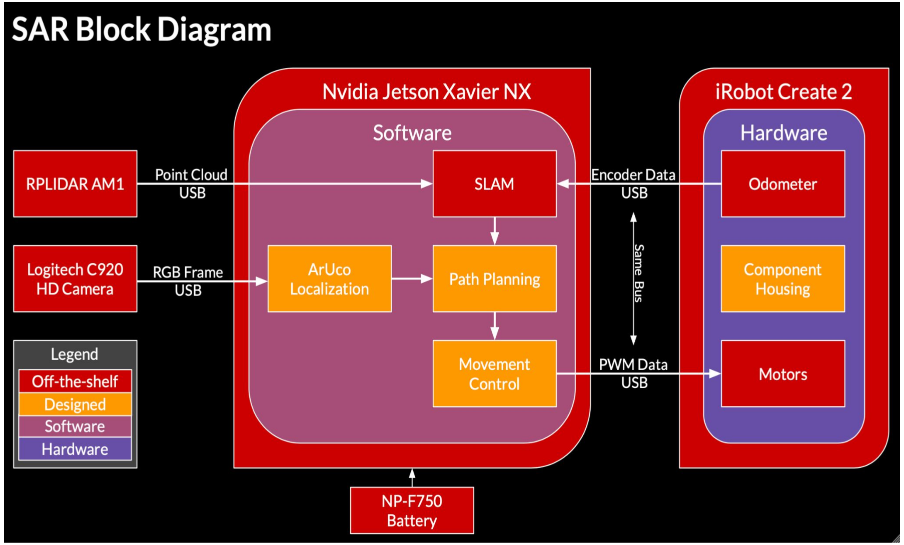
- 100% autonomous operation
  - Should be able to navigate unknown environments without entering an infinite loop
- Locate ArUco tags with 0% false negative
- Detect all tags in an obstacle-filled room within 60 seconds
- Entire system's weight must not exceed 15lbs
- Battery life of system must exceed at least 15 minutes

Solution Block Diagram (Original vs Updated)

Original

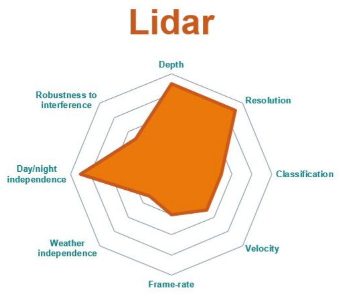


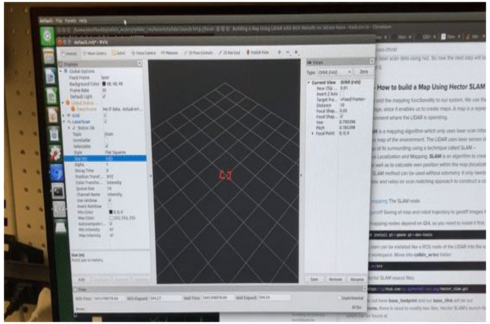
Updated

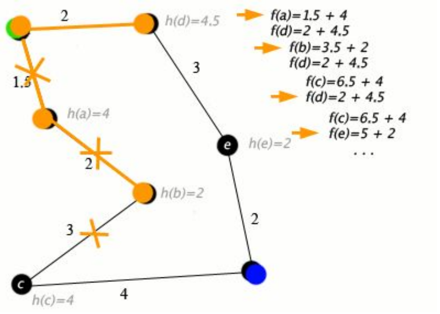


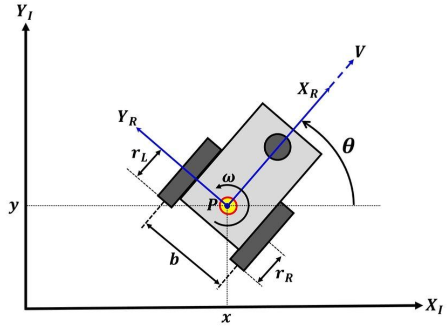
Solution Approach (Updated)

- Sensors
  - LIDAR sensor
    - Slamtec RPLIDAR-A1
  - Webcam
    - Logitech C920 HD Camera
  - Odometer
    - iRobot Create 2
- Software - ROS
  - Path Planning
    - A* algorithm
    - Use the arUco tags as human analogues
  - SLAM
    - GMapping (with odometry)



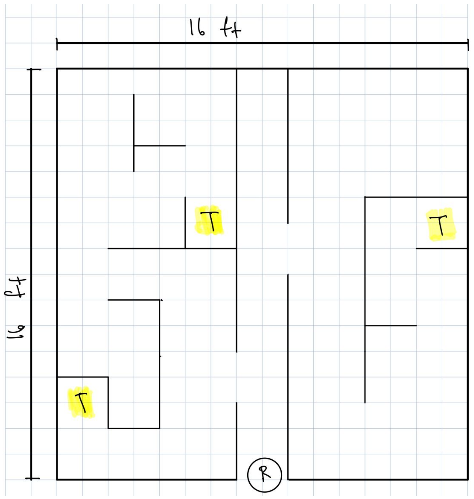


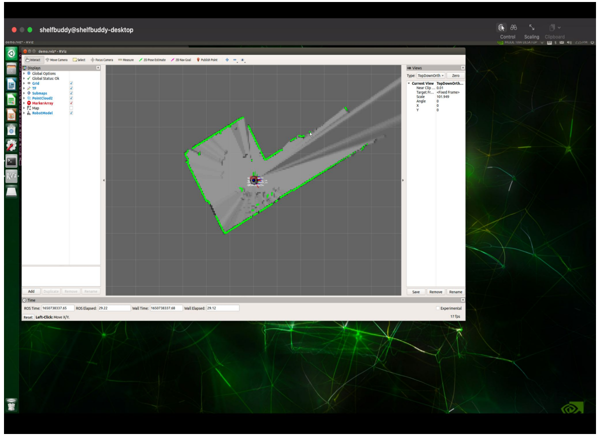




Complete Solution

- Simulate hallway in 16 ft x 16 ft area using cardboard
- Maze-like layout within rooms
- Demonstrate mapping and place location of arUco tags on map





Testing & Verification/Validation (Original)

Requirements	Testing	Metrics
Autonomously map environment	View SLAM data in a set of environments	Subjective comparison between true and mapped environment
Autonomously navigate through environment	Let the robot explore a set of environments	<2% chance of robot getting stuck
Lightweight and portable	Weigh robot on scale	Weigh less than 15 pounds
Minimize false endpoint detection	Place varying number of beacons in environment	5% error in localizing the true amount of beacons
Battery life	Exhaust robot resources	Able to visit every room on battery power
Ensure odometry	Move the robot through a path that ends in a specified location	<1m offset between true endpoint and localized endpoint

Testing & Verification/Validation (Updated)

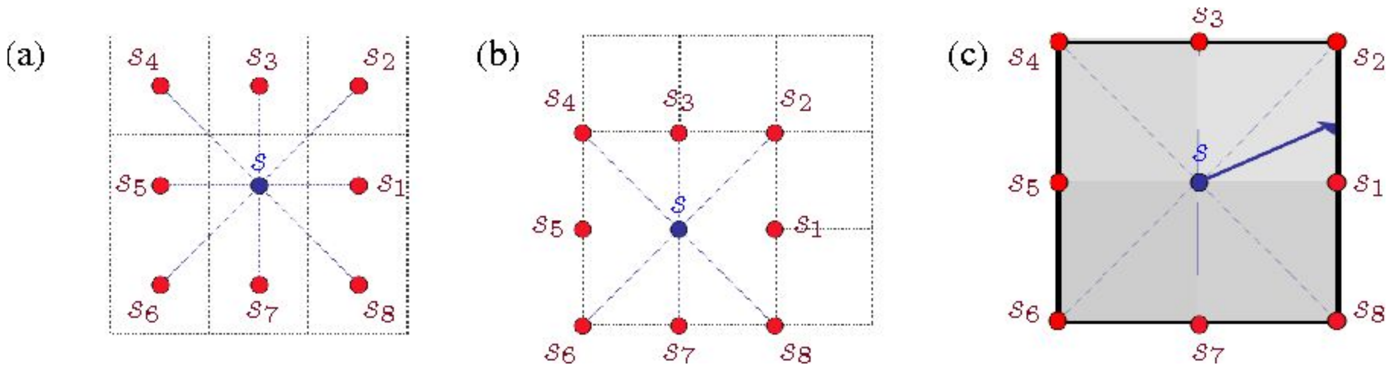
Requirements	Testing	Metrics
Autonomously map environment	View SLAM data in a set of environments	Subjective comparison between true and mapped environment
Autonomously navigate through environment	Let the robot explore a set of environments	0% chance of robot getting stuck
Lightweight and portable	Weigh robot on scale	Weigh less than 15 pounds
ArUco marker detection	Place ArUco markers in environment	Detects 100% of markers
Battery life	Exhaust robot resources	Explore 3+ rooms on battery power
Ensure odometry	Move the robot through a path that ends in a specified location	< 1m offset between true endpoint and localized endpoint

Subunit Testing/Use-case requirements

Subunit / Use-case	Test	Passing Value/Result	Actual Value/Result
Logitech C920 HD Camera	Ensure that camera is able to detect multiple ArUCo markers	Correctly identify whether 0, 1, or more markers in image	Correctly identifies
NP-F750 Battery	Battery lasts long enough for system to explore 3+ rooms	N/A	N/A
RPLIDAR A1	Ensure that LIDAR is accurate	Qualitatively compare visualization with actual environment	Visualizations are relatively accurate
Overall weight	Weigh entire system	Less than 15 pounds	14.1 pounds
SLAM	Qualitatively measure performance	Visibly decent mapping of surrounding environment	Creates map of environment when non-autonomous
System can navigate environments quickly	Time system in testing environment	7 minutes to fully navigate	N/A
System is robust to different environments	Place system in new environments	Marks all tags on created map of environment	N/A

Design Tradeoffs

- iRobot Create 1 or iRobot Create 2
- Odometry vs. no odometry
- Full autonomy vs. driver control
- A* vs D* Lite



Original

	Tasks	Start	End	Team Member
Part 1	**Proposal and Planning**			
	Brainstorm different projects	1/18	1/25	Everyone
	Project abstract	1/26	1/26	Everyone
	Proposal presentation	2/7	2/9	Everyone
	Finalize parts required	2/5		Everyone
	Brainstorm algorithms/implementation	2/5		Everyone
Part 2	**Implementation and Design**			
	Milestone 1: Proof of concept			
	Order necessary components			Everyone
	Planning and movement algorithms			Jai Madisetty
	Interfacing with all sensors			Keshav Sangam
	Learn to program ROS			Raymond Xiao
	Milestone 2: Integration			
	Implement basic SLAM			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

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 27

SPRING BREAK

SLACK

Updated

Tasks	Start	End	Team Member
Proposal and Planning			
Brainstorm different projects	1/18	1/25	Everyone
Project abstract	1/26	1/26	Everyone
Proposal presentation	2/7	2/9	Everyone
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Implementation and Design			
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Integrate components with ROS			Raymond Xiao
Interface with Jetson Xavier			Raymond Xiao
Milestone 3: Final Design			
Set up testing/verification environment			Everyone
Improve and debug SW algorithms			Jai Madisetty
Finalize path planning			Everyone
Systems integration check			Everyone
Verification and Optimization			
Rigorous testing in different scenarios			Everyone
Tweak design parameters (accuracy, speed, etc.)			Everyone
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Record video explaining project			Everyone
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Conclusion

One of the primary applications of robotics is the ability to replace human intervention in dangerous conditions; a firefighting/SAR robot is the epitome of this idea.

Our project is a first step in creating a fully featured robot that can help firefighters and save lives.