Proposal Presentation: First Response Fire Brigade

Autonomous Fire Fighting Robot Smart Home System

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Motivation

- On average, 7 people per day die in house fires in the United States.
- Building fires are responsible for > $10 billion of property damage annually.
- On average, it takes a minimum of 5-10 minutes for first responders to arrive after fire is detected by an automated fire detection system.
- This project aims to reduce loss of life and reduce property damage by shortening the time between when a fire starts and when it is responded to.

Qualitative goals

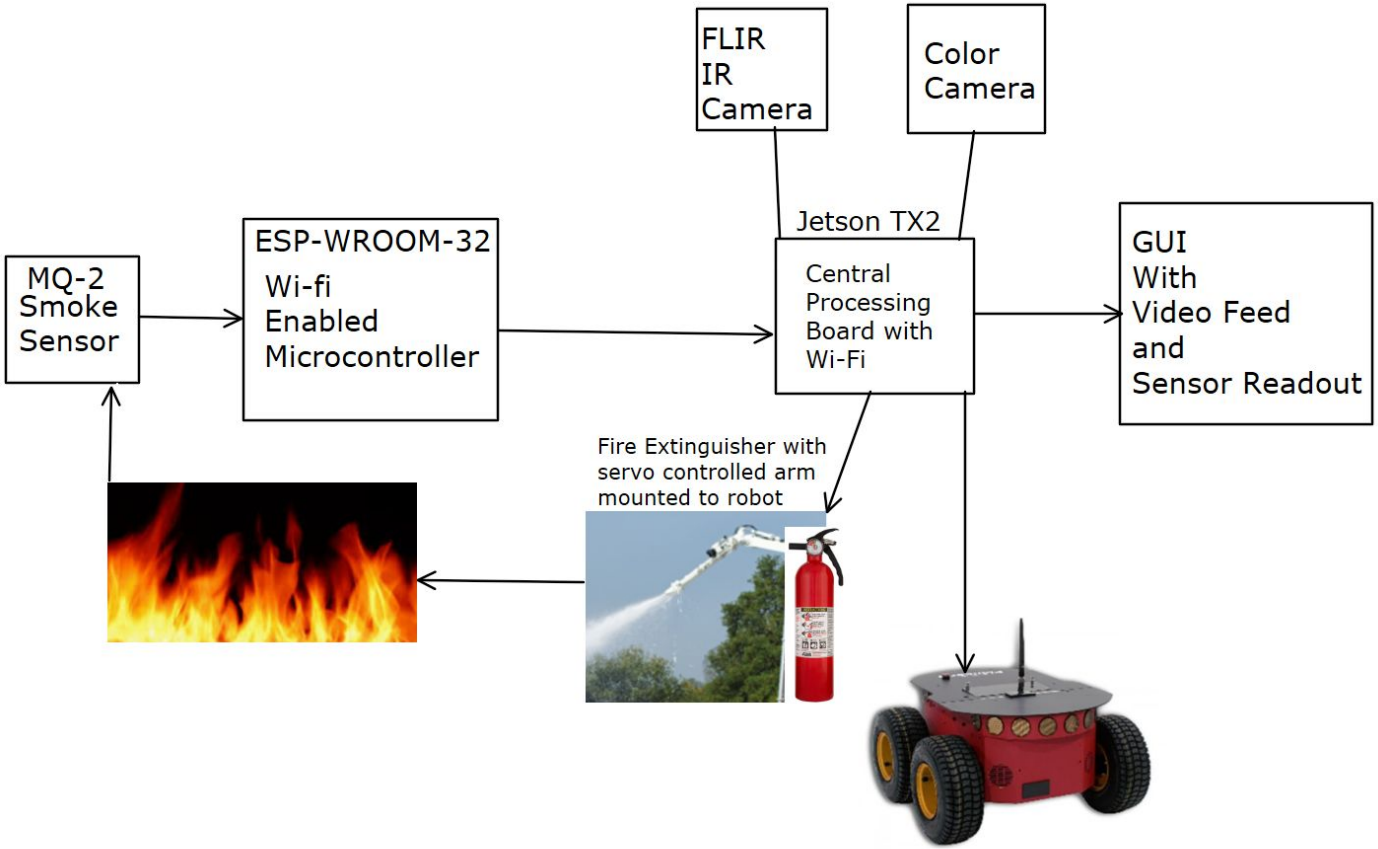
- Develop a robot that can respond to fires in a home or office
  - Self-localize and navigate to specific, known rooms in a single story of a residential home
  - Search a room and locate fires using an IR camera
  - Extinguish or suppress common household fires
    - Aim and actuate a fire extinguisher
    - Control spray while extinguisher is activated
- Develop a system of smart fire detectors that can dispatch the robot
  - Detect fires at an early stage
  - Relay data and warnings to the robot
  - Relay data and warning to an interface for user monitoring
  - Perform as a fire alarm
    - Emit a loud, distinct noise upon detection of a fire

Quantitative specifications

- Robot
  - Start responding to fire within 5 seconds of detection
  - Handle navigation at robot's full speed of 2 ft/s
    - Limited to 1 floor, open plan. Robot cannot transcend steps or open doors
  - Locate and accurately spray fires from up to 10 feet away
  - Put out incipient fires of type A, B, and C
    - A - wood, paper, cloth, etc.
    - B - gasoline, oil, etc.
    - C - electrical wiring
  - Max Payload: 20 Kg

- Smoke detector
  - Detect smoke at a threshold of 550 PPM
  - Use MQTT to directly convey location of fire to Robot

Design approach



Software and Hardware selection

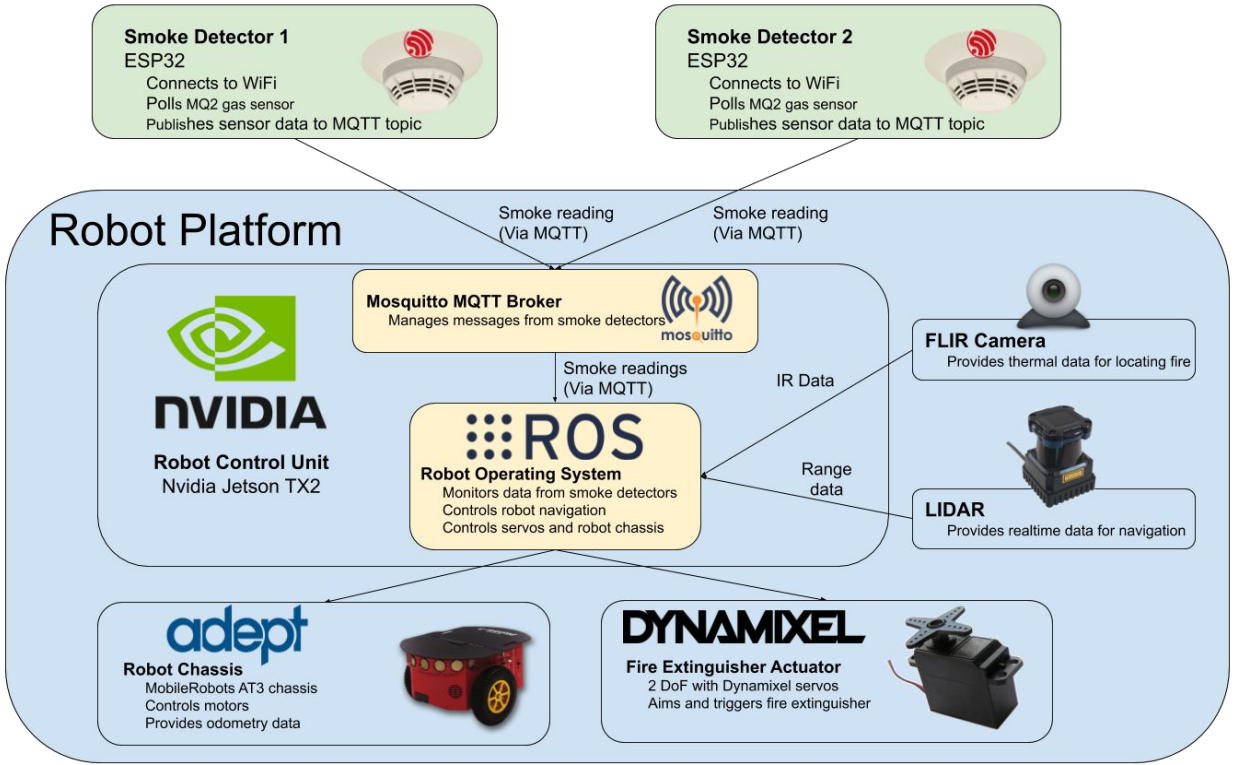
- General robot control: Robot Operating System (ROS)
  - Provides intuitive framework for modular control software
  - Provides extensive libraries for sensor processing, navigation, and monitoring
  - Provides a built-in system for running parallel nodes and passing messages
- Communication with smoke detectors: MQTT
  - Lightweight network messaging protocol with publisher/subscriber model
  - Using Mosquitto MQTT broker on the jetson to manage message passing
  - Using ros `mqtt_bridge` library to forward mqtt topics to ros topics

Block Diagram

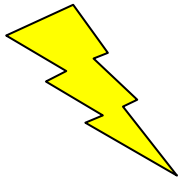
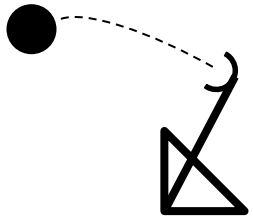
Hardware unit

Software unit

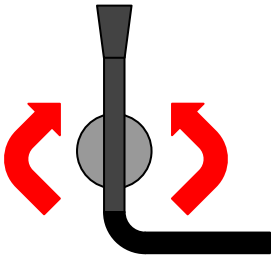
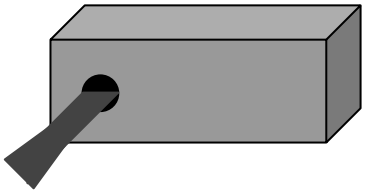
Combined HW/SW



Ideation

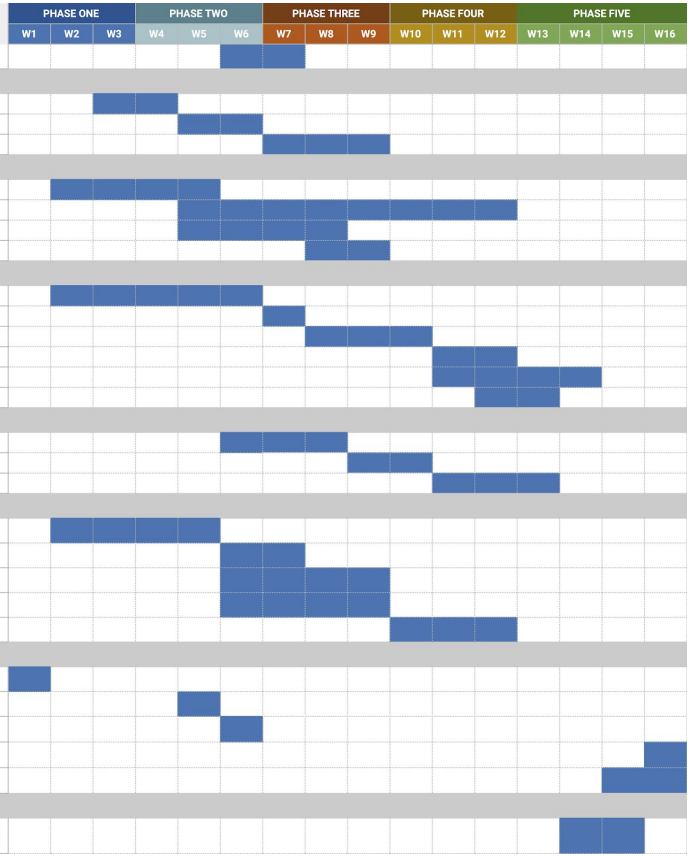
Requirement	Solutions				
Fire Extinguisher Type	 Conventional			 Ball	
Activate Fire Extinguisher	 Electricity	 Push	 Pull	 Projectile	 Roll

Ideation

Requirement	Solutions	
Aim Fire Extinguisher	 Rotate Portion of Hose	 Rotate Entire Extinguisher
Mount Fire Extinguisher	 Bracket	 Enclosure

Schedule

TASK NUMBER	TASK TITLE	RESOURCE	START DATE	DUE DATE	DAYS	DEPENDENCIES
0.1	Order Parts	Chris	09/23/19	10/02/19	10	
1	**Fire Detectors**					
1.1	Get the Smoke Detector Chip connected to a network.	Zack	09/02/19	09/15/19	14	
1.2	Set up MQTT intergration with ROS	Zack	09/16/19	09/30/19	15	1.1
1.3	Get Smoke detectors reliably powered	Thomas	10/03/19	10/17/19	15	0.1
2	**Robot Navigation**					
2.1	ROS 2D Navigation using preloaded map	Adrian	08/26/19	09/24/19	30	
2.2	AI Search of Room for Fire (locating flames)	Natalie	09/25/19	11/07/19	44	2.1
2.3	Obstical Avoidance	Thomas	09/25/19	10/09/19	15	2.1
2.4	Avoid getting lost/ stuck	Natalie	10/10/19	10/21/19	12	2.1, 2.3
3	**Processing for Fire Detection**					
3.1	Camera and Sensors on Robot relaying data	Deniz	08/26/19	09/29/19	35	
3.2	Decide on an appropriate algorithms to use	Deniz	09/30/19	10/06/19	7	3.1
3.3	Implementation of the algorithms	Deniz	10/07/19	10/24/19	18	3.2
3.4	Testing and fixing	Deniz	10/25/19	11/07/19	14	3.3
3.5	Depth perception	Deniz	10/25/19	11/21/19	28	3.3
3.6	Detect fire patterns to provide to first responders	Deniz	11/01/19	11/14/19	14	3.3
4	**Servo Control System**					
4.1	Design and implement servo plant system model	Ricky	09/22/19	10/12/19	21	
4.2	Servo paramater identification	Ricky	10/13/19	10/26/19	14	0.1, 4.1
4.3	Design and implement camera feed position control	Ricky	10/27/19	11/16/19	21	4.2, 3.1
5	**Mechanical**					
5.1	Fire Extinguisher Selection and Purchase	Ryan	08/26/19	09/24/19	30	
5.2	Fire Extinguisher Mounting	Ryan	09/22/19	10/02/19	11	5.1
5.3	Fire Extinguisher Activation	Ryan	09/22/19	10/17/19	26	5.1
5.4	Fire Extinguisher Aiming	Ryan	09/22/19	10/17/19	26	5.1
5.5	Thermal Modeling	Ryan	10/23/19	11/06/19	15	
6	**Milestones**					
6.1	GT 4823 project pitch	All	08/19/19	08/21/19	3	
6.2	Oral presentation	All	09/15/19	09/19/19	5	
6.3	Review design proposal	All	09/20/19	09/26/19	7	
6.4	Final project demonstration	All	11/30/19	12/02/19	3	7.1
6.5	Design Expo	All	11/25/19	12/02/19	8	7.1
7	**Project Performance / Monitoring**					
7.1	Overall Testing	All	11/22/19	12/01/19	10	1.3, 2.2, 2.4, 3.4, 3.5, 3.6, 4.3, 5.4



Status

- Smoke detectors working, sending out Mqtt messages
- ROS launch file to bring up robot control and sensors
- Generated a rudimentary map of our testing area to use for robot navigation

Codes and Standards

- OSHA 1910.157 - Portable fire extinguishers
- Robot Operating System (ROS) standards
- IEEE 801.22 WIFI

Tradeoffs

Using SLAM VS Using a static map

Color camera VS FLIR camera for fire identification and location

Low power smoke sensing VS Active, IR-based flame detection in smoke detectors

Demonstration

- Closed presentation with live fire and extinguisher in a mock apartment layout
  - Recorded and played at Expo to demonstrate qualitative specifications

- Prior unit testing to verify quantitative specifications