

ECE4011/ECE 4012 Project Summary

Project Title	Residential Autonomous Fire-Fighting Robot
Team Members (names and majors)	Thomas Wyatt - Computer Engineering Zachary Elliott - Computer Engineering Natalie Rakoski - Computer Engineering Ricky Marscel - Electrical Engineering Christopher Wang - Computer Engineering Deniz Bozkurt - Electrical Engineering
Advisor / Section	Michael West
Semester	2019/Spring Circle: Intermediate (ECE4011) or Final (ECE4012)
Project Abstract (250-300 words)	<p>An average of 7 people per day die in house fires in the United States. An in-home autonomous fire extinguishing robot could combat this issue by allowing an immediate, first-response fire control system that could target flames seconds after smoke detection and minutes before firemen could arrive. This team proposes a smart home system of connected smoke detectors and a companion robot that can autonomously navigate around obstacles on one floor of the home given the floor plan, but can not transcend steps or open doors. Lidar will be used to localize the robot and detect obstacles, ROS 2D Navigation Stack will plan paths, and an exploration algorithm will be modified to search a room for fire. Initial fire detection will occur using a network of smart smoke detectors, then once smoke/fire is detected the robot will drive to and investigate the house sector in question using an infrared camera and computer vision to detect flames and avoid them. The main processing unit for the system will be a Jetson TX2 board which has a GPU for performing computer vision and will be placed on the robot connected directly to the infrared camera. The robot will use an embed-controlled mechanical system to aim the fire extinguisher in the direction of the flames. Feedback control will be used to counter the force of the fire extinguisher so that the robot can remain stable while extinguishing. We plan to use a pre-manufactured research robot and custom built smart smoke detectors to manage engineering requirements of one semester. Our goal for system improvement will be to detect, navigate, and find the source of smoke/flames as fast as possible.</p>

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List codes and standards that significantly affect your project. Briefly describe how they influenced your design.	<p>Available wireless standards for networking: ZigBee, Z-Wave, IEEE 802.11 WiFi. Of these, WiFi is by far the easiest to integrate, leading us to choose the Espressif ESP32 chip for the wifi smoke detectors.</p> <p>National Fire Protection Association (NFPA) codes and standards need to be adhered to. This is what led us to choose to use an actual fire extinguisher, rather than trying to use a pump and a reservoir to manually pump fire suppressant onto the fire.</p> <p>The Robotic Operating System (ROS) has a standard for how ROS packages are written which will be followed for our project's software development as it will be deployed as a ROS package. Also for any open source software that is used, like ROS, its license must be included in our project.</p>
List at least two significant realistic design constraints that applied to your project. Briefly describe how they affected your design.	<p>One constraint we faced was the number of sensors used for fire detection. We considered placing IR cameras on both the robot and smoke detectors to enhance the system's ability to search for fire within a room. However this would require a greater number of IR cameras to be purchased and an in-home central server to allow for more processing power which would significantly increase project cost. Instead we decided to not place IR cameras on the smoke detectors, decreasing processing power required, and run a central web server on an embedded device placed on the robot for overarching control of the system. This decision decreases cost, simplifies the system to become more modular, and increases the level of autonomy of the robot.</p> <p>Another design constraint was the cost and development time of the actual robot. We have access to two different robot designs that we could use for free. Our desire to use one of these available robots limited the scope of what actions the robot could perform, specifically, preventing us from climbing stairs or opening doors. Therefore our design will be limited to one floor of a house with an open floor plan.</p>
Briefly explain two significant trade-offs considered in your design, including options considered and the solution chosen.	<p>A tradeoff that our team encountered was the method of localization used when the robot is navigating to the detected fire location and searching for fire. Our first inclination was to explore the option of using lidar and a Simultaneous Localization and Mapping (SLAM) algorithm for localization during navigation. However, upon further research, we realized that lidar performs poorly in smoky conditions and so our team decided to switch from a SLAM approach to performing navigation by localization via a fixed map of the home floor plan preloaded to the robot beforehand. The tradeoff for this design decision was having to completely change the method of navigation and obstacle avoidance in order to increase system reliability.</p> <p>For fire detection purposes, an infrared camera was chosen over a visible-range camera, because an infrared camera has the ability to perform well in low light situations even though it is more expensive.</p> <p>Another trade-off considered was which robot to use. We had the option of using a large and powerful robot from Dr. West, or a smaller less powerful robot from Dr. DeMarco. We chose the smaller robot, for the ability to navigate more easily indoors and because it comes with a powerful lidar, though that will limit the amount of weight that we can build onto the robot.</p>

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<p>Briefly describe the computing aspects of your projects, specifically identifying hardware-software tradeoffs, interfaces, and/or interactions.</p> <p><i>Complete if applicable; required if team includes CmpE majors.</i></p>	<p>There are several computing aspects to be considered for the project. The smoke detectors must be able to get data from attached sensors and be able to send that data wirelessly to the robot/processing hub. The tradeoffs to be considered here are the need for low power vs the need to analyze data reliably and send results wirelessly. Additionally, the method of communicating between the smoke detectors and the robot is an interaction that must be addressed, finding a way to “wake up” the robot when needed, but for it to be “asleep” otherwise.</p> <p>Additionally, we want to be able to identify flames using computer vision from the robot. The consideration here is that computer vision is very computing intensive and plays a major role upon what device we use to run the central processing on the robot. Without computer vision, we could do central processing with a PI, but since we want to use the computer vision, we chose to use a Jetson TX2 board, which we had access to through our Advisor.</p> <p>Another interaction of note is that between the robot, cameras/sensors, and the servos to aim the fire extinguisher. It will be a complex set of interrupts, and it needs to be determined how to interface between the driving of the robot to the fire location, locating the fire, and aiming the servos. Additionally, we have the option of either aiming with the robot or with the servos.</p>
<p>Leadership Roles (ECE4011 & Forecasted for ECE4012) (NOTE: ECE4012 requires definition of additional leadership roles including:</p> <ol style="list-style-type: none"> 1. Webmaster 2. Expo coordinator 3. Documentation 	<p>Team Lead/Navigation Lead: Natalie Rakowski</p> <p>Documentation/Control System Design: Ricky Marscel</p> <p>Network Integration Lead: Zack Elliott</p> <p>Sensor Integration Lead/Webmaster: Chris Wang</p> <p>Expo Coordinatior/System integration: Thomas Wyatt</p> <p>Computer Vision Lead: Deniz Bozkurt</p>
<p>International Program: Global Issues (Less than one page) (Only teams with one or more International Program participants need to complete this section)</p>	N/A