Network Reconnaissance Rovers for Disaster Environments

Simon Galas
Independent Scientific Research
Baylor School, Chattanooga, TN

INTRODUCTION

In the US alone, there was 1.345 million fires reported in 2015 (NFPA). Every day, thousands of firefighters answer these calls of help to save people's lives and to stop fires [1].

According to the National Fire Protection Association, there was over 60,000 injuries and 68 firefighter deaths in the year 2015. Many of these deaths and injuries are caused by the firefighters going into situations that are too dangerous [1].

Whether it is a raging forest fire or a collapsing structure, many firefighters do not know the conditions of the fire or structure.

Robotic solution are currently in development to learn more about the conditions before first responders enter a disaster-related scenario [2] .

Using swarm technology, the robots can communicate between each other and with first responders in order to survey areas more efficiently and safely.

BACKGROUND

The SAFFiR (Shipboard Autonomous Firefighting Robot) can be considered the flagship model for firefighting robots. This robot is specifically for combating fires in the environment of a navy vessel. The robot is 5' 10" and weighs 143 pounds(Shadbolt). The robot includes a gas sensor, camera, infrared camera, and the inherited ability to not be affected by toxic fumes [3].

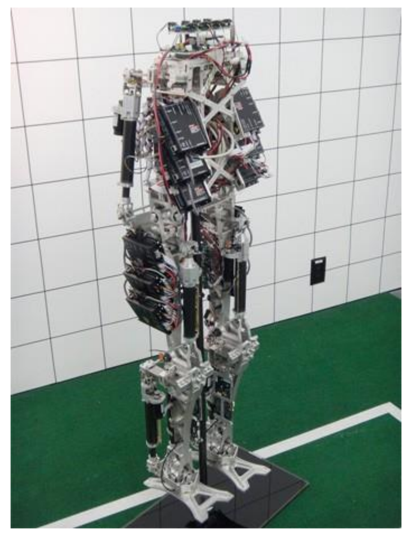

Figure 1. SaFFiR

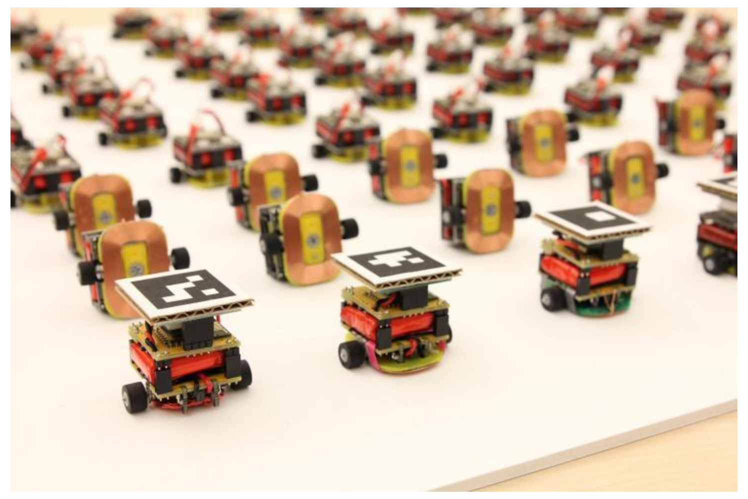

Figure 2. Testing swarmed robots at the Georgia Tech Robotarium

Swarm robotic technology is a strategy being implemented by many different institutions. The Robotarium developed at Georgia Institute of Technology is a perfect example of the technology evolving into being easier to implement and understand [4].

MATERIALS AND METHODS

Each Rover unit is comprised of the following modules:

- DFRobotshop Rover 2, which includes an Arduino Uno microcontroller
- XBee 2mW Wire Antenna - Series 2 (ZigBee Mesh)
- Sensors:
  - Temperature Module
  - MQ-7 Carbon Monoxide Detector
  - KY-026 Flame Sensor Module
  - HC SR04 Ultrasonic Distance Sensor

Rovers were constructed using DFRobotshop Rover 2 kits (Figure 3).

Sensor modules were added to a Rover unit to test environmental surveillance (Figure 4).

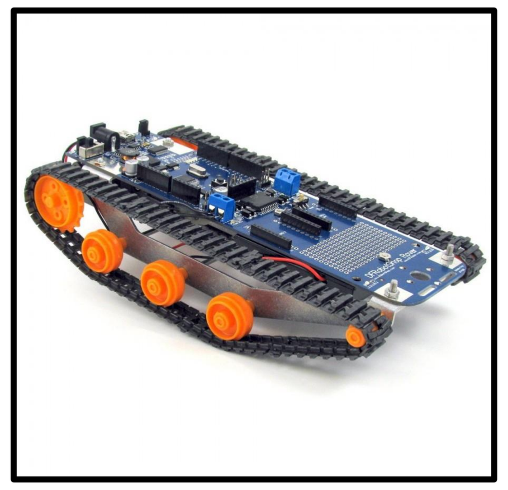

Figure 3. DFRobotshop Rover 2

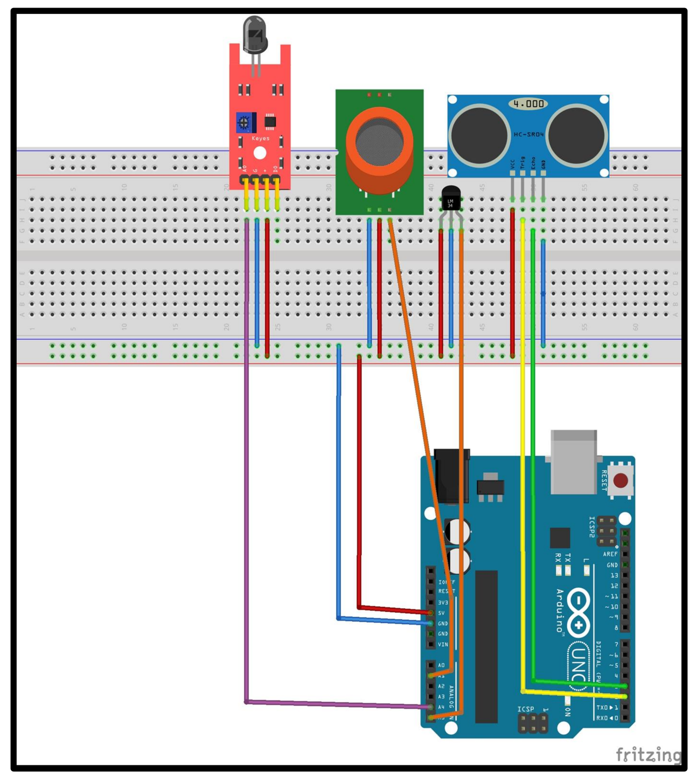

Figure 4. Circuit Diagram of Sensors Used on Rover (Fritzing)

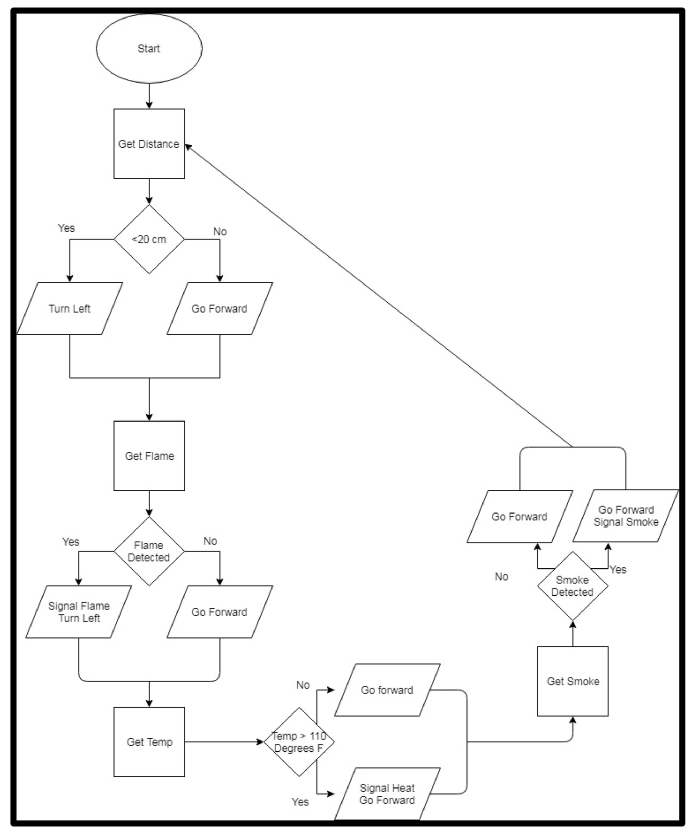

Figure 5. Code Flow Diagram

Rover units were coded to 1) roam autonomously, avoiding obstacles and 2) received sensor data and send information to coordinator module (Figure 5).

RESULTS

The fully constructed Rover unit is shown in Figure 6. The DFRobotshop Rover 2 kit was built, sensors were added and 3D printed sensor housing unit was designed and installed.

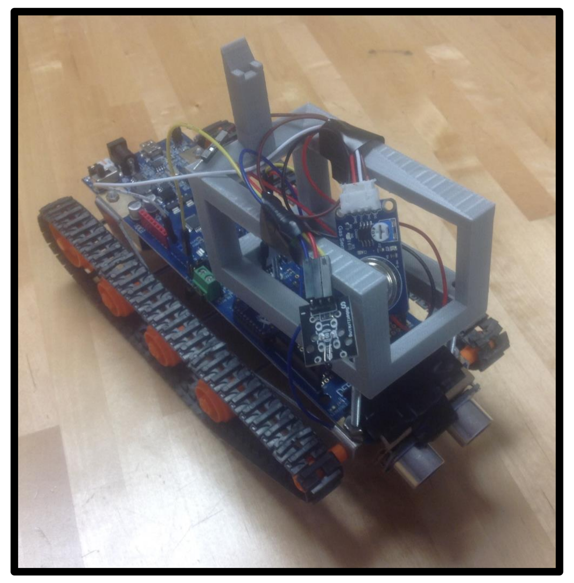

Figure 6. Rover Unit

Figure 7 demonstrates the current configuration of the wireless network. The Rover units act as End Nodes, streaming sensed data to the Coordinator via serial wireless communication.

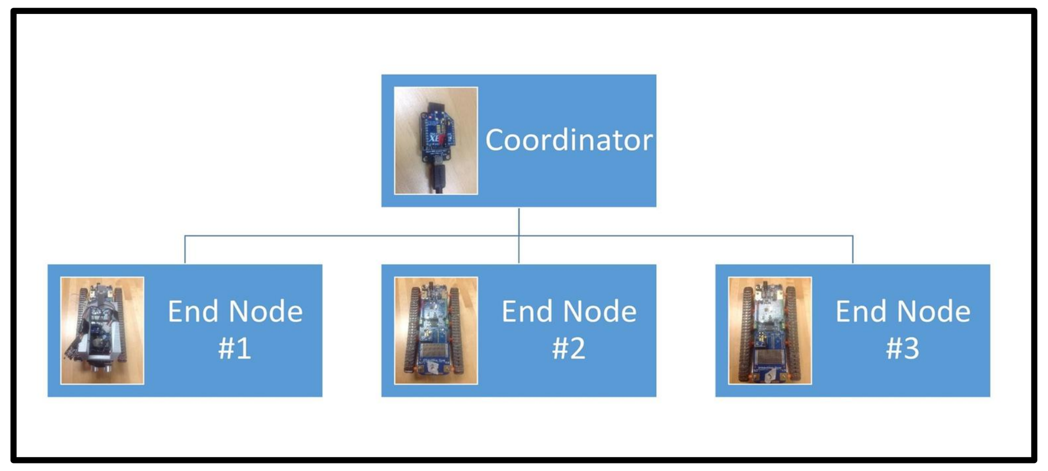

Figure 7. Wireless Rover Network Configuration

The input data from the XCTU console shown in Figure 8 includes values from the Flame sensor, Smoke sensor, Fire sensor, and the ultrasonic sensor.

The input is begun with the robot designation. In this case it is Bot:1. The following information is data sent from the XBee on board the rover. The values have not yet been calibrated to be accurate to real world values. The obstacle detection by the ultrasonic notifies when the rover is 2 cm away from the obstacle. The result of the detection is to rotate the rover to the left to attempt to avoid the obstacle.

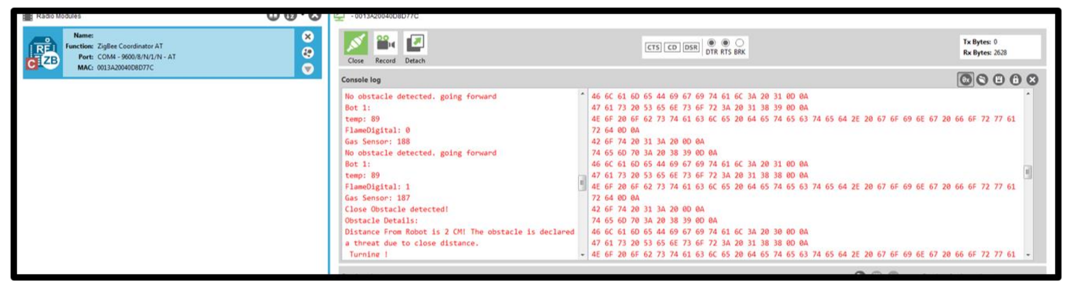

Figure 8. Results from sensors on robot #1

FUTURE DIRECTIONS

- The other two Rovers need to be equipped with the sensors that are currently on Rover 1. Before installation, sensors need to be calibrated and tested to ensure the setup is the most efficient way of surveying a building in a fire scenario.
- The current system of communication is using a single Coordinator connected to a computer with XBees on the robots; this will not change, however, the XBees are acting as end nodes currently with no communication between each other. To utilize the maximum potential of this setup, the robots need to be able to communicate between each other in order to quickly coordinate the next move depending on the position of the other robots.
- The robots also do not have a method of locating one another. The method of accomplishing this is still being considered. Potentially the robots will be able to scan the area for LEDs mounted on all of the robots

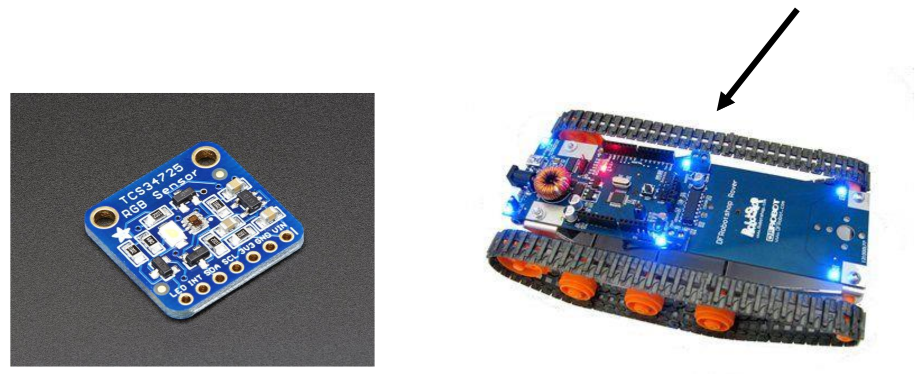

Figure 9. Using LEDs for Rover to Rover communication

WORK CITED AND ACKNOWLEDGEMENTS

1. James, Hylton J.G. "Firefighter Injuries in the United States." Firefighter Injuries in the United States, NFPA Report, Oct. 2016, www.nfpa.org/news-and-research/fire-statistics-and-reports/fire-statistics/the-fire-service/fatalities-and-injuries/firefighter-injuries-in-the-united-states
2. Milan, et al. "Help from the Sky: Leveraging UAVs for Disaster Management." IEEE Pervasive Computing, vol. 16, no. 1, 2017, pp. 24–32., doi:10.1109/mprv.2017.11.
3. Shadbolt, Peter. "U.S. Navy Unveils Robotic Firefighter." CNN. Cable News Network, 12 Feb.2015. Web. 31 Oct. 2016.
4. D. Pickem, E. Squires, M. Egerstedt, "The Robotarium: An open, remote-access, multi-robot laboratory", unpublished

I would like to thank Sherry Tang, Sam Govan, and Niko Blanks for helping build the initial disasterbot prototype. Sidon Kwon designed the protective enclosure used in the most recent disasterbot implementation. I'd also like to thank Dr. Mary Loveless for advising and Baylor Research for funding this project.