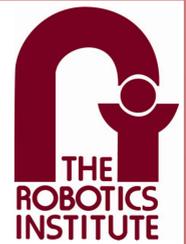


# A Robotic System For Enhancing Situational Awareness In Mine Rescue

Aashish Sheshadri, Uland Wong, Red Whittaker



## Background

Robots are better suited to hazardous environments, hence a compelling solution to the problems of mine rescue. This research develops an interactive situational awareness system in the form of a graphic user interface, displaying data actively as sensed by the robot. The user interface is the communication channel between the rescue team and the robot, and also provides control of the robot itself.

Mine	Year	Fatalities	Survivors	Rescue Report
Upper Branch Mine	5 <sup>th</sup> April 2010	29	0	Rescue effort hampered by high and explosive levels of Methane and Carbon Monoxide.
Crandall Canyon Mine	6 <sup>th</sup> August 2007	6	0	The search for the six trapped miners called off, too dangerous for continued rescue effort.
Sago Mine	2 <sup>nd</sup> January 2006	12	1	Twelve of the men die from carbon monoxide poisoning by the time rescuers reach them.

- ❖ **Situational awareness** is the perception of the elements in the environment, comprehension of their meaning, and the projection of their status in the near future.
- ❖ **Situational understanding** is product of applying analysis and judgment to the unit's situational awareness to determine the relationships of the factors present and to form logical conclusions.
- ❖ Achieving situational understanding in minimal time is presented with the following challenges
  1. Assume the user has no specific knowledge about situational awareness data.
  2. Provide for ease in situational understanding without any prior training in using it.
  3. Provide the user with complete control.
  4. Require minimal access time to obtain situational awareness data.
  5. System behavior should reflect the state of the environment.

## Methodology

### ❖ Robot Design

The Robot takes the role of scouting ahead and recording situational awareness data. Depending on the rescue mission requirement it can

- Drive ahead of the team autonomously and report back or await further instructions.
- Be driven manually by the user.

### ❖ User Interface

The user interface has been developed using Qt, an open source C++ framework. It communicates with the robot using TCP/IP.

1. The layout has been designed for comfortable use with safety gear on the user.
2. Enables access to all necessary data without the user having to open other menus or choose options.
3. Startup colors are chosen to associate a sense of calmness and all data are color coded to describe the severity of the situation.
4. Provides options for fly through, slow and quick access within the data set.
5. Necessary robot controls are provided on the interface.
6. There are two tabbed windows for a total of 4 views, giving different visuals of the environment including gas levels and the temperature.

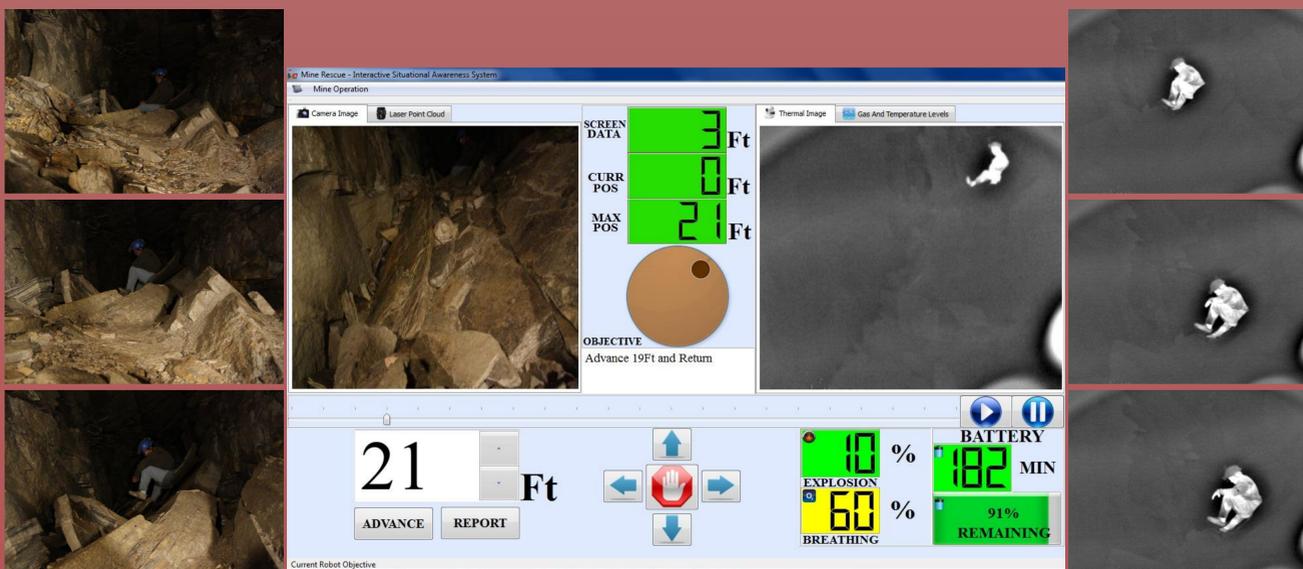


Figure 1. Primary View Of The Interface

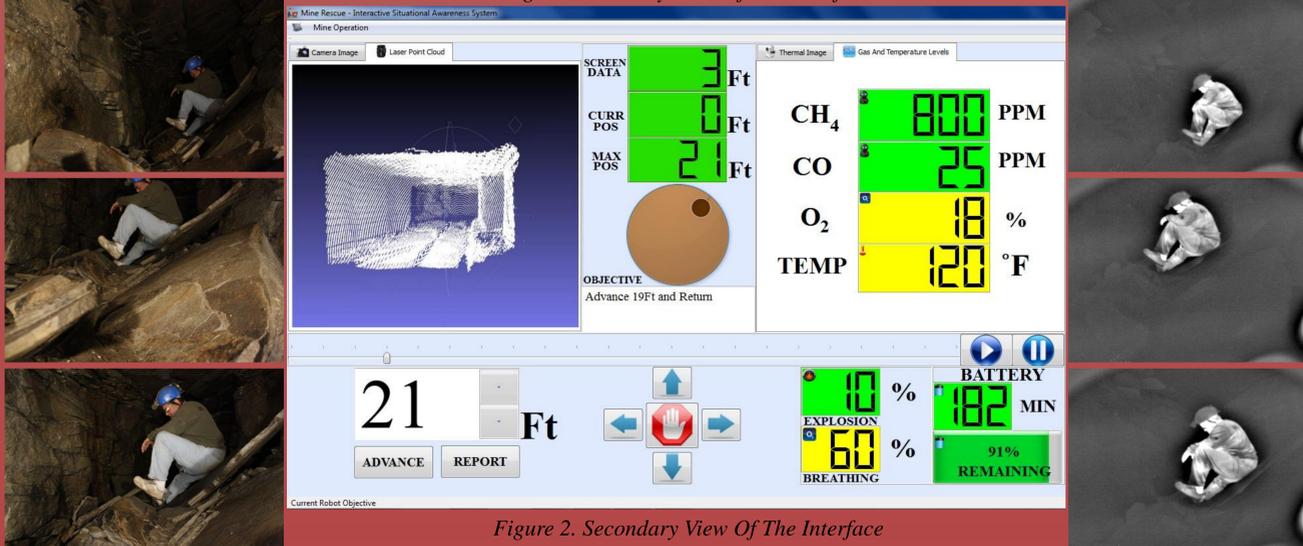


Figure 2. Secondary View Of The Interface

Figure 3. Camera Images Taken At 1ft Intervals

Figure 4. Thermal Images Taken At 1ft Intervals

## Experiments

Data was collected from two field locations for the purpose of testing the system.

- ❖ Bruceton Research Coal Mine
  1. Data of a corridor view was collected by mounting 4 different cameras on a robot, in incremental steps of 3 ft for a total of 24 ft.
  2. Images of mine machines, doors and screens were recorded
- ❖ Walkers Mill Cave
  1. Data of a corridor view was collected with the same resources as the one in the coal mine, but incremental steps of 1 ft for a total of 24 ft.
- ❖ This robotic system is evaluated based on the following metrics
  - Data access time
  - Threat Assessment
  - Survivor Identification
  - Robot Maneuverability



Figure 4. User Interface Secondary View

## Future Work

- ❖ Perform a user study with the collected data set to test the design.
- ❖ Investigate the use of gravity aligned images
- ❖ Add a dynamic map to the interface for better perception.
- ❖ Upgrade or add sensors to the robot.
- ❖ Plot Situational Awareness Curve and find optimal rate at which data is to be updated.
- ❖ Provide a 3D point cloud visualization.