

A. Title Page

**Final Report for Study of Simultaneous Localization and Mapping (SLAM) Using the
Kinect Sensor**

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B. Restatement of problem researched or creative activity

Natural disasters like earthquakes, tornados, landslides, and hurricanes can produce collapsed buildings in which people can be trapped in the rubble. Search and rescue teams are sent to disaster areas to save people. However, sending rescue personnel into collapsed/damaged buildings put them in a great danger. Sending a robot capable of navigate into collapsed building would be extremely desired. Robot navigation relies on two key *competences*³: *path planning* and *obstacle avoidance*. There are a great variety of obstacle avoidance approaches that have demonstrated to be competent. Path planning⁴ is a strategic problem-solving competence that involves identifying a trajectory that will cause the robot to reach the goal location. This strategic competence needs a map of the environment, the current robot's location and the goal location. Hence, obtaining the robot location and a map of the environment is fundamental to enable robot navigation. Collapsed buildings normally have unpredictable changes in their layouts. Hence, it is necessary to generate a new map of the buildings' interiors to be able to have effective robot navigation. Robot navigation is possible if a map is available and it is possible to locate the robot on it. Generating a map of collapsed buildings and then used it to robot navigation is not a practical task during disaster conditions, because the urgency of rescuing people. Therefore, it is important to develop algorithms that allow the robot to locate itself and build the map of its surroundings simultaneously. Simultaneous Localization and Mapping is an approach developed by the robotics community to solve this challenging problem. Currently, the standard sensor used for implementing SLAM algorithms is a Laser range-finder. However, this type of sensor has a relative big price tag. Since the introduction of the Kinect sensor for controlling the Xbox game system by Microsoft, the range-finder capability of the Kinect sensor has motivated the robotics research community. The Kinect presents a more affordable price tag.

An additional advantage of the Kinect is the capability of build three dimensional (3D) maps of environments. This capability has the potential of providing a better awareness of the surroundings than the knowledge provided by 2D camera or 2D range-finders. Therefore, the main purpose of this research activity is to develop an indoor robot equipped with a Kinect sensor and carry out experiments to analyze the performance of this sensor in the implementation of SLAM of unstructured and unknown environments.

C. Brief review of the research procedure utilized

In this proposal an indoor robot called the Turtlebot was purchased to test the algorithms for Simultaneous Localization and Mapping (SLAM). This robot is based on the iRobot Create and the Microsoft Kinect, Clearpath Robotics company has developed the TurtleBot structure and a mounting hardware frame that allow the easy installation of the Kinect sensor, a gyro sensor, a netbook and the iRobot Create. The robotic software development environment include

- An SDK for the TurtleBot
- A development environment for the desktop
- Libraries for visualization, planning, and perception, control and error handling

The provided netbook has installed the Ubuntu Linux. The SDK for the TurtleBot is based on the Robotics Operating System (ROS). ROS is an open source (BSD) software package that provides libraries and tools to help software developers create robot applications¹.



Figure 1. Turtlebot Robot

D. Summary of findings

The ROS navigation stack was configured and tuned to be able to work with the TurtleBot robot.

The tuning of the navigation stack proved to be a delicate process. The TurtleBot robot successfully produced a map of a section of the second floor of the Corley as shown in Figure 2.

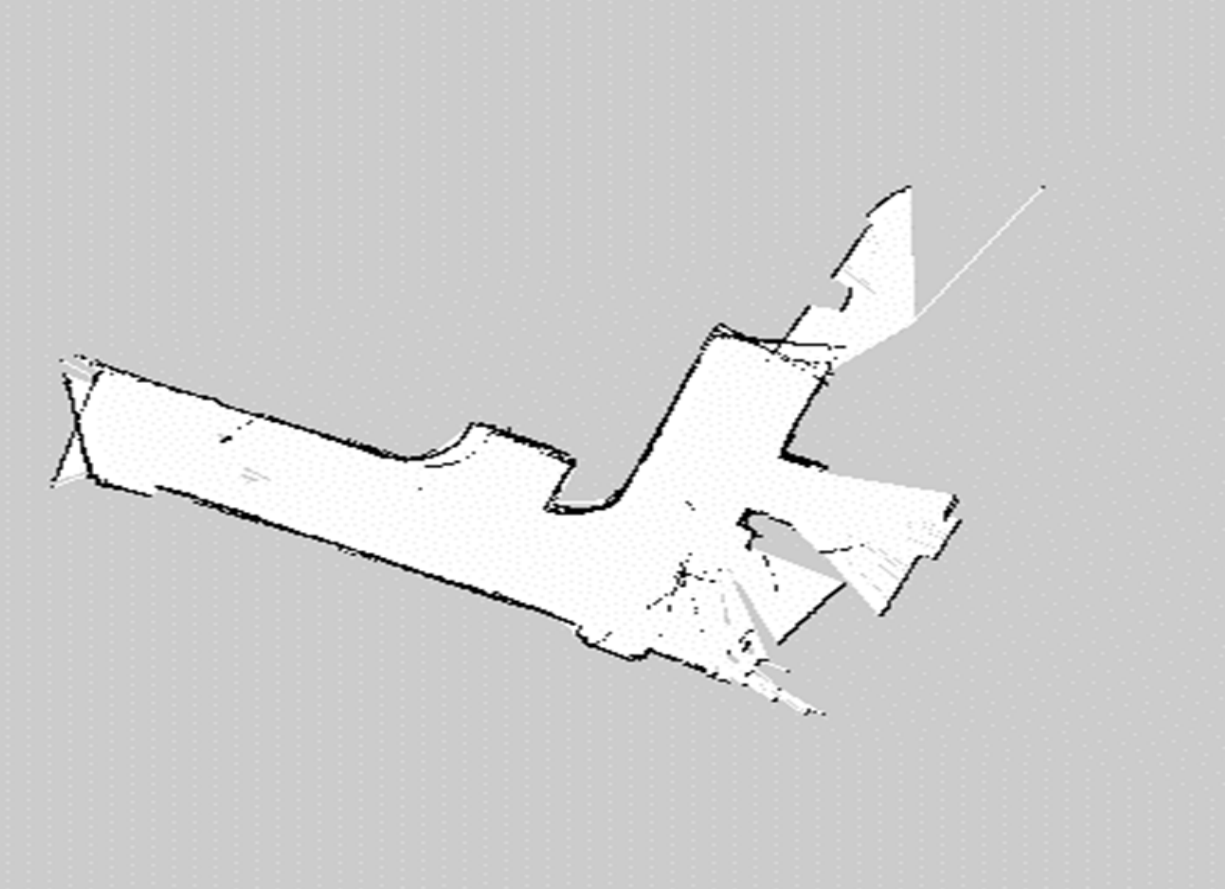


Figure 2 A generated map of the second floor of the Corley building using the Kinect Sensor

Figure 3 shows a screenshot of RViz which is a 3D visualization environment for robots using ROS².

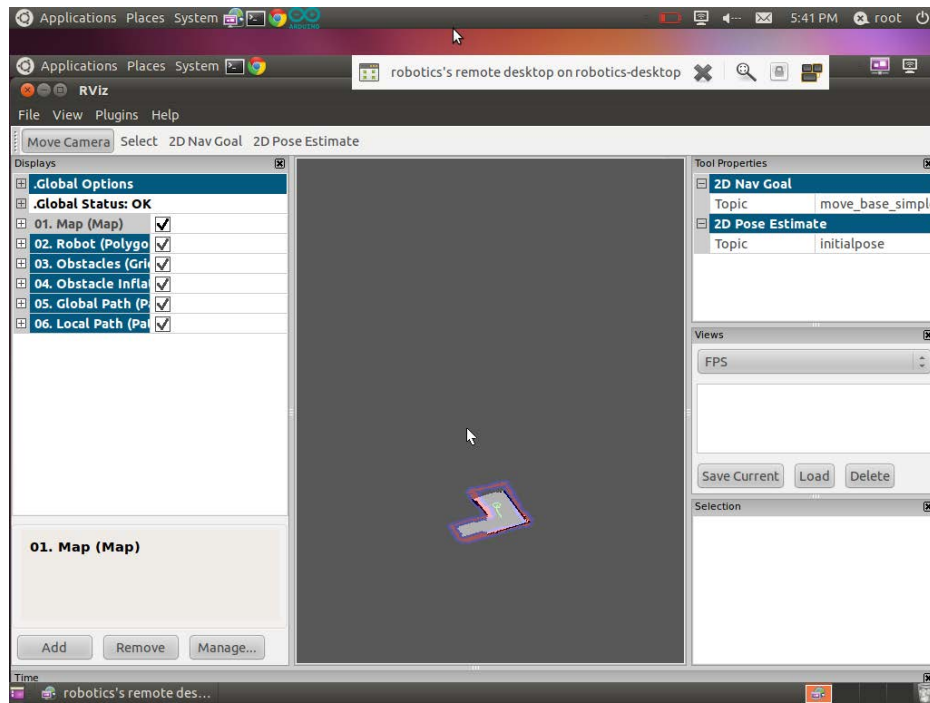


Figure 3 Screenshot of RViz (3D ROS Visualization environment)

E. Conclusions and recommendations

In conclusion, the TurtleBot has been used to perform SLAM. Regarding the fact that ROS has a very steep learning curve, the libraries and tools provided are extremely useful. The development time of an SLAM capable robot is substantially reduced through the use of ROS. Future research plans includes the implementation of sensor fusion techniques that allow us to combine the information provided by the Kinect sensor and LIDAR sensor, in order to improve the accuracy of the maps obtained and better robot navigation.

REFERENCES

¹ <http://www.willowgarage.com/pages/software/ros-platform>

² <http://www.ros.org/wiki/rviz>