RISCBOT: Mobile Robots Exploration And Mapping In 2D

Sithisone Kalaya, Hussain A. Alhazmi, Advisor: Prof. Tarek Sobh
Robotics, Intelligent Sensing & Control (RISC) Lab.
School of Engineering, University of Bridgeport.

Abstract

The objectives of the robots are to explore the whole environment as a group, while maintaining communication with the base computer throughout the entire exploration. Our method was implemented using a mobile robot equipped with a sonar range finder, a communication unit, and a software module. The robot performs collision free navigation, dynamic object detection, data collection, and communication with a base computer. This work demonstrates that multiple robots can improve overall mapping performance of an unknown environment.

Introduction

The ability of a mobile robot to move freely, avoid obstacles, collect data while exploring the environment, and transferring this data to a host computer are considered challenges in this work.

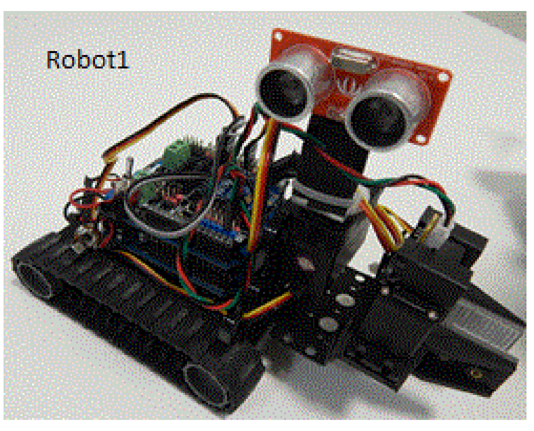
In this paper, we applied a system consisting of simpler, smaller robots and a host computer. This system is capable of exploring and gathering information in an office-like environment and construction of a map from data collected. The approaches we used required two simple tasks. These are: robots task and host computer task. The object avoidance capability on the mobile robots is based on the algorithm using heading range information provided by front mounted measuring sonar device. A transmission of data between mobile robots to a host computer, we used communication unit installed on each robot as well as on a host computer.

Subsequently, our mobile robot can be developed to add the capabilities to localize itself in an unknown environment as well as the ability to create the local map from data collected during the exploration.

System Overview

We built two mobile robots for this experiment based on DFRobotShop Rover V2-Arduino Compatible Tracked Robot from RoboShop (fig. 1 and fig. 2). The robot was fitted with a Seeed Ultrasonic Sensor, a distance measuring module and a Bluetooth/XBee communication device. The Seeed Ultrasonic Sensor provided detecting range from three centimeters to 400 centimeters at 40k Hz frequency. The Seed Ultrasonic Sensor is positioned in front of the robot on a simple servo-based pan system. This sensor provides three measured distances in front of the robot in 180º sonar scan coverage.

The software module uses the ARDUINO IDE framework which is an open-source used for programming electronics prototyping platform developed and supported by Arduino. This language incorporates high-level features that facilitate the development of parallel and event-based applications. On each mobile robot and a host computer we implemented a Bluetooth/XBee communication unit to ensure a constant communication link between the two. On our host computer we also installed Putty release 0.63, a Telnet/SSH client for Windows and terminal emulator



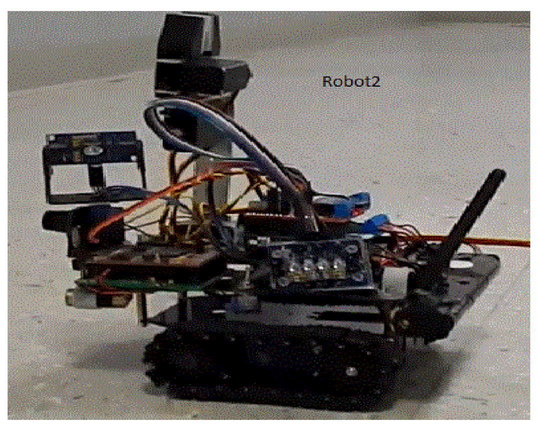


Figure 1, 2 The two robots used in this experiment.

Basic Navigation

The navigation algorithm was developed to keep the robot moving safely in the environment. The design is based on the concept of even-driven terminology. That it reacts by moving forward, turning left/right, or stops and reverse to avoid obstacle and maintain a minimal distance from objects. This behavior is useful as the accuracy of the sonars is maximized in the proximity of detectable objects. This is important due to the fact the robot sonar range sensor is the only way to obtain information about the environment. To ensure the robot can move freely in the unknown environment we separated its boundaries based on the circular arrangement of the sonars. This is to guarantee that obstacle avoidance was implemented by limiting the space around the robot into appropriate sensory regions. The area in front of the robot was divided into the safe zone and the critical zone (fig. 3). The critical zone has distance less than fifteen centimeters from the front of the robot. Safe zone is located between fifteen to twenty centimeters from the front of the robot. An object in the critical zone represents an obstacle which causes the robot to turn appropriately to avoid collision. The side distance consists of the edge dividing the area on each side of the robot. The right side of the robot requires a minimal distance of the boundary, twenty centimeters. This distance is the distance between the robot and the entire wall in the room environment which the robot uses as its tracing boundary.

Forward motion: The robot is designed to move forward in a straight line in a fixed distance of twenty centimeter at a time. If an obstacle is not detected, the robot is continuously assigned another target distance (Yn+1 = 20 centimeters) which results in uninterrupted forward motion. At the end of each target distance the robot scan for sample points for X_1, X_2, and X_3 then transferring X_1, X_2, and X_3 to a host computer for storage and processing.

Obstacle avoidance: To avoid any obstacle in the given environment robot1 is preprogramed to always turn to its left and robot2 is to always turn to its right at 90º angle. For example, when robot1 detected and object in the critical zone. Its reaction is to stop then backup for ten centimeters, measure front distance X_2 must be greater than fifteen centimeters then make a left turn. It then move forward for another twenty centimeters, stop, X_1, X_2, and X_3 if no object in the critical zone makes a right turn, move another twenty centimeters and makes a left turn to continue on its straight path (fig. 4). However, Robot2 turned the opposite way, right – left – right when obstacle is detected in its critical zone.

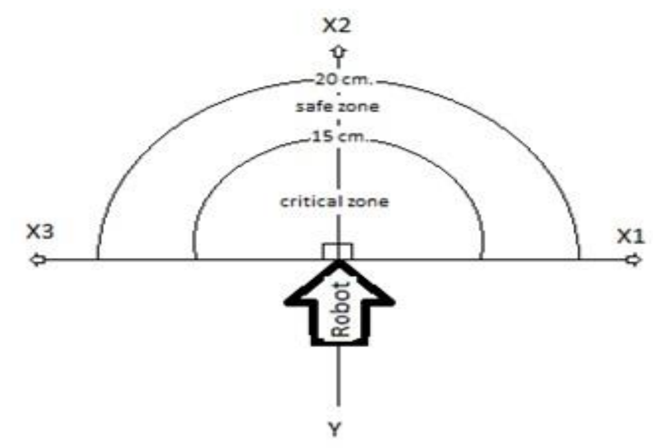


Figure 3: Zones around the robot.

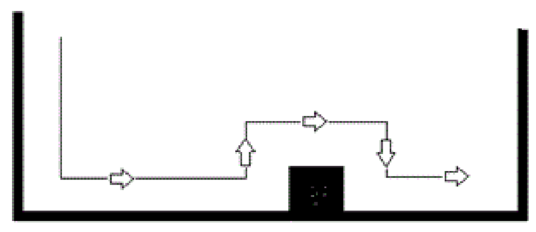


Figure 4: Obstacle avoidance behavior.

Communication

To ensure a reliable communication in the system we implemented a Bluetooth/XBee communication unit, which guarantee a constant communication link between our mobile robots and a host computer. During the exploration both the robot and a host computer constantly maintained its communication link. Transmissions of data(X_1, X_2, and X_3) from the exploration robot are to be send at the end of each target distance(fig. 6).
Communication to base station algorithm:
If multiple robots are used
Enable system clock each cycle 100 milliseconds
1st system clock cycle enable transmission from robot 1
2nd system clock cycle enable transmission from robot 2
The system clock is continuously running to allow data transmission from each robot to a host computer until the end of exploration(fig. 5).

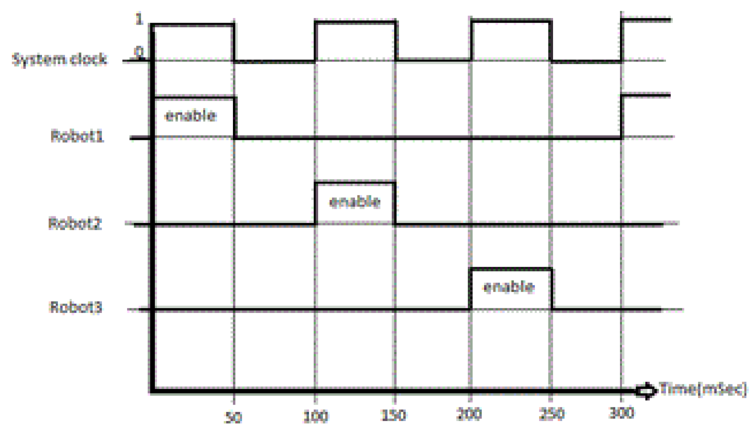


Figure 5: System clock need to allow data transmission to avoid interfering.

Figure 6: Ranges information received from each robot.

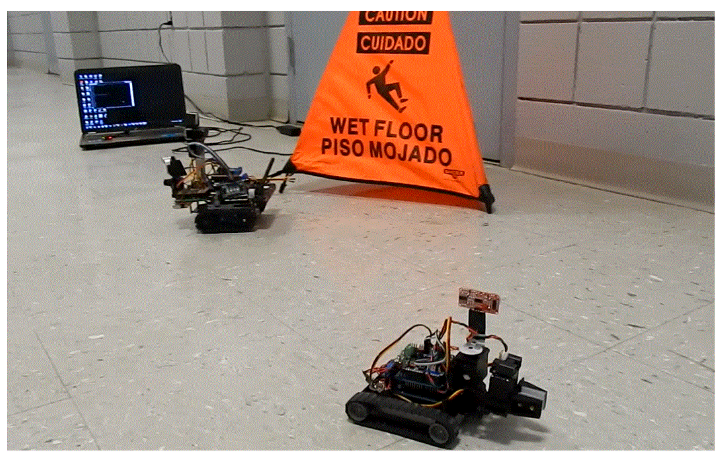


Figure 7: Both robots working under experimental condition.

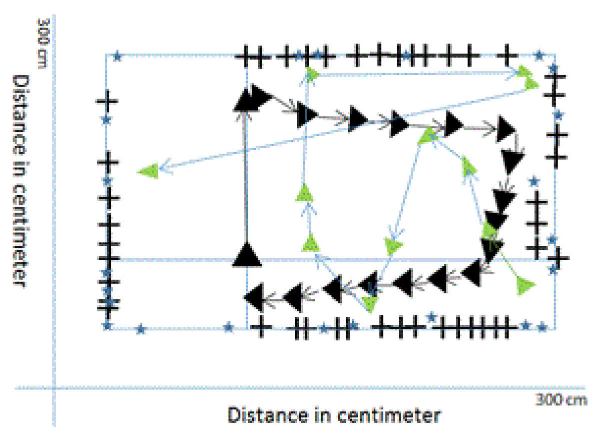


Figure 8: Map generated from robots sensor data.

Conclusion

We have tested our robots system in partial corridor environment (fig. 7). The transmission of data from the robots to the host computer is working as expected (see fig. 6), as well as our robots objects avoidances capability. The data received from both robots were retrieved and used to plot a 2D map as show on fig. 8. Future additional enhancements to maximize their capabilities includes implementing EKF-SLAM algorithm, Web enable to allow multiple users to access data from different locations, and implementing laser scanner for more accurate measurements.
For further information, code, pictures, and experimental videos please visit: http://cpsc460robotics.weebly.com/.