

Building a Mobile Robot



Dr. Rohan Munasinghe
BSc, MSc, PhD, MIEEE
Department of Electronic and Telecommunication Engineering
Faculty of Engineering
University of Moratuwa 10400

Learning Objectives

- Learn about a mobile robot, which has been designed and build to carry out a simple specific task
- Understand about different parts of such a robot and learn how these parts work together to make the robot able to perform that task effectively.
- Generalize and apply that knowledge to design a mobile robot to perform a given task

Target Tracking Robot

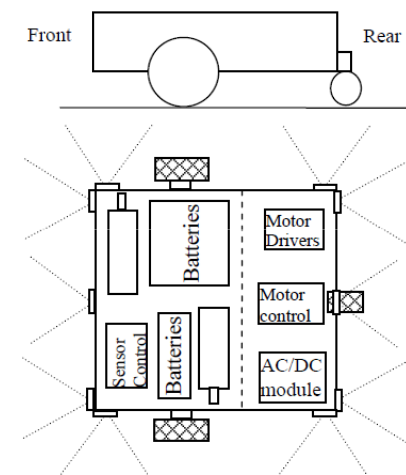
- Track a moving object keeping a distance of 50cm from it.

Robot Functionality

- Detect the distance (d) to the target
 - Target can be at any direction of the robot (front, left, right, back)
 - Therefore, sensors are required to be placed around the robot
 - 12 sensors: 30° apart
- If $d > 50\text{cm}$ move towards the target
 - Turn towards the target
 - Check which sensor (say 4th clockwise one) detects the target
 - Turn $4 \times 30^\circ$ clockwise
 - Move forward as long as $d > 50\text{cm}$
- If $d < 50\text{cm}$ move away from the target
 - Turn to opposite direction
 - move as long as $d < 50\text{cm}$

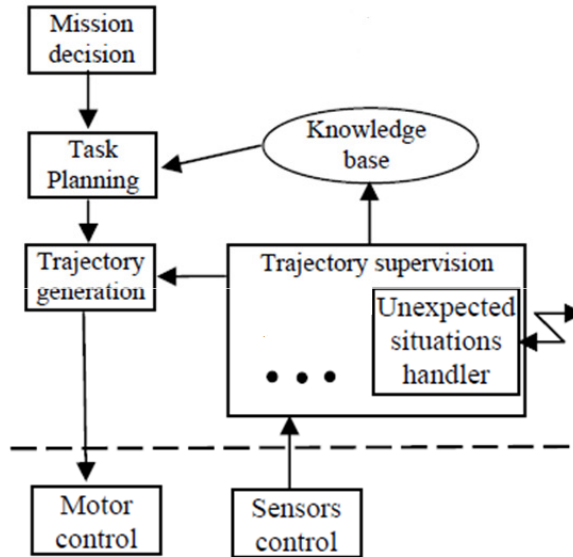
Hardware Architecture

- Differential driving system with two independent driving DC electric motors
 - Can turn around a single axis
- Passive castor wheel
 - Keep the balance
 - Allows turning
- Optical encoders in motor shafts
 - Detects turning angle
- Independent power sources for motors and electronic modules
 - Quite environment for electronic circuits
- Distance sensors (sonar,IR)



Software Architecture

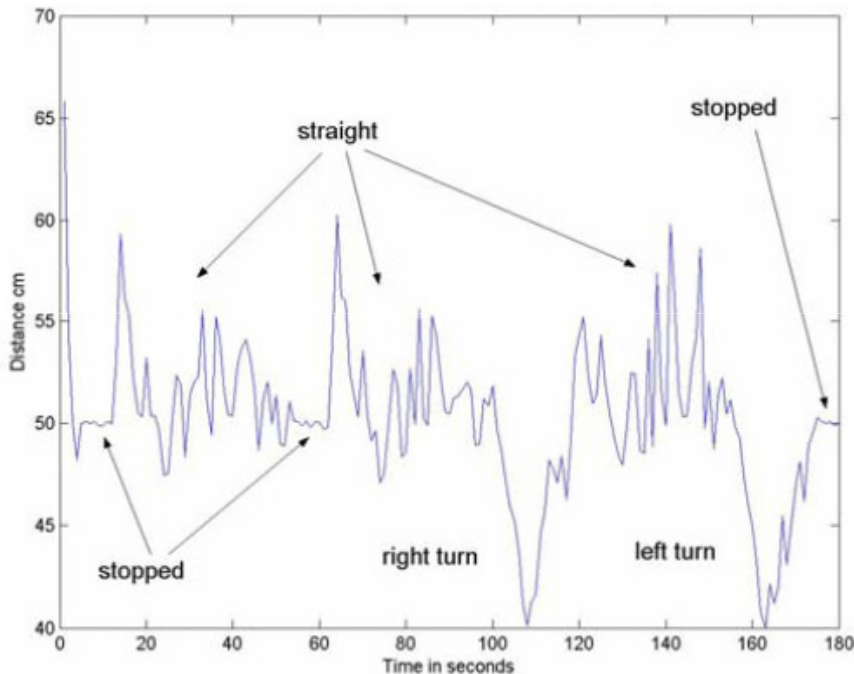
- Mission Decision
 - Keep $d=50\text{cm}$
- Task Planning
 - Turn, move
- Trajectory Gen
 - Turning pattern
 - Moving pattern
- Motor Control
 - Send commands
- Sensor Control
 - $d=?$, target direction?
- Knowledge Base
 - Physical dimensions
 - Speed, acceleration limits, etc



Performance Test

- Target was located at 66cm in front of the robot
- Target was kept unmoved for about 10s
- Target was moved forward for 40s
- Target was stopped for about 10s
- Target was moved forward for another 40s
- Target was turned right by 60° within 15s
- Target was moved forward for another 40s
- Target was turned right by 60° within 15s
- Target was stopped

Test Results



Results and Conclusion

- Max error = 10cm (acceptable)
- When target is stationary, robot can keep $d=50\text{cm}$, however, when the target is moving (at nonuniform speeds) robot finds it difficult to maintain $d=50\text{cm}$
- Huge errors are evident when the target takes turns
 - Multiple sensor readings \Rightarrow Perception problem
- When the target moves faster, robot finds it difficult to maintain distance (simply out of its capability)
- If there are other targets, robot will confuse, as it cant distinguish targets.

Design Issues

- Most appropriate mobile platform
- Most appropriate motors
- Motor controller capacity (ampere rating)
- Best sensor suit
- Accuracy of sensor readings
- Perception with multiple sensors
- Total weight of the robot \Rightarrow max acceleration
- Weight balancing, and dynamic stability
- Robustness of the robot

Useful Tips

- Firm electrical connections
 - No hand wound connections
- Tie up wires to mobile platform neatly. Bundle them whenever possible
- Don't leave moving parts on board (PCBs, batteries)
- Make a compartment for batteries, and use straps to tie up batteries to the platform.
- Make the platform as light as possible
 - Low power motors can be used

Useful Tips

- Use a fuse of max current rating of the motor at the battery +ve so that in case of a short cct, fuse will blow without damaging motors or electronic modules.
- Use on/off switches for each and every subsystem (sensors, motor drives, etc) so that your can check them without disassembling

Four Stages of Robot Building

- Designing
 - Take time to discuss, explore, and decide your best robot design. You have to consider the problem, cost, your capability in building the robot, available time
- Construction
 - Take time to construct the design in the proper way leaving provisions for convenient debugging and testing. Each member has to undertake to construct a piece of the robot' Each subsystem should work properly in isolation.
- Testing/debugging
 - Take time to improve the proper functionality of each subsystem when they are integrated and working together
- Training/customizing
 - Leave time to try the robot in competition field. Modify control algorithms and further improve performance.