Proceedings of Mechanical Engineering Research Day 2018, pp. 121-122, May 2018

Development and localization of a mobile robot

Nur Aqilah Othman[1,*], Muhammad Irfan Jaffar[1], Hamzah Ahmad[1], Mohd Hasnun Arif Hassan[2]

[1)] Instrumentation and Control Engineering (iCE) Research Cluster, Faculty of Electrical and Electronics Engineering, Universiti Malaysia Pahang, 26600 Pekan, Pahang, Malaysia.
[2)] Innovative Manufacturing, Mechatronics & Sports Lab (iMAMS), Faculty of Manufacturing Engineering, Universiti Malaysia Pahang, 26600 Pekan, Pahang, Malaysia.

[*]Corresponding e-mail: nuraqilah@ump.edu.my

Keywords: Mobile robot; localization

ABSTRACT – An autonomous mobile robot needs to have the capability to locate itself within an environment, besides the ability to avoid any obstacles during its movement. This paper covers the development of an autonomous mobile robot. It was equipped with two ultrasonic sensors for obstacle avoidance purposes. The mobile robot was tested within a static environment. The results show that the robot is capable of navigating itself in the defined environment without being provided with a prior map. In summary, the mobile robot was successfully developed, and its localization capability was achieved.

1. INTRODUCTION

Robotics field has achieved a great success today where robotic arms, for instance, are seen in almost all factories worldwide. Nonetheless, one of the drawbacks of robotics industry is the mobility of the robots itself. Most robots are fixed at a defined location and they are unable to move freely, thus limiting its function [1]. The world today is moving towards autonomous robots that can move freely within an environment without any help from human.

An autonomous mobile robot requires an accurate localization of its own position in different environments [2]. The difficulty faced are the inaccuracy of sensors and will affect the position tracking and global positioning. Localization errors might occur due to wheel slippage [3], wheel misalignment, internal and external noises, and inaccurate odometer. It is problematic when a mobile robot cannot locate its position accurately within the provided map due to the systematic and non-systematic errors [4].

An autonomous mobile robot must have accurate and precise information about the surrounding environment for it to make or decide any movements. The localization and mapping have become very important towards a fully autonomous mobile robot. An autonomous mobile robot needs to accurately locate its position within the environment without a prior map. This paper describes the development of an autonomous mobile robot within a static environment. It is a two-wheeled mobile robot with integrated on-board sensors such as encoder, IMU and two ultrasonic sensors. The functionality of the developed mobile robots was tested in a few experiments described in the subsequent sections.

2. METHODOLOGY

Figure 1 shows the developed two-wheeled mobile robot. Each wheel was connected to a DC geared motor with encoder to measure the distance travelled. The robot employs an Arduino Mega as its micro-controller, to which two ultrasonic sensors were connected for obstacle detection purposes. A six degree-of-freedom IMU was also installed to measure its orientation.

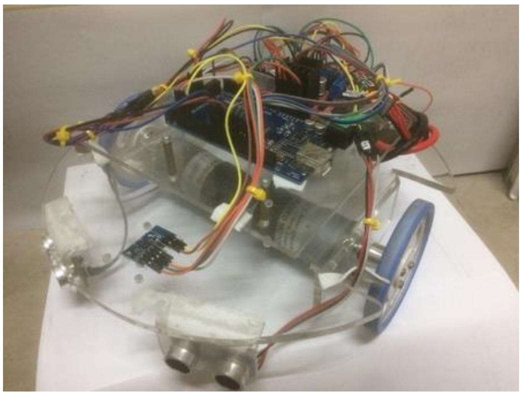

Figure 1 The developed mobile robot.

A unidirectional square path test was performed in counter-clockwise direction to evaluate the robot's localization capability. A square line path of 1 x 1 m was setup as shown in Figure 2. The perpendicular walls serve as a reference to measure the differences between its absolute and calculated position and orientation before and after the test run.

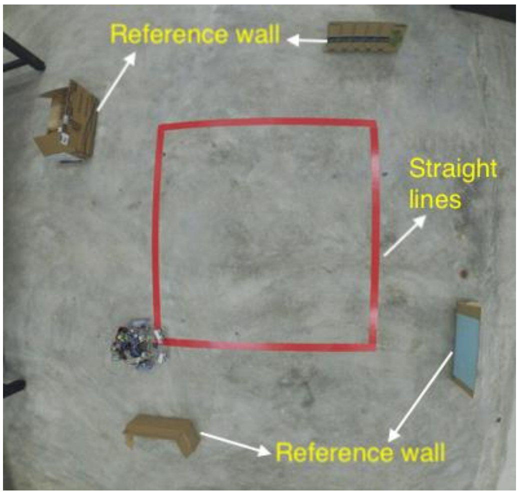

Figure 2 Mobile robot localization test.

3. RESULTS AND DISCUSSION

The function of the dual ultrasonic sensors is to measure the distance between the mobile robot and the obstacle. The range for the detection is about 20 to 4000 mm and its measuring angle is about 15°. An experiment was performed to evaluate the error of the ultrasonic sensor measurement by comparing the measured distance and the actual distance. It was seen that the distance measurement errors of the ultrasonic sensor throughout the testing were acceptable (less than 10%) as shown in Figure 3.

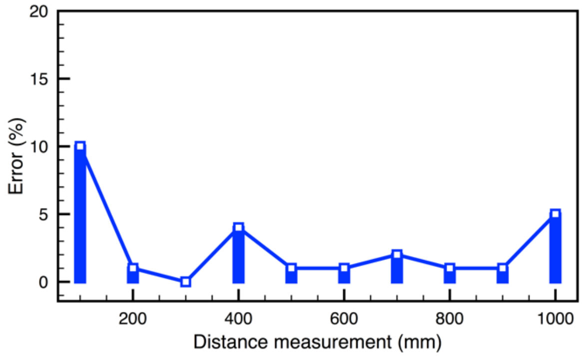

Figure 3 Ultrasonic sensor measurement error.

The measurement of the DC geared motor with encoder was also evaluated through an experiment. The mobile robot was set to travel for 1 m in 20 trials and the measured and actual distance were compared. Figure 4 shows the calculated error of the DC motor encoder measurement. It is apparent that the measured values are in a good agreement with the actual distance since the errors were less than 5%.

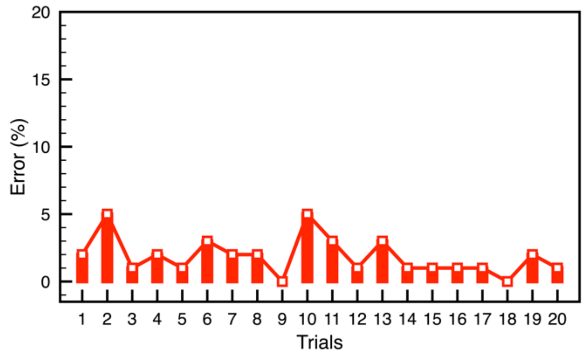

Figure 4 DC motor encoder measurement error.

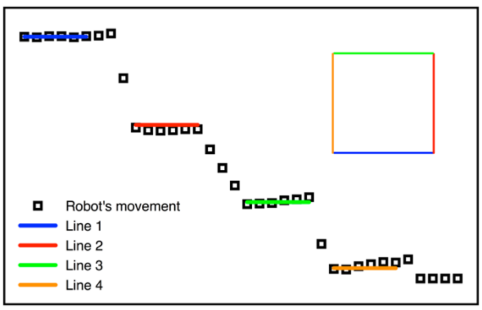

Figure 5 Robot motion for 1 lap.

The robot's localization capability was evaluated through a unidirectional square path test. There were four lines forming a square of 1 x 1 m. Figure 5 shows the path of the robot navigating on these lines. It is evident that the mobile robot was capable of tracking its own path without being equipped with a map of the surroundings.

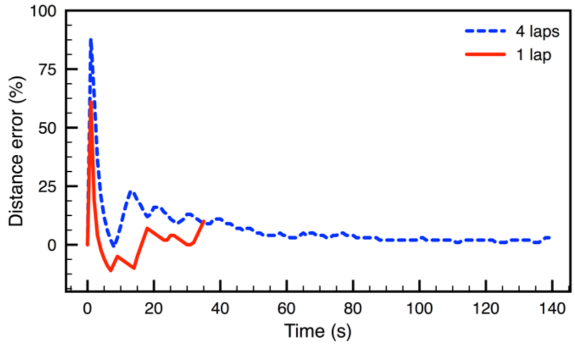

Figure 6 Distance measurement error.

We also measured the distance travelled by each wheel and calculated the differences to look at the errors. Ideally both wheel should travel the same distance in order for the robot to move in a straight path. It is seen from Figure 6 that upon initializing its motion, the robot had some difficulties moving in a straight path. But as it progressed, the errors were significantly reduced up to less than 10%. This is more evident in the four continuous laps movement.

4. CONCLUSION

An autonomous mobile robot was successfully developed. It utilises two ultrasonic sensors for obstacle avoidance purposes. The ultrasonic sensors and the DC motors were tested with all producing minimal errors of less than 10%. The robot was able to navigate its way in the unidirectional square path test without being pre-provided with a map. Slight distance measurement errors were recorded at the initial stage of the movement, but these errors were significantly diminished as the robot progressed. The future work should look into reducing the initial errors of the DC motors to ensure an accurate movement.

ACKNOWLEDGEMENT

This study was supported by the Universiti Malaysia Pahang (UMP) internal grant RDU170369.

REFERENCES

[1] Siegwart, R., Nourbakhsh, I. R., & Scaramuzza, D. (2011). *Introduction to autonomous mobile robots*. MIT press.

[2] Ahmad, H., & Othman, N. A. (2015). The impact of cross-correlation on mobile robot localization. *International Journal of Control, Automation and Systems*, *13*(5), 1251-1261.

[3] Betke, M., & Gurvits, L. (1997). Mobile robot localization using landmarks. *IEEE transactions on robotics and automation*, *13*(2), 251-263.

[4] Othman, N. A., & Ahmad, H. (2016). Examining the eigenvalues effect to the computational cost in mobile robot simultaneous localization and mapping. *Computers & Electrical Engineering*, *56*, 659-673.