Tele-operation communication system development for a differential-wheeled mobile robot for radiation field mapping

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Introduction

A major application of mobile robots is the monitoring of nuclear radiation levels in order to assist experts in the wake of cataclysmic nuclear accidents . The reported work is motivated by the goal of building an inexpensive, simple-to-implement tele-operation communication stack for a differential-wheeled mobile robot capable of indoor nuclear radiation monitoring. To study the performance of the robot, odometry error calculation with the University of Michigan Benchmark test (UMBmark test) [1] was conducted . In this paper the architecture of the developed communication system, the experimental setup and experimental data, are discussed in the subsequent sections. Finally, the conclusion of the work and future prospects are discussed.

System Architecture

The mechanical structure of the robot body is an nonfuncional Pioneer 3-DX model robot, with its electronic components removed. The most prevalent control method for wheeled robots is differential wheel drive. The key components that have been incorporated in the mobile robot platform are a Raspberry pi 3 platform, an Arduino Uno board, two DC motors with encoders. The schematic architecture is shown in figure 1. The encoders are directly coupled with two 12V DC motors. The DC motor and wheel gear ratio is 32:1. The encoder pulses per revolution is 5000. The mobile robot transfers and receives data with a computer via Wi-Fi communication by incorporating two LoRa (Long Range) transceiver modules .

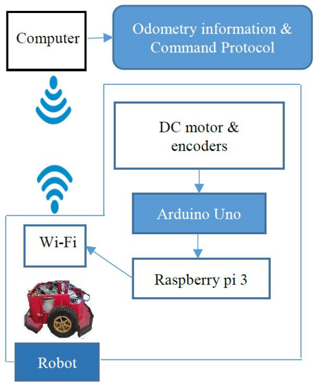

FIG. 1: Schematic diagram of the architecture of the robot Platform

The Wi-Fi data transfer rate is 2.4 GHz. The command is given from the computer to the Raspberry Pi 3 module. The Raspberry Pi 3 module communicates with the Arduino Uno via serial port communication with a band rate 19200.The system can record continuous remote logging data from the robot.

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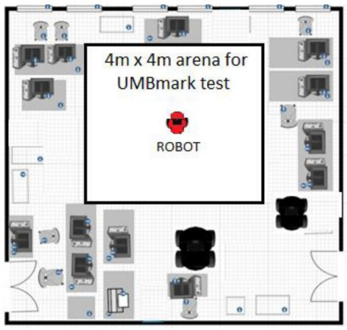

FIG. 2: The indoor environment for UMBmark test

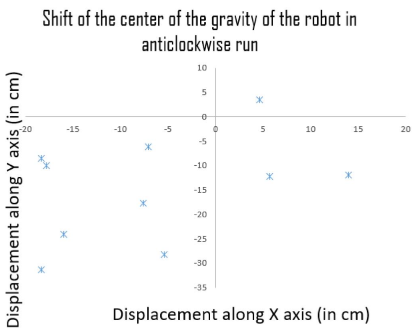

FIG. 3: Shift of the center of the gravity of the robot in anticlockwise run

Experimental Results

The University of Michigan Benchmark test (UMBmark test) is the standard calibration scheme for wheeled differential mobile robots, and it employs the final location errors of the bidirectional square test to eliminate systematic odometry errors. It is ought to be noted that the UMBmark methodology relies on the presumption that wheel diameters and wheelbase alone constitute the majority of errors, despite all other causes of errors becoming insignificant or eliminated. Performing this test on uneven, rocky terrain or surfaces with poor traction would yield erroneous results. Hence we have used a indoor environment 4m x 4m smooth ceramic tile surface for the experiments (FIG.2). Furthermore, the functionality of encoders and motors was tested beforehand.The UMBmark test's experimental results are plotted in figure 3 and figure 4. The systematic error in odometry accuracy was determined to be 36.8cm for anticlockwise motion. For anticlockwise rotation, the systematic error in odometry accuracy was found to be 20.1cm. In terms of real-world application, the highest possible error is the primary concern; hence, the value from the clockwise experiment or 36.8cm is chosen.

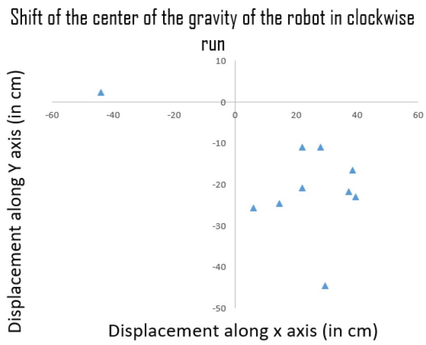

FIG. 4: Shift of the center of the gravity of the robot in clockwise run

Conclusion and future outlook

In this paper, we have presented the tele-operating stack development and odometry evaluation of a low-cost differential-drive robot. The measured odometry error is currently being corrected by using an MPU 9250 inertial measurement unit (IMU). Furthermore, the robot is being equipped a radiation detector for radiation detection in an indoor environment. Future plans call for creating an obstacle avoidance feature, for which the robot needs to be fitted with multiple sensors.

References

[1] Borenstein, Johann and L. Feng. "UMBmark : a method for measuring, comparing, and correcting dead-reckoning errors in mobile robots." (1994)..