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Development on low cost autonomous mobile robot based radiation detection system

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Introduction

In nuclear power plants and nuclear research facilities, radiation leakage is a very serious and hazardous problem. In emergencies like rector meltdown, humans cannot do the required task due to high exposure towards radiation. In disastrous radiation catastrophes, mobile robots can be used to help the experts in rescue or radiation monitoring missions. With this motivation, development of telecontrolled robots and autonomous robot systems [2] for monitoring of radiation on a pre-planned path has been done. Here we have reported our progress towards the development of a low-cost system using an autonomous robot for radiation monitoring. In the following sections we have described the mobile robot we have used (e-puck2), the calculation of systematic odometry accuracy using University of Michigan Benchmark test, sensor fusion of the robot using Kalman Filter.

E-puck2 robot and odometry accuracy test result

We have used a differential drive robot for our purpose named e-puck2. E-puck2 was developed by Michel Bonani and Francesco Mondada. Odometry is a very common position sensor for mobile robots.But it can accumulate errors due to many factors like unequal wheel diameter, uncertainty about the effective wheelbase, misalignment of wheels. The University of Michigan has developed a test procedure which has been widely used as a benchmark procedure for calculating systematic and non-systematic accuracy. We have conducted the University of Michigan Benchmark Test (UMBmark test) on our mobile robot. The attached image the basic experiment protocol(Fig1) of the UMBmark test is presented along with results (Fig.2,Fig.3) . The details of the procedure are described by Johann Borenstein et. al [3]The measure of odometric accuracy for systematic error using the UMBmark test was found to be 14.77mm for clockwise motion and 15.4mm for counterclockwise motion. As for practical application, we are concerned about the largest possible error in odometry. Hence, we have selected the value from a counterclockwise motion experiment.

Sensor fusion test result using Kalman Filter

Kalman filtering is an algorithm which does linear quadratic estimation of noisy measurements over time . It produces more accurate estimates of unknown variables. By using a system's known control inputs, dynamical model and sequential measurements from the sensors, it calculates a better estimate of the system's varying quantities. For this quality, this technique is extensively used in sensor fu-

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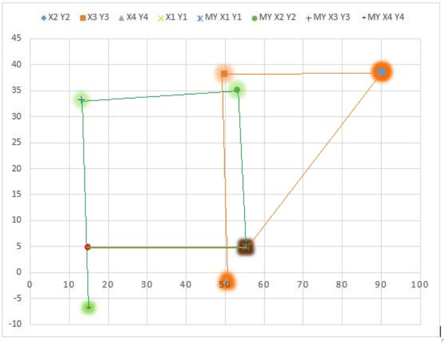

FIG. 1: Co ordinates of two counterclockwise runs of the robot

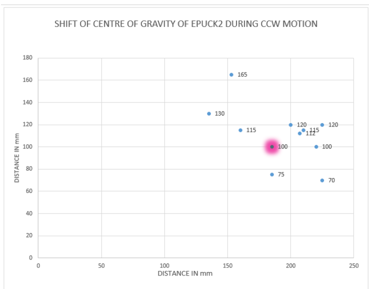

FIG. 2: Centre of gravity cluster during counter-clockwise motion

sion.

Epuck-2 has an inertial measurment (IMU-9250) consisting of 9 degrees of freedom (from gyroscope,magnetometer and accelerometre). The data from the sensors were very erroneous . Hence, we have employed techniques to get rid of errors. In the following graph (fig4), ori-

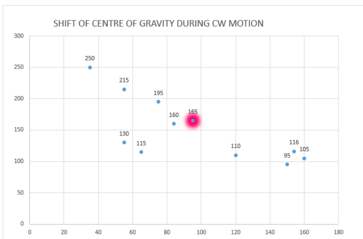

FIG. 3: Centre of gravity cluster during clockwise motion

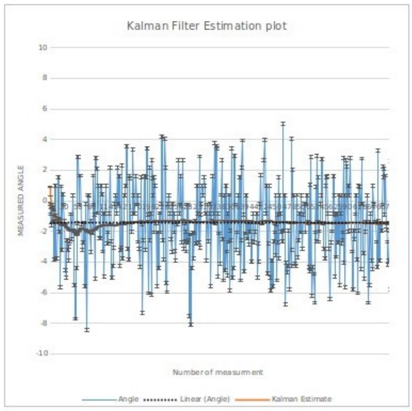

FIG. 4: Estimation of orientation of robot from IMU sensor data using Kalman Filter

entation of the gyroscope at static condition was kept at 1.5 degrees. After a few iterations, the noisy data from the gyroscope was corrected by implementing the Klaman filter.

Conclusion and future outlook

Here we are reporting successful odometry accuracy measurement and sensor data correction using the Kalman filter. This makes our robot a suitable candidate for low-cost and autonomous system development. Sensor fusion in the static condition of odometer and gyroscope sensor for the accurate and precise navigation of the robot has been achieved. We are working on localisation of the robot inside a radiation vault . For further development we have to employ a Geiger Mular counter mounted with the robot for radiation mapping.

References

[1] Development of autonomous radiation monitoring robots, Abd. Hafiz Zakaria et. al. ,2016 IEEE Symposium on robotics and intelligent sensors

[2] UMBmark: A Benchmark Test for Measuring Odometry Errors in Mobile Robots, Johann Borenstein et.al ,1995