Outdoor Robotic Localization

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Introduction

Robotic Localization is a vast area of research & implemented in different scales. Many researches are carried throughout the world to find optimum and most cost effective method of implementing a localization system. In these researches, technologies like Computer Vision, GPS, Wi-Fi, GSM, RFID and ultrasonic are used for the localization. The main concept of robotic localization is similar where it uses a known stationary position as the base and calculates the relative position with different technologies. Outdoor localization involves handling environmental ambient noises as well as adapting system to sudden changes in parameters such as light level variation. The motivation of this research is to address this issue and find an optimum trilateration algorithm for robotic localization. CV, Wi-Fi, GSM, RFID and Ultrasonic sensory localization uses trilateration algorithms. Trilateration algorithms are used for localizing robot in a limited area with a higher accuracy. Researchers are carried out in trilateration algorithm either using ultrasonic sensors or computer vision. Ultrasonic sensory trilateration involves higher error ratio due to variations of environmental air velocity, moisture level and air density. CV mainly lacks adjustability to light condition variations. Higher the accuracy in CV, greater the cost of implementation. This research is based upon combining both algorithm to get a higher accuracy output and making the algorithm viable with higher ambient noise with a low cost.

Methodology

Three stationary ultrasonic receivers was placed in known distance apart with a colour tag(red) (Figure 1). Robot was assembled with colour identification using a web camera *(to track the colour tag on the receivers)* and an ultrasonic transmitter (Figure 2). RF signal was initiated simultaneously with the ultrasonic burst which directed towards the receivers. The time taken for the ultrasonic burst to be received after receiving the RF signal was recorded for three receivers separately and distance from each station was calculated. Trilateration was used to predict the position and Kalman filtering was used to filter out the noises.

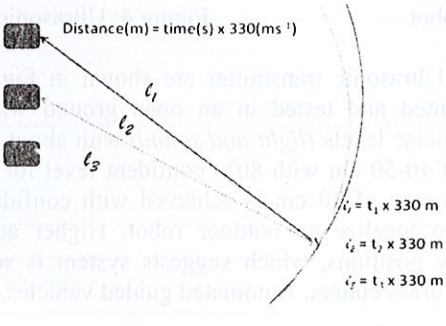


Figure 1: Wave propagation

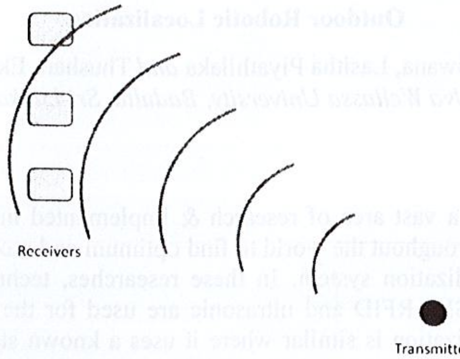


Figure 2: Distance calculation

Results and Discussion

Figure 3: Fabricated robot

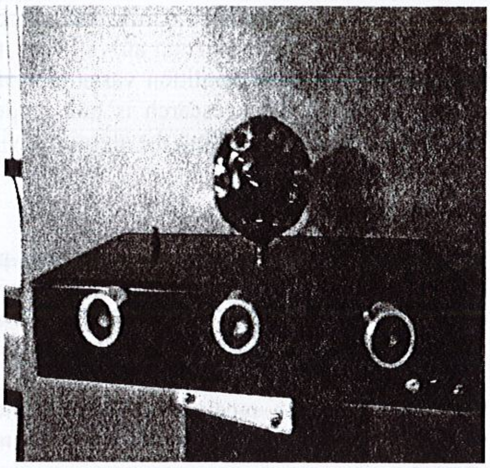
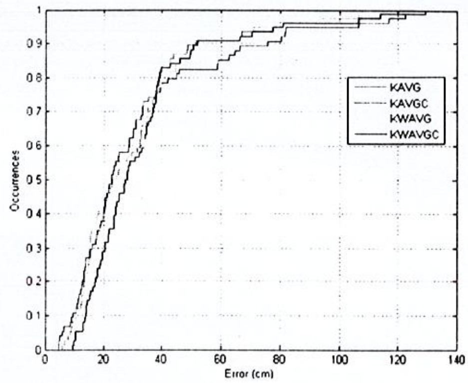


Figure 4: Ultrasonic transmitter

Fabricated robot and Ultrasonic transmitter are shown in Figures 3 and 4 respectively. System was implemented and tested in an open ground which has minimal obstacle disturbances but high noise levels *(light and sound)* with about 1000 m^2 area and was able to achieve accuracy of 40-50 cm with 80% confident level for stationary robot and while moving at 1 ms^{-1} accuracy of 60 cm is achieved with confident level of 80% which is acceptable accuracy to localize an outdoor robot. Higher accuracy of 40-50 cm was obtained for stationary positions, which suggests system is suitable for localizing slow moving robots such as grass cutters, Automated guided vehicles, combined harvesters etc.

Measurements were taken in several stationary positions *(50 positions)* to estimate the Root Mean Square Error with extended Kalman filters.

$$\text{RMSE} = \sqrt{\frac{\sum(\text{Actual Distance} - \text{Estimated Distance})^2}{\text{No of estimations}}}$$



Conclusion

Final results show that system has accuracy of 40–50 cm over 80% confident level for stationary robots and while moving at 1ms^{-1} accuracy of 60cm is achieved with confident level of 80% which is acceptable accuracy to localize an outdoor robot.

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