STRATEGY ENGINE FOR LOCALISATION

***Abstract*—**

I. Introduction

Recently, the use of robots in indoor environments has received significant interest in numerous applications. They are used in situations like disaster (earthquakes, chemical spills, nuclear accidents etc.), in industries, as assistive robots and in situations where human interactions is limited. These applications require efficient and cost effective indoor localization, navigation and mapping methods. One of the primary challenges in indoor environments is localization, and is important for the other two functionalities to work effectively. Therefore we primarily focus on indoor localization of robots.

For indoor localization, several technologies are used, like WiFi, Laser Rangefinders, cameras, IR, Ultrasound etc, or a combination of these. RF based techniques like WiFi and RFID are one of the commonly used solutions. WiFi is easy to use since most indoor spaces are equipped with WiFi, and is also a cheap technology. WiFi based localization techniques include trilateration, dead reckoning and fingerprinting. The former two approaches are easy to implement, but lack accuracy. In fingerprinting both deterministic approaches like kNN and probabilistic techniques are used. While the accuracy of these approaches are better, they involve a lot of effort for the radio map generation. Laser based approaches while providing accuracy, are very expensive. Other technologies like IR and Ultrasound require extensive instrumentation. Camera based approaches are complex to implement and fail in low light conditions and presence of occlusions.

The use of Inertial Measurement Sensors(IMU) for localization has gained more popularity. Low cost, small dimensions and low power consumption are the reasons for their popularity. The IMU sensors are used extensively in smartphone based localisation. They use accelerometer to determine the step length and finally distance, while they use the gyroscope sensor to determine the orientation of the smartphone. This method has been extended to the mobile robots. The distance moved by the robot is calculated either by the motor encoders or the accelerometer sensor and the orientation is calculated by the gyroscope and magnetometer. The above methods were subject to the application of filters like Kalman filter, extended Kalman filter , particle filter , complementary filter etc. to give the estimation of position and orientation. But the results did not give the expected outcome as the accelerometers are sensitive to the drifts and suffers from measurement error while the gyroscope sensor suffers from static drift. And encoders have their slippage ,measurement etc. errors. To get a better result, the researchers put forward the idea of sensor fusion where more than one inputs are taken from the existing sensor based localisation systems and are combined in a efficient way to get a better output. For example,one approach combines the IMU sensors and WiFi RSSI,to find the position of the robot. Similar to the above mentioned method many methods based on sensor fusion were developed.

Even though a lot of work has been done in the area of localization, some critical issues need to be explored and resolved. The issues which need to be resolved are many: First, many methods are infrastructure dependant that is they require WiFi ,RFID. So, this method becomes void in situations where there is no WiFi etc. Second, accelerometers accumulate measurement error over time, gyroscopes accumulate drift errors over time and encoders accumulate errors due to slippage etc. These errors affect the accuracy of the position and orientation obtained from the dead reckoning method. Third, the methods that require laser, camera etc require huge installation costs. Fourth, generating a unified framework for the localization system becomes cumbersome as the sensors and physical platforms vary significantly from environment to environment.

Our paper focuses on designing a strategy engine which decides which localisation method is best for the scenario. The existing methods work under the assumption that it works well in all the scenarios but that is not the case. Some approaches work well in certain situations and fail in other situations. Here, we break this assumption, and determine the situations where the corresponding sensor combination gives better result. With the experimental results, a strategy engine is designed. The Strategy engine determines the localisation method to be used for the scenario in which the robot is present currently. The localisation methods to be used in the strategy are IMU based and distance sensors(infrared and ultrasonic) based localisation.This approach provides better results and does not include the need of external infrastructure as we determine the position of the robots with the help of only IMU sensors.

The contribution to the paper are: First, detailed experimental analysis of the methods to be used in the strategy engine for predetermined scenarios. And check for their accuracy and error rate. Second, developing a strategy engine based on the the experimental results of the methods. Third, testing the strategy engine algorithm in an indoor environment.

II. Related Work

The fundamental requirement for indoor mobile robots is localization. Many localization techniques have been developed and implemented in robots over a period of time. Common indoor localization methods for robots rely on external infrastructures and sensors which are part of the robot. Localization techniques use RF technologies such as RFID ,WiFi and bluetooth, While other prevalent techniques that operates with infrared and ultrasonic sensors rely on additional external infrastructure like RF antennas and ultrasonic transceivers placed in the environment. On the other hand, techniques that use cameras, laser range finders or inertial sensors do not rely on external infrastructure.

In the former set of approaches, RF based localization is one of the most prevalent techniques and is easy to implement. In RF based approaches, the robot requires external infrastructure like antennas/reference tags placed in the environment for communication with the tags or receiver which is carried by the robot[1]. RF based localization techniques can be either finger printing or non-finger printing approaches.The non-finger printing approaches include the trilateration method. The trilateration method estimates the position of the target using three reference points [2]. Received Signal Strength Indication (RSSI) from the Reference points helps in determining the distance between the moving object and the reference point location. [3].The WiFi fingerprinting technique compares the RSSI observations made by the mobile node with a trained database to determine the location of the moving object [4]. This method involves two phases: the offline phase and the online phase. In the offline phase, the RSSI fingerprints are taken at different target locations throughout the area of interest and recorded in the database.In the online phase, the mobile device first measures the prevailing RSS value and then matches it with the database[5].The K-NN (K Nearest Neighbors)[21], Bayesian[22,23] and decision tree methods[24] are representative techniques used in the fingerprinting approach.The approach used for localization with the help of RFID tags, is to deploy a large number of RFID tags in the environment which act as reference points. Each reference point will be recorded with signal strength to an RFID reader. So, when a new RFID tag enters the space its signal strength will be compared with the reference points to determine its location[6]. Another technique is using the algorithm which fuses an RFID system with an ultrasonic sensor[7]. The main disadvantages of the above techniques is that, in trilateration method,the accuracy of the position of the robot is not accurate while in fingerprinting technique,a lot of location fingerprints must be collected at each of the points in the site during offline phase which is extremely tedious and time consuming. In RFID based localization, accuracy is a major issue when reference tags are not used. In addition, high accuracies have been demonstrated for smaller and controlled environments, and the performance of these algorithms for larger environments is yet to be explored.

The techniques that do not rely on infrastructure involve the use of laser range finders, cameras and inertial sensors. Vision based localisation approaches can be classified according to the method used for representing the image. The approaches are based on global descriptors, local features, Bag-of-Words(BoW) and combination of these[8]. In global descriptors approach,the image is represented by a general descriptor computed using the entire visual information as input.The local descriptors approach involve the use of interest points. Interest points are found in the image and then a patch around this point is described in order to identify them in other images while methods based on the BoW algorithm involve the use of local features. They are quantized according to a set of feature models called visual dictionary, representing images as histograms of occurrences of each word in the image. And methods based on combined descriptors use the combination of the above methods to form a new solution. The demerits of vision based approach is that,these methods are usually prone to occlusions, changes in scale, rotation and illumination[8].The methods used to locate a robot via laser range finders is that, a laser emits rapid pulses that are usually reflected off a rotating mirror from which the time of flight is measured and is used to calculate distances. This is performed at high rates, obtaining dense point by point distance measurements of the environment for the purpose of map building. This can either be compared to a prior knowledge, if available, or to acquire new perception[16..20].The main issue with this method is that Laser range finders are expensive.

The use of low-cost sensors such as accelerometer and gyroscope for localization has gained popularity. Recent research work use basic inertial sensors present in smart phones for localization purposes[9][10].The technique used in smartphones, is that the accelerometer sensor values are used to estimate the number of steps taken by the person holding the smartphone, and gyroscope values are used to determine the direction the person takes. The values from the sensors are sensitive and hence errors arise. The errors are removed to an extent with the help of filters like particle, complimentary, kalman etc. The same methodology is also used in localization of the robots[11]. Using only one of these sensors is insufficient to provide desired accuracies, since each of them have high error rates, even with filters. So it is essential to account for these errors and increase the performance; a sensor fusion based approach can help achieve this [12][13]. The sensor fusion methods combine both accelerometer and gyroscope values, and the application of filters to the combined sensor values to remove the noise/error. In [25...28], the sensor data from encoders, accelerometer, gyroscope and vision sensor data are combined with kalman filter to obtain the location of robot. The RSSI and IMU based localization technique is explained in [29]. Even after combining the sensor values, there is still error in the finding the exact position of the robot.

Many research work is still going on to find an error-free solution in localising the robot. The complexity of the environment, the errors from the sensors and the infrastructure dependence make the robot localization problem ill posed. So,the paper focuses on designing a strategy engine to determine the best possible localisation method. The localisation methods included in the strategy engine are: encoders, Gyroscope, combination of both encoders and gyroscope, combination of accelerometer and gyroscope and distance sensors based localisation.

III. Conclusion

Appendix A
Proof of the First Zonklar Equation

Some text for the appendix.

Acknowledgment

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References

[1] H. Kopka and P. W. Daly, *A Guide to LaTeX*, 3rd ed. Harlow, England: Addison-Wesley, 1999.

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