STRATEGY ENGINE FOR LOCALISATION

***Abstract*—**

I. Introduction

Robotic indoor localization, is the method in which the position and orientation of the mobile robot is determined with respect to the indoor environment. Robotic localization form the important part of an autonomous mobile robot. The autonomous robot systems are used in many 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. In order to get the best out of the applications mentioned above, there is a need for accurate and efficient localization algorithms. Over the past decade , there has been significant developments in the mobile robot localization. But, it still remains a open problem to achieve efficient and robust localization.

Robotic localization techniques has been implemented with the help of sensors embedded in the robot. The optical encoders and the Inertial Measurement Unit(IMU) sensors has been used in the dead reckoning method. Ultrasonic systems, camera and laser based systems has been used in map making and self localization. Some localization methods use active beacons such as landmarks(position is known with respect to environment). Distance sensors(Infrared and ultrasonic) has also been used to avoid the obstacles in the environment and help in localization of the robot. These methods do not provide accurate results because every sensor and the localization method has its own limitations. Therefore, it is unlikely that one sensor or one architecture will provide a uniformly superior solution for localization problems.And Robots tend to depend heavily on the dedicated sensors which often tend to be unreliable. So,sensor fusion techniques have been proposed which will solve the problem to a certain extent.

Sensor fusion is the process in which the data from the sensors are fused to a combined estimate, resulting in a better solution to localization. The different types of sensor fusion techniques are complimentary, competitive and cooperative. The simple instance of sensor fusion would be taking the mean of two sensor values provided they have the same belief. But this will not work when the system is complex and requires precise data. Over the years there have been many sensor fusion approaches proposed with a considerable degree of success. However, every sensor and the localization algorithms used has its own limitations, due to which we believe no localization algorithm is universally applicable to all situations.

In this paper, we develop a strategy engine. The strategy engine decides the best localization algorithm to be used for the current scenario. The decision taken by the strategy engine is based on the experimental analysis and results of the localization algorithms. The methods/algorithms used in this paper are: position and orientation estimates from encoders, orientation from gyroscope, Application of kalman filter to the angles obtained from encoders and gyroscope and use of distance sensors(infrared and ultrasonic) to determine the position and orientation estimates. The concept of decision tree is used to determine which localization approach is used for the current situation. The overall result of this architecture will be better as we use the best method in each scenario.

The contribution to the paper are: Integration of a sequence of observations from a number of different sensors into a single estimate and identification of the right combination of sensors. Evaluation of the sensor fusion methods over the variety of indoor scenarios and detailed analysis of the obtained results. And the efficient implementation of the strategy engine.

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. These IMU sensors are used in dead reckoning method. The accelerometer is used to find the distance while gyroscope and magnetometer is used. Accelerometers are sensitive to drifts and suffers from measurement error.Gyroscope also suffers from static drift. And magnetometer produces error if magnetic interference occurs. The errors are removed to an extent with the help of filters like particle, complimentary, kalman etc[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 in this context is the translation of different sensory inputs into reliable estimates. The types of sensor fusion are: complimentary, competitive and cooperative. In complimentary fusion, sensors which are not dependant on each other are fused to give a estimate. For example, positioning of cameras at distinct points of the room and combining them to give us a estimate. The competitive approach fuses sensors which give the same information. Example of this approach is fusing the orientation estimate obtained from both encoders and gyroscope. The cooperative approach combines sensors to get a new estimate which cannot be obtained by using a single sensor alone. Example is using the output from the cameras placed at distinct viewpoints to obtain a three dimensional view. These approaches provide better results. But due to limitations each sensor and algorithm poses there is no localisation system which is applicable to every situation.

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 make the robot localization problem ill posed. So,In our paper we design a strategy engine to determine the best possible localisation method. The decision is based on the experimental analysis and results of the methods.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. The algorithm used in strategy engine for making decisions is the decision tree. The strategy engine gives us better results.

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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