Design of Autonomous Navigation system for Mobile Robot using vSLAM Algorithm and Distributed Filter techniques

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Abstract: **Simultaneous localization and mapping (SLAM) algorithm for mobile robots is a feature problem in the field of robotics. The determination of the SLAM problems also has gained significant research momentum in recent times. In this paper, a low cost and robust navigation system that can guide the autonomous mobile robots in known as well as unknown environment is presented. Simultaneous Localization and Mapping means the robot can simultaneously determine its position and reconstruct the surrounding environment. In this paper, vision-based SLAM method to improve navigation performance of mobile robot has been used, which has used two encoders to calculate its position. To overcome this limitation, of obtaining navigation information from GPS navigation, DR (Dead Reckoning) system is required. The navigation error is also increased in DR system because of accumulation of sensor error and noise.**

Keywords – Vision based SLAM (vSLAM).Distributed Filter, Navigation technique

I.INTRODUCTION

Simultaneous Localization and Mapping (SLAM) is the problem of a robot being autonomously able to build a map of an unknown environment and simultaneously localize itself in the environment. This ability makes a mobile robot truly autonomous. While performing Simultaneous Localization and Mapping (SLAM), the robot observes the environment around it and detects the position of some features in the environment. Some of the detected features serve as landmarks for the Simultaneous Localization and Mapping (SLAM) process. The estimation of positions of these landmarks constitutes the mapping part of Simultaneous Localization and Mapping (SLAM) process. As the robot moves, it observes the landmarks again. Currently observed landmarks are then matched with the previously unknown landmarks and discrepancy between the expected and currently measured positions of landmarks is used to adjust the estimate of robot position, this is the localization part of Simultaneous Localization and Mapping (SLAM). Classically, laser and sonar sensors where used for the perception of environment and thus performing Simultaneous Localization and Mapping (SLAM). Simultaneous Localization and Mapping (SLAM) using vision sensors. Visual Sensors/Cameras provide rich information.

An Autonomous Navigation System which is able to do work on its own operation means it does not depend on other system to do its work. The SLAM technique refers to Simultaneous Localization and Mapping (SLAM). In this system the vehicle simultaneously localize the position and built a map as well depends on the information which is gathered .

II. THE SLAM PROCESS

2.1 The SLAM process consists of a number of steps.

The goal of the process is to use the environment to update the position of the robot. Since the odometry of the robot (which gives the robots position) is often erroneous. Laser scans can be used of the environment to correct the position of the robot. This is accomplished by extracting features from the environment and reabsorbing when the robot moves around. An EKF (Extended Kalman Filter) is the heart of the SLAM process. The EKF keeps track of an estimate of the uncertainty in the robots position and also the uncertainty in these landmarks it has seen in the environment. An outline of the SLAM process is given below.

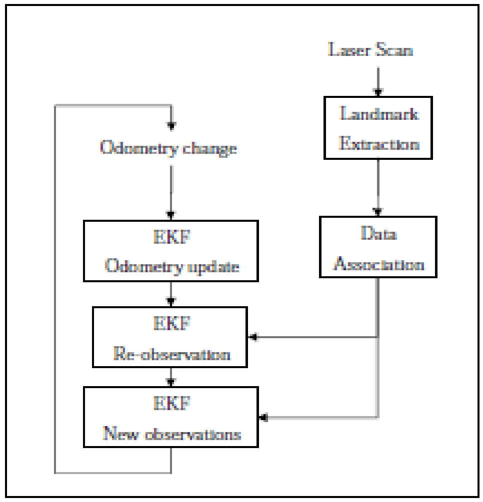


Figure: 1 Overview of the SLAM process

When the odometry changes because the robot moves the uncertainty pertaining to the robots new position is updated in the EKF using Odometry update. Landmarks are then extracted from the environment from the robots new position. The robot then attempts to associate these landmarks to observations of landmarks it previously has seen. Re-observed landmarks are then used to update the robots position in the EKF. Landmarks which have not previously been seen are added to the EKF as new observations so they can be re-observed later. It should be noted that at any point in these steps the EKF will have an estimate of the robots current position.

2.2 The ekf

The Kalman filter has long been regarded as the optimal solution to many tracking and data prediction tasks. Its use in the analysis of visual motion has been documented frequently. The filter is constructed as a mean squared error minimiser, but an alternative derivation of the filter is also provided showing how the filter relates to maximum likelihood statistics. The purpose of filtering is to extract the required information a signal, ignoring everything else.
The Extended Kalman Filter is used to estimate the state (position) of the robot from odometry data and landmark observations. The EKF is usually described in terms of state estimation alone (the robot is given a perfect map). That is, it does not have the map update which is needed when using EKF for SLAM. In SLAM a state estimation

2.3 Navigation system

Inertial navigation is a well-established technique which has taken key roles in the aerospace industries, as well in other areas such as undersea navigation or dynamic positioning systems. It has also recently emerged as an enabling technology under the forms of MEMS (Micro-machines electromechanical systems) sensors in numerous low-cost applications (ground robotics, cell-phones, among others). With MEMS sensors, those drift appear over short time periods. Inertial navigation system is introduced focusing on strap down systems based on MEMS devices. A combination of measurement and simulation is used to explore the error characteristics of such systems. For a simple inertial navigation system (INS) based on the Xsens Mtx inertial measurement unit (IMU).

2.4 System Modeling

Figure 2 shows a simple mobile robot platform having only planar dynamics. It has vision sensor and two encoders. Vision sensor acquires image continuously, then feature points are selected and tracked. The encoders are equipped on wheels and provide wheel rotation data. Given the information about wheel radius, distance between two wheels and pulses per rotation of encoder, range and heading information can be numerically computed.

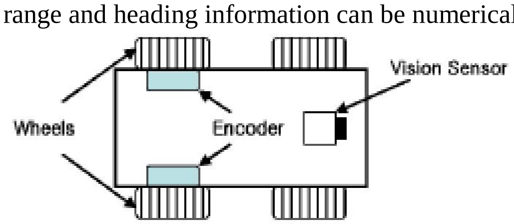


Figure: 2 Mobile Robot equipped with encoders and vision sensor.

2.5. Fast local cross-correlations of images

Cross-correlations are found everywhere in digital signal processing. We use cross-correlation to compute filters that shape one signal to another, and to estimate relative shapes between two signals. to computer prediction error filters, and to estimate orientation of features in multi-dimensional images.

The cross-correlation of two real continuous functions, $\emptyset_{xy}$ is defined by

$$\emptyset_{xy}(t) = \int_{-\infty}^{\infty} x(\tau - t)\, y(\tau)\, d\tau \qquad (1)$$

If we compare it to convolution

$$x(t) * y(t) = \int_{-\infty}^{\infty} x(t - \tau)\; y(\tau)\, d\tau \qquad (2)$$

We can see that the only difference is that for the cross correlation, one of the two functions is not reversed. Thus,

$$\emptyset_{xy}(t) = x(-t) * y(t) \qquad (3)$$

Since the operation of time reversal is the same as taking the complex conjugate in the frequency domain, we can write

$$\emptyset_{xy}(t) = FT[\varphi_{XY}(T)] = X(f) * Y(f) \qquad (4)$$

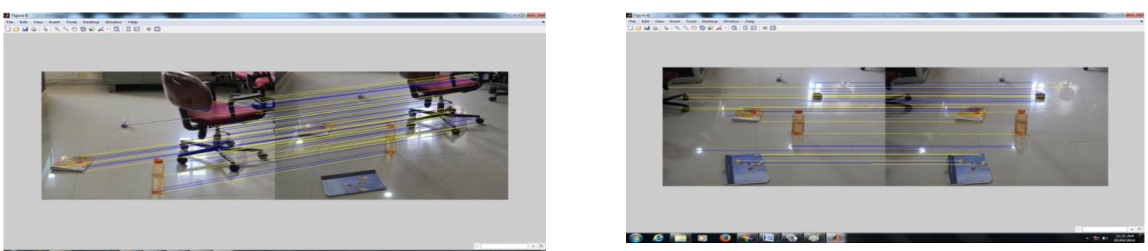
Unlike convolution, cross-correlation is not commutative but we can write

$$\emptyset_{xy}(t) = \emptyset_{xy}(-t) \qquad (5)$$

In Matlab cross-correlations are computed with the function xcorr which works in the frequency domain. Note that to obtain the discrete version of φxy as defined by equation (6), one reverses the arguments (i.e., one calls phixy = xcorr(y,x)). xcorr also pads the end of the shorter input with zeros so that they are the same length. Since Matlab cannot have zero or negative indexes the cross correlation sample with zero lag is the central element in the output vector. An alternate way of doing the cross correlation without padding with zeros is using the conv command (phixy = conv(y,x(end:-1:1)))

III. EXPEREMRNT AND RESULTS

Our simulation carried out using MATLAB software. This gives us correlation between two images. From which we can calculate the percentage correlation between one reference image and other images. SIFT method is used for correlation between two images. The chart of percentage correlation is as shown in table (1). Our second simulation result gives us edges of the different images using CANNY edge detection method. The simulation result for edge tracking,pose estimation localization and mapping of mobile robot for navigation system by using distributed kalman filter & SLAM technique is given in figure no.- 4,5and 6 simultaneously.



(a) (b)

Figure: 3- a,b,c,d are the experiment results for Image correlation method used for pose estimation of mobile robot.

Table - 1 Calculated Percentage Correlation for pose estimation of mobile robot

Reference Image	New Image	% Correlation calculated
1	1	100
2	3	20
4	5	90
6	7	0

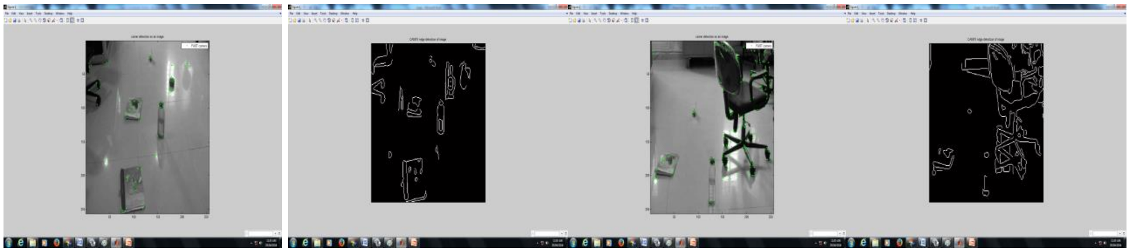


Figure: 4 Edge Tracking Method for Localization of Mobile Robot

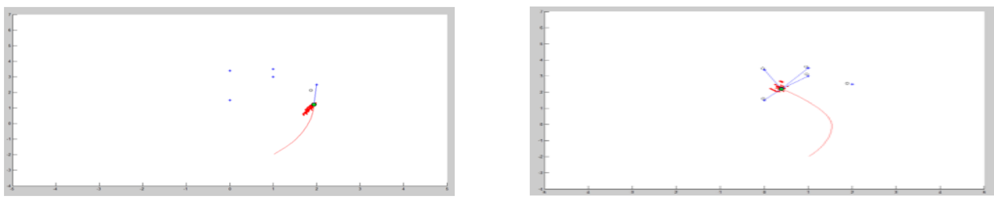


Figure: 5 Simulation result for pose estimation of mobile robot

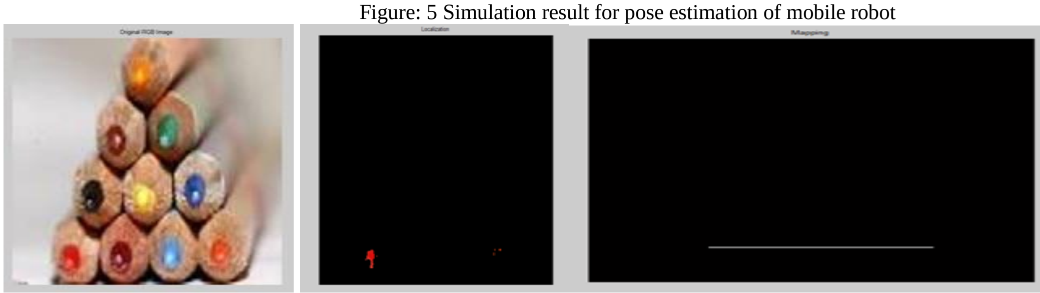


Figure: 6 Simulation results for mapping between two red dots in the given image

IV. PROTO TYPE DESIGN FOR SELF LOCALIZATION OF MOBILE ROBOT

In this paper the Scout-II robot as a mobile robotics platform by Dr Robot Inc [15]. Scout –II is a WMR for research. Scout-II uses Wi-Fi (802.11b/g) for communication. The dimensions of Scout-II are 43.0 cm x 38.0 cm. Scout-II sends all sensors reading at rates of 10Hz to a server.

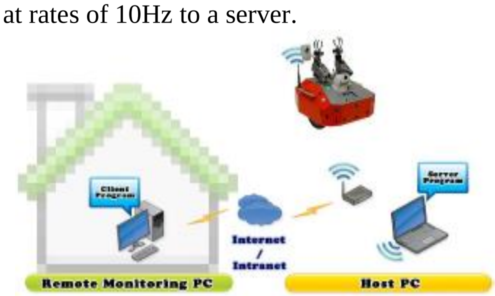


Figure: 7 A block diagram of self Localization of mobile robot using image correlation and vision based SLAM technique

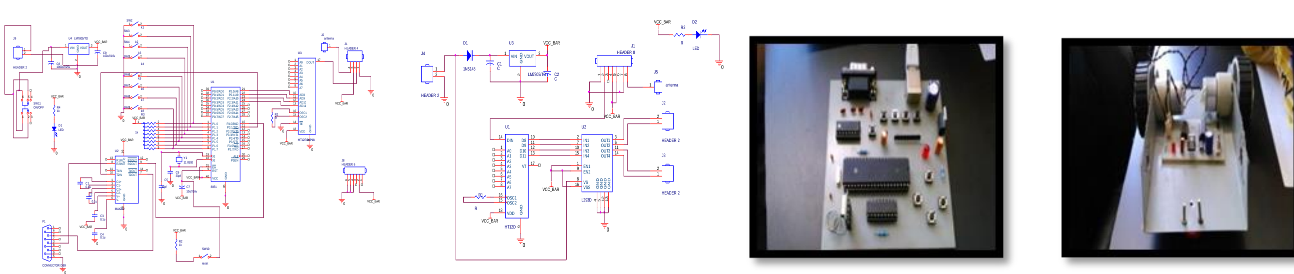


Figure 8 – A proto type design for Self Localization of mobile robot for autonomous navigation system along with Tx .and Rx, circuits

From the figure no 8 the prototype design of autonomous navigation system for mobile robot was design along with transmitter and reception circuit the MATLAB as a programming environment, and the wireless communicated respectively up to the range of 213 feet (56 meter) indoor.

V. CONCLUSION

In this paper, vSLAM and encoder integrated system is presented for mobile robot navigation. By considering the nonlinear measurement model and feature point availability around trajectory, distributed particle filter approach is applied. The image correlation method proposed for calculating the pose of mobile robot. From a practical perspective, it is a required for the SLAM algorithm to be both robust to radiometric variations as well as accurate. However, in general, the achievement of both this requirement is not trivial. Method such as image correlation has achieved robustness to some extent

REFERENCES

[1] Sheng Fu, Hui-ying Liu, Lu-fang Gao and Yu-xian Gai, "SLAM for Mobile Robots Using Laser Range Finder and Monocular Vision", IEEE Int, Conf. Mechatronics and Machine Vision in Practice, December 2012

[2] Mitch and Salah Sukkarieh, “Bearing-OnlySLAM for an Airbone Vehicle”, Australian Conference on Robotics and Automation, 2014

[3] Edward Rosten and Tom Drummond, "Fusing points and lines for high performance tracking”, IEEE Int. Conf. Computer Vision, October 2011, pp. 1508-1511

[4] J. Leonard and H. F. Durrant-Whyte, "Simultaneous map building and Localization for an autonomous mobile robot," IEEE Int. Wkshp. Intell. Robots Syst.,Osaka, Japan,

[5] P.-J. Bristeau, E. Dorveaux, D. Vissière, and N. Petit, “Hardware and software architecture for state estimation on an experimental low-cost small-scaled helicopter,” Control Engineering Practice, vol. 18,

[6] Jonghyuk Kim and Salah Sukkari, "SLAM aided GPS/INS Navigation in GPS Denied and Unkown

[7] Mitch and Salah Sukkarieh, "Bearing-Only SLAM for an Airbone Vehicle", Australian Conference on Robotics and Automation,

[8] Environments", The International Symposium on GNSS/GP Jiang Yan, Liu Guorong, Luo Shenghua, Zhou Lian, “A Review on Localization and Mapping

[9] Dae Hee Won, Sebum Chun, Sangkyung Sung, Taesam Kang and Young Jae Lee, “Improving Mobile Robot Navigation Performance using Vision based SLAM and Distributed Filters,” 2012 International Forum on Information Technology and Applications.

[10] Adams, M.D., Sensor Modelling, Design and Data Processing for Autonomous Navigation. World Scientific Series in Robotics and Intelligent Systems. Singapore, World Scientific Publishing Co. Ltd.,

[11] Borenstein, J., Everet,t H.R., Feng, L., Navigating Mobile Robots, Systems and Techniques. Natick, MA, A.K. Peters, Ltd., C, Siciliano, B., and Bastin G. (editors), Theory of Robot Control. New York, Spinger-Verlag,