International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 07 Issue: 03 | Mar 2020 www.irjet.net p-ISSN: 2395-0072

Autonomous Simultaneous Localization and Mapping

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Abstract — From undiscovered forests to underwater caves to planetary bodies such as Moon or Mars, exploring and discovering new places has always been a passion of many. Exploring and mapping these various terrains would be much better and convenient if we did not have to put the life of men in danger. This report describes the various AI and ML algorithms that can be used for localization and mapping of any area, without putting the life of men in danger. These algorithms are based on the features extracted from the video captured by the camera.

Keywords—Localization, Mapping, Machine learning algorithms, Image processing

1. Introduction

Autonomous Simultaneous localization and mapping (SLAM) is the process of constructing a map using a robot that explores the environment while using the map it develops. SLAM is technique behind robot mapping. The robot draws a course in an area, but at the same time, it also has to figure out where it is located in the environment. The process of SLAM uses a complex array of computations, algorithms and sensory inputs to move around an unknown environment or to modify and update a map of a previously known environment. SLAM enables to explore surroundings where the environment is too dangerous or small for humans to map.

SLAM is similar to a person trying to find his way around an uncharted place. First, the person looks around to find recognizable signs. Once the person observes a familiar landmark, he can figure out where he is in relation to it. If the person does not identify the landmarks, he will be labelled as lost. However, the more that person examines or monitors the environment, the more landmarks the person will know and begin to build a mental picture, or map, of that environment. The person may have to explore the environment several times before becoming familiar with an unknown place.

In this project we have used image processing to determine the environment, from the data extracted from the video that is captured from the camera that is attached to the robot. We use several AI and ML algorithms to map the surrounding that the robot is in.

This report can be used by geologist, military or common man to understand the layout of the ground.

In the same way, a SLAM robot tries to map an unknown environment while figuring out where it is at. The difficulty comes from doing both these things at the same time. The robot needs to figure out its location before answering the question of what the environment looks like. The robot also must figure out where it is at without the advantage of already having a map.

It would be immense help if the process of Topological and Environmental mapping would be automated somehow without putting human life in danger in some cases. In the beginning this appears to be a chicken-and-egg problem there are various algorithms that are used for solving it, at least approximately, in tractable time for certain surroundings. SLAM algorithms are custom-made to the accessible resources, hence not aimed at excellence, but at operational compliance.

The main problem of slam is that it is a chicken-egg problem:

• A map is needed for localization and

• A pose estimate is needed for mapping

2. Literature Survey

In paper[1] : **H. Durrant-Whyte and T. Bailey**, proposed a system for SLAM. To the probabilistic SLAM problem involve finding an appropriate representation for both the observation model and motion model that allows efficient and consistent computation of the prior and posterior distributions in and. By far, the most common representation is in the form of a state-space model with additive Gaussian noise, leading to the use of the extended Kalman filter (EKF) to solve the SLAM problem. One important alternative representation is to describe the vehicle motion model in as a set of samples of a more general non-Gaussian probability distribution. This leads to the use of the Rao-Blackwellized particle filter, or FastSLAM algorithm, to solve the SLAM problem. While EKF-SLAM and FastSLAM are the two most important solution methods, newer alternatives, which offer much potential, have been proposed, including the use of the information-state form

In paper[2]: Sebastian Thrun, proposed a system for SLAM. We presented the FastSLAM algorithm, an efficient new solution to the concurrent mapping and localization problem. This algorithm utilizes a Rao-Blackwellized representation of the posterior, integrating particle filter and Kalman filter representations. Similar to Murphy's work, FastSLAM is based on an inherent conditional independence property of the SLAM problem, using Rao-Blackwellized particle filters in the estimation. However, Murphy's approach maintains grid maps with discrete values similar to occupancy grid maps [12], hence does not address the common SLAM problem of estimating continuous landmark locations. In FastSLAM, landmark estimates are efficiently represented using tree structures

In paper [3]: H. Choset and K. Nagatani have formulated a new approach to SLAM of unknown regions using a topological map annotated with some geometric features. We term this procedure T-SLAM. The specific map used in this work is the GVG, the locus of points equidistant to two obstacles in the plane, but this work is general to other topological maps. Already, prior work has rigorously shown that the GVG is sufficient for motion planning. Therefore, constructing the GVG is akin to provably complete exploration because once the robot knows the GVG it can plan a path between any two locations.

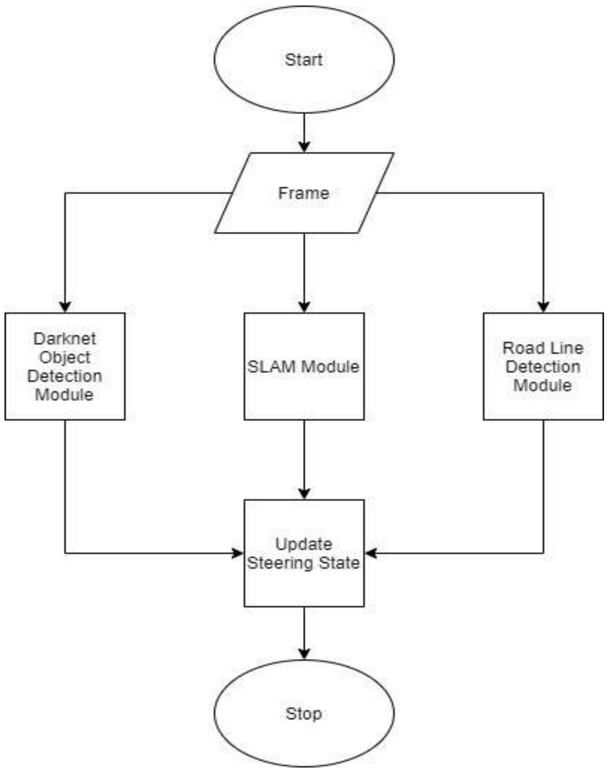
In paper [4]: Ra´ul Mur-Artal*, J. M. M. Montiel and Juan D. Tard´os, This paper presents ORB-SLAM, a feature-based monocular SLAM system that operates in real time, in small and large, indoor and outdoor environments. The system is robust to severe motion clutter, allows wide baseline loop closing and relocalization, and includes full automatic initialization. Building on excellent algorithms of recent years, we designed from scratch a novel system that uses the same features for all SLAM tasks: tracking, mapping, relocalization, and loop closing. A survival of the fittest strategy that selects the points and keyframes of the reconstruction leads to excellent robustness and generates a compact and trackable map that only grows if the scene content changes, allowing lifelong operation. We present an exhaustive evaluation in 27 sequences from the most popular datasets. ORBSLAM achieves unprecedented performance with respect to other state-of-the-art monocular SLAM approaches. For the benefit of the community, we make the source code public.

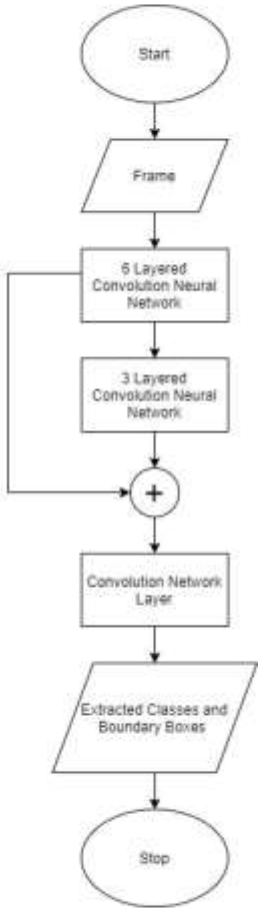
3. Problem Statement

Exploring new and unknown terrains or environment has always been an amusement or obsession of men. To explore a foreign territory without the benefit of the a map and to answer the question of what the surrounding looks like. The difficulty comes from doing both these things at the same time, i.e. localizing and mapping at the same time

The problem arrives when the humans cannot reach the terrain or its risky for humans to go to the terrains. Here the problem arrives to map the unknown terrain.

4. Proposed System





Flowchart 1: System Overview Flowchart 2: Darknet Object Detection

The proposed system is an automated simultaneous localization and mapping system or Monocular SLAM that uses a video input received from the camera attached to the robot. It uses this data to localize the robot to its surroundings and plot a map of the same.

The ML model in the proposed system is trained for land or roads. This system can be further extended to autonomous drones and submarines

The system achieves this by using various technologies such as Python and Darknet for object detection. This model has various advantages over classifier-based systems. It looks at the entire image at test time so its predictions are informed by global context in the image. It also makes predictions with a single network evaluation unlike systems like R-CNN which require thousands for a single image. This makes it extremely fast, more than 1000x faster than R-CNN and 100x faster than Fast R-CNN.

Fig 1: Corner Detection

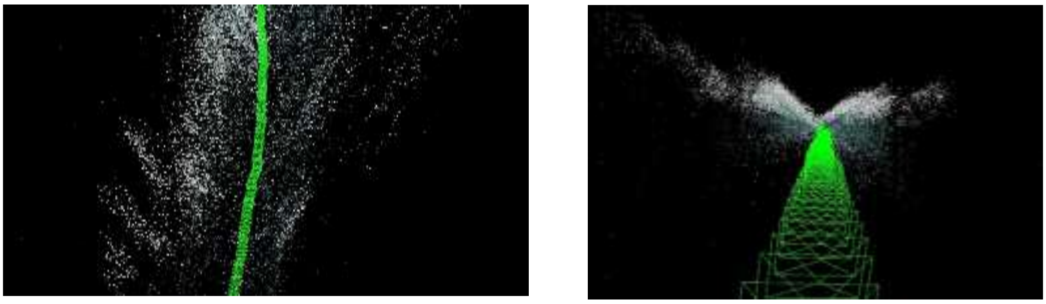


Fig 3: SLAM Top View and video perspective

We are also using frameworks such as OpenCV for computer vision, Pangolin for OpenGL window, SDL2 to make the video player, Skimage for algorithms, Coco Dataset to train the neural network and Numpy to handle matrix and related operations.

The algorithms that the system uses are Ransac for fundamental matrix estimation, shi tomasi corner detection for feature extraction, Norm Hamming Brute Force match for matching frames, Triangulation for point reconstruction, 8 point algorithm for extraction of Essential matrix, Oriented Fast and Rotated Brief (ORB) for feature detection, KNN algorithm for finding the closest matches, Gaussian Blur for reduction of noise in an image, Canny edge detector for detection of edges and Hough Line Transform for detecting straight lines.

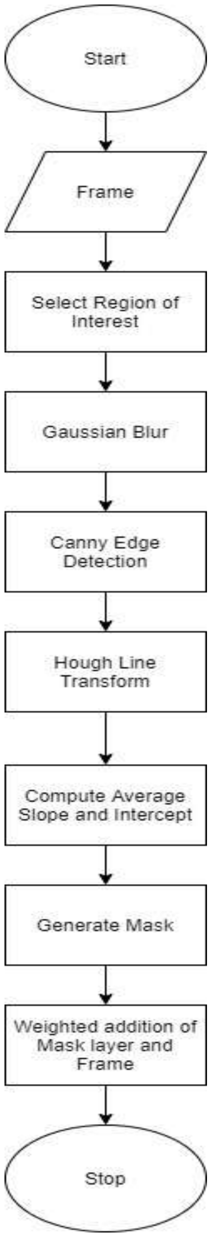
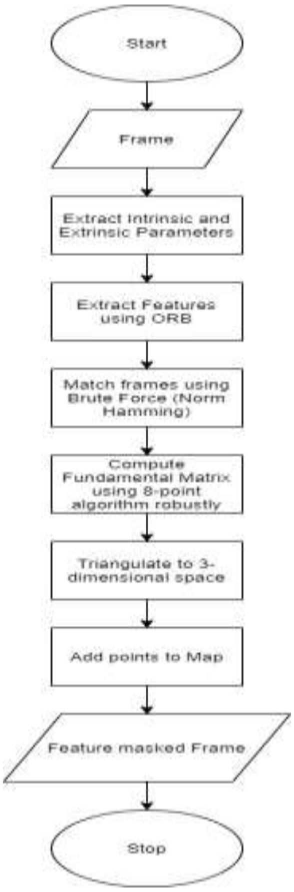


Fig 4: Object Detection Flowchart 3: Road Line Detection



This system can be executed on something as simple as an Android cell phone with camera. The Environmental reconstruction module can be performed using OpenGL technology which is a 2D and 3D vector rendering library used in modern games.

5. Conclusion

The proposed system automates the simultaneous localization and mapping by using the various frameworks, algorithms and technologies. It gives us a 3D map of the surrounding. It also detects any kind of obstacle in the frames.

6. Acknowledgement

We would like to express our gratitude to our mentor and teacher, who gave us the great opportunity to participate in this project. The project helped us in better understanding machine learning algorithms and image processing

References

[1] H. Durrant-Whyte, T. Bailey, “Simultaneous localization and mapping”, Australian Centre for Field Robotics, Sydney Univ., NSW, Australia submitted in IEEE
[2] Michael Montemerlo, Sebastian Thrun, Daphne Koller, Ben Wegbreit, “FastSLAM: A Factored Solution to the Simultaneous Localization and Mapping Problem”, Carnegie Mellon University Pittsburgh & Stanford University Stanford, CA 94305-9010 submitted in AAAI
[3] Ra´ul Mur-Artal*, J. M. M. Montiel and Juan D. Tard´os: ORB-SLAM: A Versatile and Accurate Monocular SLAM System
[4] Multiple view geometry by Richard Hartley, Andrew Zisserman
[5] Monocular ORB SLAM: https://github.com/raulmur/ORB_SLAM2
[6] Rainer Kümmerle: G2O A General framework for Graph Optimizer
[7] Rublee, Ethan, et al. “ORB: an efficient alternative to SIFT or SURF.” Computer Vision(ICCV), 2011 IEEE International Conference on. IEEE, 2011.
[8] Simultaneous Localization and Mapping: Part I BY HUGH DURRANT-WHYTE AND TIM BAILEY
[9] Simultaneous Localization and Mapping (SLAM): Part II BY TIM BAILEY AND HUGH DURRANT-WHYTE
[10] University name: ETH Zurich: https://www.youtube.com/watch?v=U6vr3iNrwRA&list=PLgnQpQtFTOGQrZ4O5QzbIHgl3b1JHimN_