Visual-SLAM for Environment Detection and Path Planning

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Abstract - *visual SLAM enables an object to map a terrain using various algorithms, methods and techniques like SIFT, odometry, SURF, etc. SLAM - Simultaneous localization and map building is a special feature for portable robots. This way the robot generates a map and then uses it to backtrack and analyze that area without human intervention. It allows for complete autonomous activities of a body due to its ability to perceive the environment. Data from various sensors further allow tuning for this feature for precise movement of a body from an initial to final position.*

Key Words:* *Path Panning, Computer Vision, Environment Detection, V- SLAM, Mapping.

1. INTRODUCTION

V-SLAM ("Visual Simultaneous Localization and Mapping") is a solution to putting a robot in a not known environment and the use the sensors which are placed on it which in turn will help the robot to formulate a map and then use it to localize itself. One of the modern-day challenges for machines lies in mapping the environment around us. For a robot to move around autonomously, it should be able to communicate with its surroundings, recognize, reconstruct and achieve its goal. This is present regardless of any terrain, one of the common ways to do this would be using various sensors like, GPS, ultrasound, IR, SONAR, ToF Laser Sensors. Another way would be by using a single camera which would be able to visualize the entire 3D environment and be able to locate the current position of the camera in the environment. This is done using vSLAM which uses various techniques like Odometry, SIFT, KinectFusion, RGB-D. SLAM algorithms are used to perceive the environment which is unknown and pinpoint the camera. SLAM algorithms are based on Kalman Filters.

2. Literature Review

A. RGB:

"PTAM"

"DSO (Available on ROS)"

"LSD-SLAM (Available on ROS)"

"LSD-SLAM: Large-Scale Direct Monocular SLAM"

"Five Point Algorithm for Essential Matrix estimation, and FAST features, with a KLT tracker"

"SVO-SLAM. Available on ROS"

B. RGB along with Depth (RGBD):

"OpenCV RGBD-Odometry (Visual Odometry based RGB-D images)"

"Dense Visual SLAM for RGB-D Cameras. Available on ROS"

V-SLAM is a widely researched and developed by various people around the globe. In fact, V-SLAM is just an implementation of SLAM ("Simultaneous Localization and mapping"). SLAM uses various sensors like "LASER, Infrared, Ultrasound, IR, IMU, Gyroscope, FLIR Lepton, Thermal Imaging, etc.". V-SLAM alternatively uses A cameras for all its primary processing and not data from various input sources which tends to make V-SLAM much more robust and reliable due to lower external and interdependent relationships.

3. Proposed Work

As we can clearly observe, a lot of research has been done into the field of visual SLAM. Not only that, with the help of data mining methods and various odometry algorithms we can further improve the accuracy of vSLAM than it is currently at. In a known environment getting to know the path of the trajectory is relatively easier however our aim is to make the robot (machine) to be capable of working under unknown environments and still be able to detect the not known surroundings and be able to detect the path.

Future Prospect for this kind of work includes various other camera sensors like Event Based Camera or the application of simpler and quicker feature recognition methods rather than the lengthy methods used currently.

3.1 Reinforcement Learning in vSLAM

The main aim is basically to automate collection of the data so that we can build map with the highest quality in the least time and cost.

Earlier algorithms in this field have focused on building of the mapping with the help of the global position information which was a tedious operation; with the advent of machine learning this process has become relatively easier especially with the help of reinforcement learning

Reinforcement learning is a machine learning algorithm where our main aim is to maximise the reward for a particular agent taken into consideration.

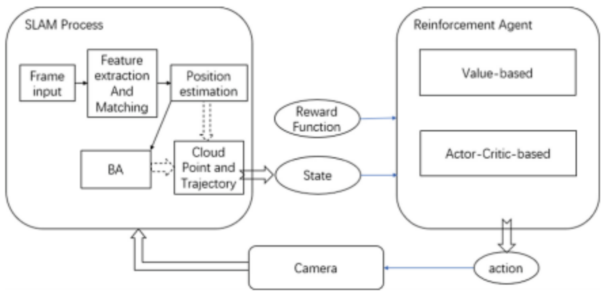
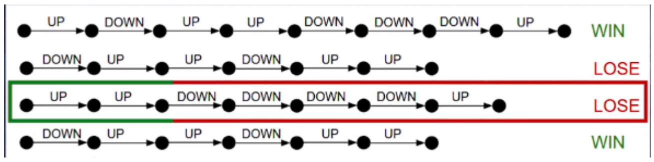


Fig. 1. Framework of combining keyframe-based SLAM and reinforcement learning.

Algorithm for processing this data with help of Reinforcement learning is:



STEP 1: For the given robot taken into consideration it acts like the agent the selection of the correct path acts like the positive reward and if the path along the hurdle is taken into consideration then it will lead to a negative reward i.e. the reward parameter is multiplied with a negative constant value.

STEP 2: Let us assume that if a particular machine is able to successfully trace the path, we call it SUCCESS while if it fails to reach the correct end of the path it is FAILURE.

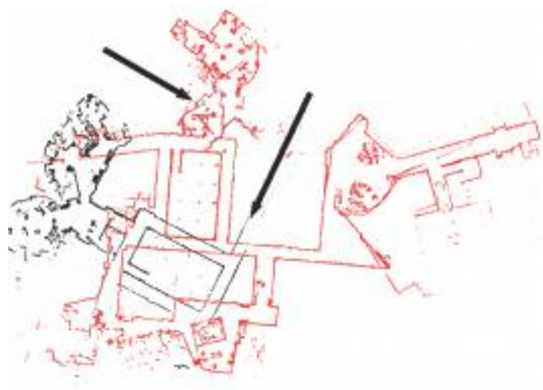
STEP 3: Initially the program starts as there is no dataset a random combination of actions is performed by the machine which in which initial results will lead to more FAILURE events as in reinforcement learning we don't provide any dataset instead let the machine learn everything by itself.

STEP 4: For everytime it wins its probability of occurrence is increased which is the reward in this case and everytime the results fail the gradient is multiplied with a negative value (-1) by which the system understands that this is an incorrect path as instead of getting the reward it was deducted.

STEP 5: From the initial stages of the data that is collected by the robot by this method it mines the data and filters the results by removing the combinations for which it did not get to the desired destination.

This way repeating the steps many number of times the accuracy of this can be increased.

(a) Raw Measurements



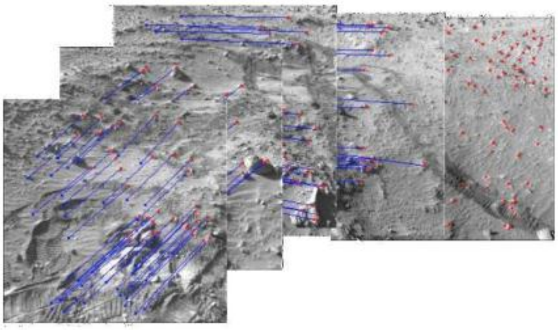
(b) Mapping Errors

(c) Corrected Measurements

as we can see in the above diagrams stages of how the path is constructed using reinforcement learning explained along with help of the above diagrams

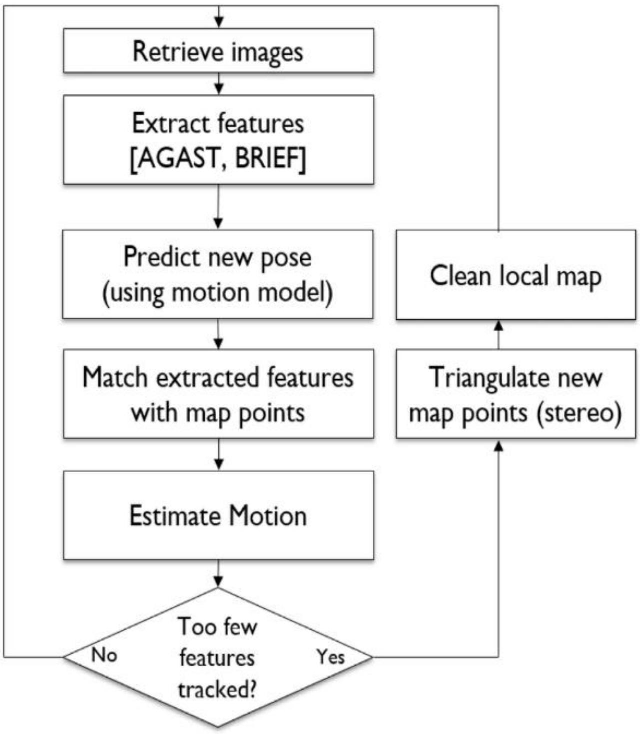
3.2 Visual Odometry

Odometry simply means the change of position over time. Visual Odometry is odometry done with the help of a camera, A camera determines the change in position of a body without help of external sensors. The Aalgorithm selects point features, these point features are either in mono or stereo format. Once the points are located, we can easily identify the motion between 2 consecutive frames by identifying the same features in the frames to come. Feature Tracking poses the major challenge as it requires us to identify points and then store data of each point, after which we can recognize data in the two frames and then landscape recognized by the co-relation formula. As shown in the image below, we track features over the same region, the lines signifying the movement between 2 captured frames



The Algorithm can be divided into 4 Major Parts:

1. Feature Detection and Matching
2. Feature Tracking
3. Motion Estimation
4. Likelyhood Estimation



As seen in the figure. The Algorithm roughly navigates as:

STEP 1. The Camera Captures images, based on the movement and the blur in the figure, an esimated sharp image is accquired by the software.

STEP 2. Once the Image is retrieved, we can use various algorithms to extract details from it using Feature Extraction Equations.

STEP 3. Using the Motion and Features from the prior model, we can easily predict the motion in the image frame.

STEP 4. Once the motion has been seen, we can find out the points in the new frame and then if new features are tracked they can be included in the global map too.

STEP 5. Doing this recreates the environment in a virtual space.

Feature Detection and Matching.

SIFT and SURF are some methods that are propietory and perform Feature Recognition and matching. These Methods perform Salient and robust feature Matching but pose serious slow downs when it comes to Feature Tracking, this is the crux of SLAM which enables it only to be used in high level applications.

Feature Tracking:

The tracking communicates with multiple images and arranges them in an understandable format. Tracking starts by getting the image from the camera, which is then used for feature recognition and then extraction. Once that happens, we can easily Predict the new pose of the model and then match extracted features which can be used to estimate motion.

Motion Estimation:

Motion Estimation is done by comparing 2 consequetive frames' points and then detecting the change in them, this can be done easily by basic trigonometry and distance-time differential equations.

Likelyhood Estimation:

The following formula is used for error estimation. The likelyhood of the Current Position and the Previous Position and then the Distance and time obvserved.

$$\mathbf{e}_j = \mathbf{P}_{Cj} - \mathbf{R}\mathbf{P}_{Pj} - \mathbf{T}$$

4. CONCLUSIONS

Thus we have successfully understood the proper working of V-SLAM along with all explanation of modern techniques for its implementation.

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