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Warehouse Automation Using Drones

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Abstract: Indoor Warehouse automation is one area which is being talked about among the top e-commerce giants mainly in order to meet the on-time delivery requirement. Amazon's KIVA [1] robot may sound promising at first but it fails, primarily due to its limitation of being restricted to ground motion. The system presented in this paper is targeted to solve this problem by using drones to do the task. The motivation behind this is to increase the reach of the inventory and also automate the process of inventory in a more dynamic way.

Keywords: SLAM (Simultaneous Localization and Mapping), PTAM (parallel tracking and monitoring), Autonomous Navigation, Object tracking and Object Detection.

I. INTRODUCTION

The project aims to develop an automated system which can perform routine warehouse inventory process without any human interference. The drone in this system navigates inside the warehouse using the image that it obtains from the primary camera it has. And in doing so it does not depend on any of the fixed markers (fixed image patterns) [2] and dynamically creates a map using the image (processed to obtain dynamic points for flying reference), obtained from the environment present in front of drone.

After creating the map, using the dynamic reference points, the drone can be guided to any location present on the map. And in this case, unlike any ground machine the movement is not limited to ground but it extends to all the three dimensions. As the drone reaches the desired point on the map it can then be asked to do inventory (RFID or barcode scan, depending on its ability).

Also, the drone can autonomously detect any box coming inside the warehouse and fly to its resting position and then can inventory the box and add the information to the inventory list. This is done by tracking the box using image recognition and detecting the coordinates of the box when it is placed in at a position. The same drone can do the dimensioning of the box and the obtained data is stored with the inventory data to further enhance the system.

II. PROPOSED SYSTEM

The system consists of following four main working parts:

A. Map creation for Navigation

The creation of the floor map based on the image captured by primary camera of the drone is based on the work presented in [3]. The system takes the image and using the method of monocular SLAM [8] called PTAM [7] (parallel tracking and monitoring), creates a map(see Fig 2) of the environment present in front of it, with the help of the processed images, which serves as our reference(see Fig 1) for the movement of the drone. The SLAM system presented in this paper for monocular camera has been enhanced by the use of an extended Kamlan Filter [9], which is used for data fusion and state estimation, which are crucial parts of PTAM. The paper [4] provides a way to create a set of steering commands (including take off, land, movement in any of the three directions) that forms our basis for the movement of the drone.

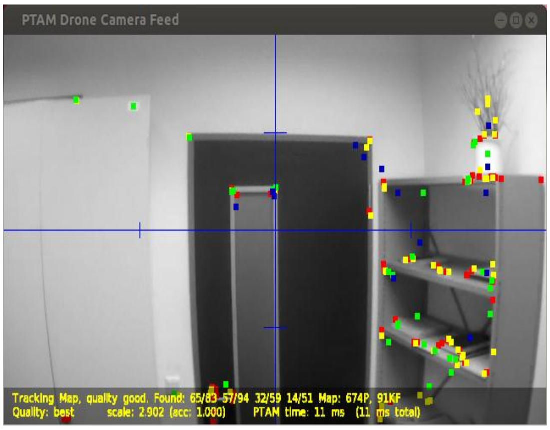

Fig 1. PTAM feed, reference image

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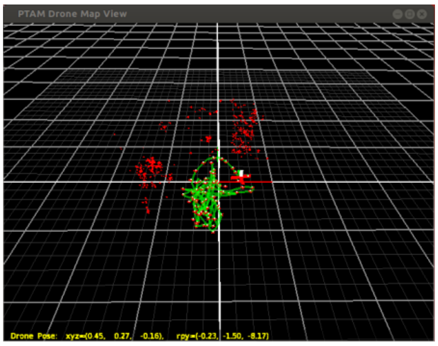

Fig 2 .Map generated using PTAM

B. Autonomous flying based on object detection

In the case of new box entering or leaving the warehouse the tracking of the box is done using the drone. The images from the ideal drone (i.e. not in flying state) are taken and processed for the presence of any boxes in them. The tracking is done till the time the box is placed at a position (and appears stable in the frame for a certain period of time). Once the processing is done we get the final resting position of the box. This location is them mapped to the floor map created in the earlier step and the drone is thus commanded using the steering commands to move to the same position. Once the drone reaches it position it performs the task of inventory and can return back to its initial position.

The steps involved in the object tracking and object detection are as follows:

- Object tracking using background subtraction: The dynamic images (see Fig 4) obtained are subtracted from an initial frame (see Fig 5) to obtain the changing (moving) part in the frame. The image thus obtained is converted to a binary image (to obtain a mask) (see Fig 5) using the technique of thresholding. OpenCV provides inbuilt function (Background SubtractorMOG) to achieve this [5].

Fig 3. Initial frame

Fig 4. Dynamic image with the object

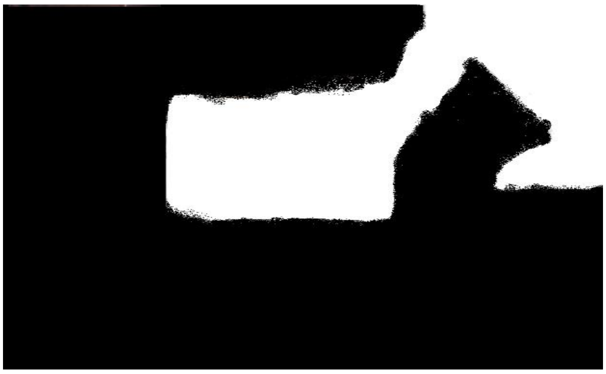

Fig 5. Result of background Subtraction

- Object/Pattern Detection: Once the object is tracked till its final position we check for the shape of the object and depending on the shape of the object we want, we perform the task of pattern/object detection in the final frame (our mask) to look for the desired shape. The required task can be performed using the template matching or shape detection techniques present in Open CV [6].

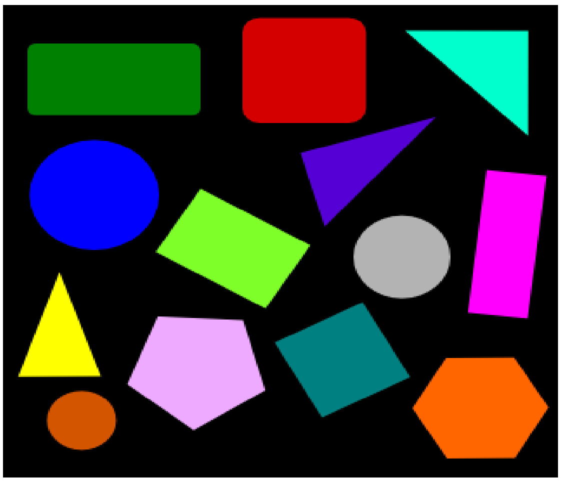

Fig 5. Image with different shapes

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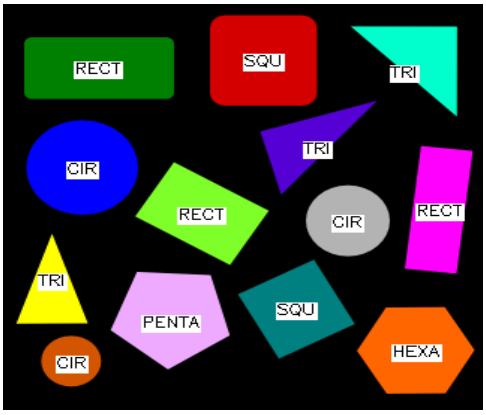

Fig 6. Image with identified shapes

C. Creating the steering commands

Once the box has been identified in the frame we calculate its position by taking the average of all the pixels that are corresponding to the desired shape. After getting the coordinates of the object we maneuver the drone to that point using our map and the coordinates obtained.

D. Performing Inventory:
Once the drone reaches its target positions it can do an inventory on the target. For most of the drones, having an embedded library [10] to decode barcodes or QR codes, enables to it do inventory based on image scan. Alternatively, attaching a RFID scanner for RF based inventory can also be used.

III. CONCLUSION

In this paper, the main focus has been on the autonomous navigation of drone without any dependencies which are posed by the fixed pattern technique generally employed for navigation. The system enables drone to dynamically create a map and track and detect any object using image processing algorithms. The proposed system, other than warehouse scenarios, can be used in variety of other use cases including Retail, Healthcare and other systems requiring object tracking.

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V. BIOGRAPHY

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