DYNAMIC OBJECTS MAPPING AND TRACKING SYSTEM FOR AUTONOMOUS ROBOT

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Abstract— For robot operating in dynamic world environments, the capability to distinguish between a new object and a mapped object represents the core of a security application based on autonomous robots. Moreover, to improve the security model, the robot should track the detected objects among many objects either it is moving or not. The last issue in such system, the robot should localize itself and map the world environment dynamically. In this paper, we will present a method to develop a laser-based security application using an autonomous robot. We describe the proposed method based on classical geometric object mapping in order to detect an unmapped object. In addition, we will define the security application components for an autonomous robot. Then, we will detail the number of crucial technologies encapsulated in a security application.

Keywords— Mapping Object, Tracking Object, Localization, Security Application, Autonomous Robot.

I. INTRODUCTION

Mobile robots are being extensively used in various different dynamic environments. While working in a dynamic environment, these robots encounter obstacles in the form of object, human, constructions and others. In order for hassle free operation these robots are expected to detect and track the obstacles and other moving objects coming in their way. In this paper, we will use a range laser finder to scan nearby area for detecting and tracking the moving object within dynamic environment [1].

Present world robots are capable of adapting themselves to practical environment and can interact with humans to perform specific activities. They can perform a wide array of activities in a dynamic environment. In such a situation it is essential to have a highly accurate sensing, detecting and tracking mechanisms for close by objects [1]. Such an accurate system will ensure collision avoidance. So far many different algorithms and models have been proposed to perform this task. One of the proposed models is detection and tracking moving object (DATMO). Based on DATMO we propose method to develop a laser-based security application for an autonomous robot. To implement this method we use Seekur mobile robot with laser range finder and camera (cf. figure 1). The Seekur is a four-wheel independent drive and steering platform, which allows it to turn in place and move in virtually any direction, including laterally [2]. Moreover, Seekur is an all-weather, all-terrain vehicle, capable of maneuvering both outdoors and indoors in a range of environments. The Seekur mobile robot equipped with a laser range finder to provide data for use it in our model.

The aim of this paper is to develop a security application based on detection and tracking moving object with dynamic environment. This paper is organized as follows. This section I describes the detection and tracking moving object methods. Section II discuss the related work. Section III presents our method for detection and tracking moving object using mobile robot with laser range sensor. Section IV show our experiments and results. Finally, section V presents conclusion and future work.

Fig. 1. Seekur mobile robot

II. RELATED WORK

Many of works has been accomplished using laser range finder in detection and tracking moving object. Some of authors have used laser radar to develop a dynamic polar coordinate environment model. This model provides sufficient information to the mobile robot for understanding its present position and that of other nearby obstacles. The data obtained from this model is used to generate a moving object tracking model. The algorithm used in the tracking model will consider the motion of robot as well as the obstacle and helps the robot to anticipate the collision with better degree of accuracy. The tracking model is based on the Extended Kalman Filtering technique. The authors have used the best among the available resources to perform the activity with high degree of precession; they have simulated the obstacle in three different ways and elaborated the results in each case.

The result shows that avoiding policies largely depend upon the speed, size and direction of the obstacle [3].
In other hands, some of authors talks about the issues faced by Autonomous Guided Vehicle (AGV) and presents an apt solution to the highlighted problem. AGV is expected to detect and track the objects in its vicinity quickly and accurately to avoid collisions. The authors developed an algorithm using laser sensors to detect a single moving object. This algorithm uses laser (2D LIDAR) scanner to scan the nearby objects. The scanned data is converted to coordinates and different features are extracted from it. The extracted features are matched with the already defined object for determining the presence of any known object. Kalman filter and other data processing techniques are used to further track the identified object. In the case of any unmatched features the object is considered as new and the details are updated along with the predefined objects. A constant velocity model is applied to the extracted data for performing the tracking operation. The authors developed and testing of the algorithm was carried out for two simple situations, the results of the experiment show an excellent performance for a moving object with vehicle in static condition. The performance however degrades when the moving object has multiple motions in different time and direction [4].
Other researchers, used laser-based system and vision-based system for tracking the object and to find out if the tracked object is a human or not. The laser-based system identifies the object through scanning and process the scanned data through simple Bayes filter. The vision-based system utilizes the particle filter and tracks the moving object by analyzing each of the acquired frames. It subsequently uses AdaBoost object detection algorithm to extract further information and to identify the presence of a human. the authors created an experimental setup for both methods and implemented the proposed system. Human and non-human objects are were made to move in the vicinity of the robot and it was found that the system performed satisfactorily [5].

III. SECURITY APPLICATION

A mobile robot which works in a dynamic environment may have to encounter many obstacles. The obstacles may be of many different kinds such as pedestrian, human, tree, vehicles and many others. In order to avoid these obstacles they need to be accurately tracked and response action has to be taken in a least possible time. Most of the available models have either large processing time or less accurate. Our security application can be track and avoid the moving obstacle by Seekur mobile robots in a dynamic environment. This security application consists of obtaining the scan data (2D) of the laser sensor and processing them to detect the moving object. The scan data is searched for the presence of cluster. The search operation is carried out by implementing a clustering algorithm. This algorithm estimates the proximity among the nearby coordinates to detect the presence of clusters. Clusters are the set of measured points with large percentage of similarity among them. The presence of cluster in the scan data denotes the object. The cluster data is filtered for noise removal and feature extraction by using Kalman filter. Kalman filters are basically driven by white noise and are applicable for discrete-time linear dynamic systems. The extracted features are matched with the predefined features to find out the exact object type [4]. After detecting the object a constant velocity model is applied to the extracted feature for performing the tracking activities. The experimental results of our application are presented in the following section.

IV. EXPERIMENTS AND RESULTS

We create an experimental setup and implemented the proposed application. Human and non-human objects in two different experiments are made to move in the vicinity of the Seekur mobile robot and it was found that the application performed satisfactorily.
The Laser-based system has a Sick LMS111 for scanning the nearby object with a specified degree of resolution and 50Hz scan frequency. The scanned information is in the Cartesian coordinate. The scanned coordinate data has the depth information and is applied to the algorithm to identify the presence of the object. The following figure show the laser depth area (cf. fig.2).

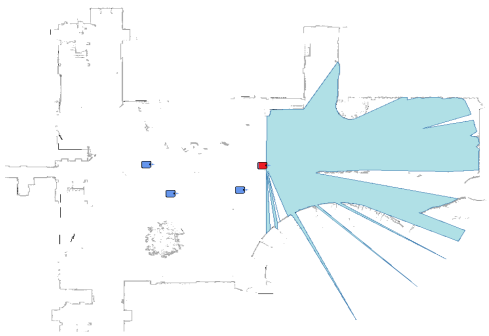

Fig. 2. Area scanning

In the figure 2, the robot did not found any objects, for that it will be scan other side to find objects (cf. Fig. 3.).

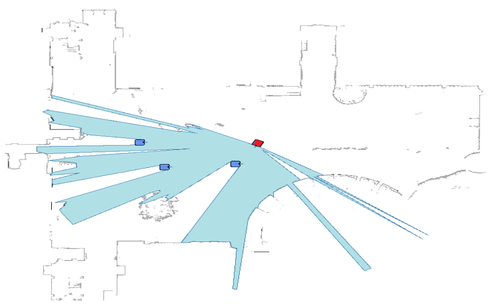

Fig.3. Scanning and identify objects

The robot find three objects that shown in blue color and it's tracking the nearby object (cf. Fig. 4, 5).

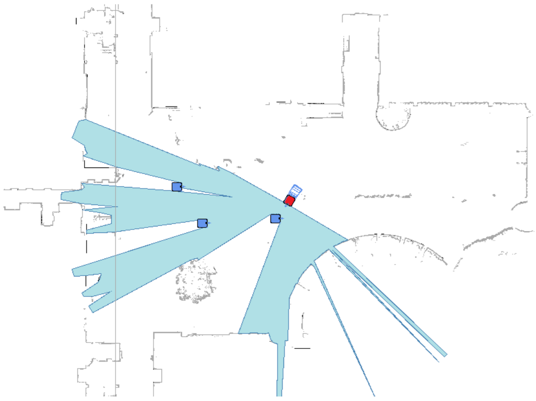

Fig.4. Object tracking (a)

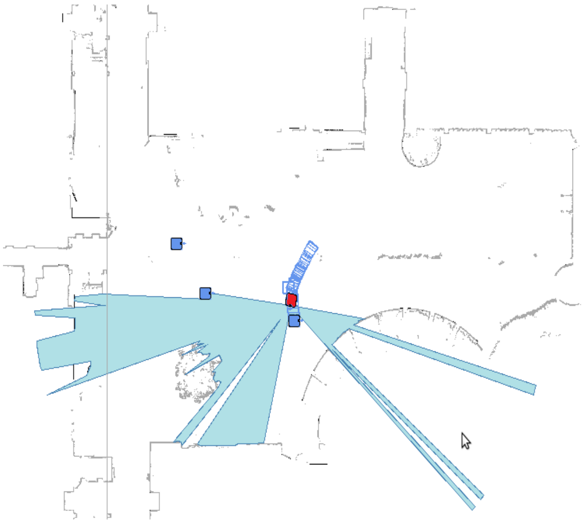

Fig.5. Object tracking (b)

When the object stops moving, the robot saves the object coordinates in the map (cf. Fig. 6.), then the robot rescan the nearby area to find any new objects (cf. Fig. 7). Moreover, in every steps the application provide the station an alarm and images of a tracked object.

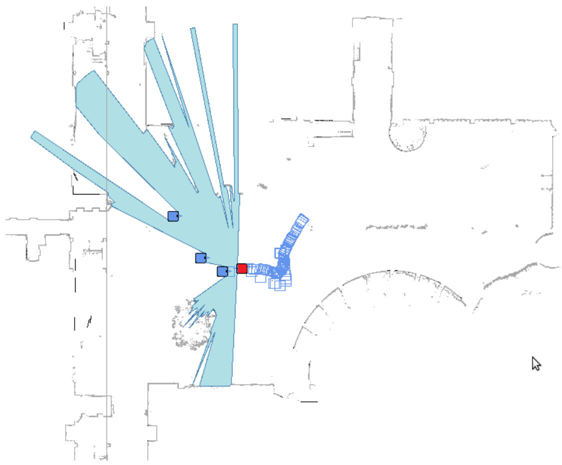

Fig.6. Save coordinates of stopped object

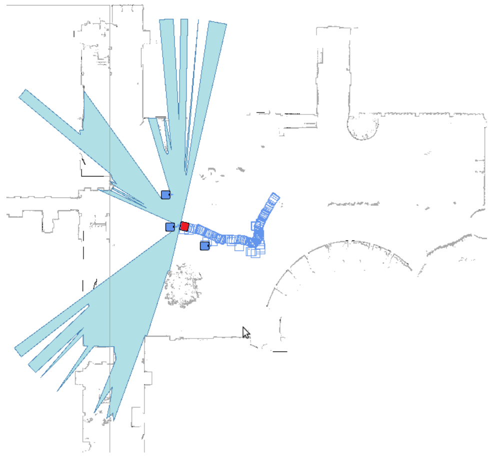

Fig.7. Rescan and follow new object

CONCLUSION AND FUTURE WORK

A mobile robot working in a dynamic environment must essentially posses a tracking and avoiding mechanism. The presented method tries to adapt with dynamic environment in order to detect and tracks moving objects quickly and accurately. The model considers all the real time situations and provides a practical solution to the problem. The avoiding policies used by the mobile robots able to adaptable depending on the obstacle size and behavior.

For future work, we plan to develop the system to work in more dynamic environment, in order to tracking multiple moving objects. For that we need collaboration between multiple mobile robots, where it will be assigned a master mobile robot to scanning around area, when the master robot found more than one moving object, it will tracking the nearby object and send the coordinates of other moving objects to other mobile robots to tracking these objects. In addition, we will use vision-based system to know the type of object such as human, vehicles or any others type, also we should be taken into account the direction and speed of other moving objects . In order to build an effective security system there must be constant communication between the robots to find the shortest path to these moving objects.

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REFERENCES

[1] S J. Almeida and R. Araujo, “Tracking multiple moving objects in a dynamic environment for autonomous navigation,” inProc. 10thIEEE Int.Workshop AMC, Mar. 2008, pp. 21–26

[2] MobileRobot. Seekur [Online]. Avalible: http://www.mobilerobots.com

[3] F. He , Z. Du , X. Liu and Y. Ta "Laser range finder based moving object tracking and avoidance in dynamic environment", *Proc. IEEE ICIA*, pp.2357 -2362 2010

[4] Abdul. H, Hairi. Z, Saiful. A. " Model-based Detection and Tracking of Single Moving Object using Laser Range Finder", 2014 Fifth International Conference on Intelligent Systems, Modelling and Simulation, 2014

[5] Aras Akbari, “Multiple Human Tracking in Dynamic Environment”, U. of Southern California, 2010

[6] Yanmin Lei. "Stepping motion coordination strategy based on environmental prediction for multiple robots system", 2009 International Conference on Mechatronics and Automation, 08/2009

[7] K. Rebai, A. Benabderrahmane, O. Azouaoui, and N. Ouadah, "Moving obstacles detection and tracking with laser range finder," in Advanced Robotics, 2009. ICAR 2009. International Conference on, 2009, pp. 1-6

[8] M. Kobilarov, G.Sukhatme, J.Hyams. People tracking and following with mobile robot using an omnidirectional camera and a laser. In Proc. Of IEEE Int. Conf. on Robotics and Automation, pages 557-562, Florida,USA, 2006

[9] A. Mendes, L.C. Bento, and U. Nunes. Multi-target detection and tracking with a laserscanner. In Proc. of 2004 IEEE Intelligent Vehicles Symposium.

[10] Jin-Xia Yu. "Detection and tracking of moving object with a mobile robot using laser scanner", 2008 International Conference on Machine Learning and Cybernetics, 07/2008

[11] Mendes, A., Bento, L. C. and Nunes, U. (2004) Multi-target detection and tracking with a laserscanner. Intelligent Vehicles Symposium, University of Parma, Parma, Italy, June 14-17.

[12] Miranda Neto, A. and Zampieri, D. (2008) Sistema de navegaçã o (semi)-autônomo de assistência ao condutor, Roberts, J e Corke, P. (2001) Obstacle detection for a mining vehicle using a 2D laser, CSIRO Manufacturing Science & Technology.

[13] M. Yang, H. Wang, K.Z. He, et al., "Environmental modeling and obstacle avoidance of mobile robots based on laser radar," Journal of Tsinghua University (Science & Technology), vol.40, no.7, pp.112-116, July, 2000, in Chinese.

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