3D Vision-Based Autonomous Navigation System Using ANN and Kinect Sensor

Daniel Sales, Diogo Correa, Fernando S. Osório, and Denis F. Wolf

University of São Paulo, Mobile Robotics Lab, Av. Trabalhador São-Carlense, 400,
P.O. Box 668, São Carlos, Brazil
{dsales,diogosoc,fosorio,denis}@icmc.usp.br

Abstract. In this paper, we present an autonomous navigation system based on a finite state machine (FSM) learned by an artificial neural network (ANN) in an indoor navigation task. This system uses a kinect as the only sensor. In the first step, the ANN is trained to recognize the different specific environment configurations, identifying the different environment situations (states) based on the kinect detections. Then, a specific sequence of states and actions is generated for any route defined by the user, configuring a path in a topological like map. So, the robot becomes able to autonomously navigate through this environment, reaching the destination after going through a sequence of specific environment places, each place being identified by its local properties, as for example, straight path, path turning to left, path turning to right, bifurcations and path intersections. The experiments were performed with a Pioneer P3-AT robot equipped with a kinect sensor in order to validate and evaluate this approach. The proposed method demonstrated to be a promising approach to autonomous mobile robots navigation.

Keywords: Mobile Robotics, Autonomous Navigation, Kinect, Artificial Neural Networks, Finite State Machine.

1 Introduction

AI techniques implementation on Autonomous Mobile Robots and Intelligent Vehicles has an important role on international scientific community [9][13][14]. One of the most desirable features for a mobile robot is the autonomous navigation capability. There are many known relevant works on this research field, as for example the Darpa Challenges (2004 and 2005 editions on desert and 2007 in Urban environment)[7][8] and ELROB [15][16].

Autonomous mobile robots usually perform three main tasks: localization, mapping/planning and navigation [17]. Localization task is related to estimate robot´s position in a well-known environment using its sensorial data. Mapping consists on creating an environment representation model, based on robot´s localization and sensorial data. Navigation is the capability to process environment information and act, moving safely through this environment.
In order to autonomously navigate into structured environments composed by streets or corridors, the robot must know its approximate position, the environment map and the path to be performed (source/destination). So, navigation in this environment consists on following a well-defined path, considering the available navigation area.

The main focus of this work is the implementation of a Topological Autonomous Navigation System able to recognize specific features in a path on indoor environments (composed by corridors and intersections). This navigation system is intended for indoor service robots in several different tasks, from the simplest ones as carrying objects until critical ones as patrolling. The implemented system for these applications must be easy to configure and use. It must be also robust allowing the robot to both navigate and detect possible abnormalities.

The proposed approach does not require a well-defined environment map, just a sketch representing the main elements, resulting in a simple path sight. Furthermore, this approach does not require an accurate robot’s pose estimation. The main goal is to make the robot navigate in an indoor structured environment deciding when and how to proceed straight, left or right, even when these three possibilities are detected simultaneously (intersections).

The topological approach uses an ANN [19] to classify sensor data and a FSM to represent the steps sequence for each chosen path. The ANN learns all possible states, and a FSM generator is responsible to convert any possible path into a sequence of states. This way, the system combines this deliberative topological behavior with a simple reactive control for a safe navigation.

The next topics of this paper are organized as follows: section 2 presents some related works; section 3 presents the techniques and resources used for state detection; section 4 presents the experimental results; section 5 presents the conclusion and possible future works.

2 Related Works

Several approaches have been used for navigation, using many different sensors (for example laser, sonar, GPS, IMU, compass) singly or fused [9][17][18]. One of the most used approaches recently is the Vision-Based navigation [20]. This method uses video cameras as the main sensor. Cameras are very suitable for navigation and obstacle avoiding tasks due to its low weight and energy consumption [1]. Furthermore, one single image can provide many different types of information about the environment simultaneously. It is also possible to reduce costs by using cameras rather than other types of sensors [2]. The Vision-based approach implementation is already usual in navigation systems for structured or semi-structured environments [3][7][9][10][11]. These systems classify the image, with track segmentation for safe navigable area identification.

Although these works present good results, the scope for a conventional camera is restricted, and many implementations demand camera data fusion with laser sensors (Sick Lidars, IBEO, Velodyne), radars or even special vision systems such omnidirectional cameras [7][8][9][18]. This fusion becomes necessary specially when