RobotGuard – Autonomous Robot for Automatic Surveillance Using Maps

M.Sc. Dissertation Theme for the School Year 2019/20

Autonomous mobile robots endowed with autolocalization and navigation capabilities can potentially automate surveillance tasks performed routinely by human guards, for instance in public, business or industry buildings, very often overnight, thus relieving humans from a tedious, repetitive, sometimes dangerous, task. Besides navigation in indoor structured environments, an autonomous robotic guard must possess other key abilities to fulfill the requirements of an automatic surveillance task. One is to patrol efficiently, i.e. sweep repeatedly, the wide space being secured, so as to minimize the risk of intrusion, theft, fire due to equipment unexpected malfunction, and other undesired events related to securing a facility. This patrolling efficiency can be especially important and complex if the task is performed cooperatively by a team of distributedly coordinated robots [1]. Not less important, is the robot using its exteroceptive sensors, e.g. cameras, to automatically perceive abnormal situations in the course of the mission and report them to a remote operator, together with precise information (e.g. location, type of event, etc.), both related with objects (e.g. unexpected object, missing equipment, open door, etc.) or people (e.g. unauthorized person, suspicious behavior, etc.). These perception capabilities are particularly complex to design and implement in a robot and are essentially open research problems in the current state of the art; they have been investigated in recent projects [2].

The main goal of this M.Sc. dissertation project is to design, implement, and test an end-to-end automatic surveillance system prototype based on a wheeled mobile robot, to be used to surveil an indoor facility. Some simplifications are assumed to make the project feasible in the course of a school year. As various complex features must be present in such a system, an initial basis already implemented in ROS [3] within previous projects will be provided to the M.Sc. candidate, which should be refined w.r.t. to some aspects referred below and integrated in a more consolidated way in the course of the M.Sc. dissertation project. That basis comprises several ROS packages inherited from previous projects, including drivers for the Pioneer P3-DX mobile robots, the Hokuyo URG-04LX laser range finder, and the Orbbec Astra Standard RGB-D camera, the Gmapping SLAM algorithm, the navigation stack, a patrolling algorithm for action decision making, and a perception pipeline for detecting and registering the complete pose of objects in a semantic map [4]. For the sake of simplicity and feasibility, an uninhabited environment will be assumed, therefore the surveillance task will cover only security situations related with quasi-static objects and will not include people detection and tracking. Moreover, the navigation map is built before the deployment, therefore it is considered static in the course of the mission (the robot does not perform SLAM during the mission). The system prototype is aimed to achieve a higher level of maturation (consolidation), usability (easier operation by non-expert users) and robustness (i.e. fault tolerance), including the following features: initial reconnaissance, i.e. SLAM and exploration in an initially unknown environment; easy deployment and mission control in the course of the mission, including abnormal situation reporting and recording, and failback behaviors to recover from possible temporary technical problems (e.g. localization errors); more consolidated/extended perception pipeline to achieve better precision and recall; software tools to aid in building datasets for training the artificial neural network used for object detection.

**Keywords:** Autonomous mobile robot; navigation; surveillance; object detection; semantic mapping; fault tolerance; ROS.


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