Autonomous Exploration Using Kinect and Laser Range Finder*

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Autonomous exploration has received a large attention in robotic community. The problem of building and maintaining a 2D map (such as an occupancy grid map or a topological map) has reached a recognized level of maturity, if an adequate sensor, like a laser range finder, is available. However, autonomous motion in indoor environments, possibly cluttered and dynamic for the presence of people and other objects, requires the construction of a 3D map to let the mobile robot reacts in real time to dynamic changes and obstacles to be avoided.

Recently, the low cost RGB-D sensor Microsoft Kinect has got more and more applications in mapping and localization, since it can provide abundant depth environment information in real time, but a robot equipped with only the Kinect sensor would face safety problems in complex scenarios.

This paper analyzes the Kinect limitations and proposes a system setup equipped with both Kinect and laser range finder to benefit from the characteristics of the two sensors, in order to achieve a safe navigation in dynamic indoor environments. The Kinect is used for global navigation planning including target finding, best target choosing and path planning, while the laser performs local obstacle avoidance. In this way the main drawbacks of the two sensors are overcome, i.e., the limited detection range of the Kinect (from 0.8 m to about 4 m) and the partial or misleading information possibly provided by the laser range finder (objects below or above the sensor perception plane are invisible, and anomalous reflections of the laser beams can be induced by some materials). Our work starts from Engelhard's code [1] to build 3D maps of the environment and localize robot position using Kinect, and fuses information coming from a laser range finder in order to achieve fully autonomous navigation without human actions. Based on the Kinect information, 3D point clouds are joined properly to create the environment map. At the same time, the point clouds are mapped into the global navigation map to plan the candidate targets, choose the best target to visit and perform path computation. In addition, we incorporate the results of our previous work on autonomous exploration with 2D laser sensor [2] to ensure the local obstacle detection while the robot is moving to the selected target.

Starting from each frame of the Kinect point clouds, containing a large amount of data, a safety area in the robot motion direction is defined: only the points

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in this particular range (i.e., the points at height above ground from 0.2m to 0.55m) are considered, whereas the points outside this area are ignored, since they do not constitute a danger for the robot. The approach for the construction of the 3D map of the environment, and the localization of the robot position within the map using only the Kinect, is similar to RGBD-SLAM [1]. The procedure is constituted by three main steps: feature extraction and matching, image registration and vision odometry calculation.

On the basis of the objects modeled in the navigation map, the optimal goal target is found and the actually free path computed to this point. The implemented obstacle avoidance algorithm creates a cost map from the laser scan reading: the obstacles are added as occupied cells in the local map and subsequently inflated to take into account the robot size. When the robot is too close to the obstacles, a new path is recomputed using the updated global map to reach the goal target.

The proposed approach for active SLAM and exploration has been coded in the ROS framework, and implemented for evaluation with two robotic platforms in lab environments. A 3D map construction experiment has been carried out on the Eyeonwheels platform at Control Engineering Group Lab of University of Twente, while an autonomous exploration experiment has been performed on a Pioneer P3DX robotic platform at the Robotics Lab of Politecnico di Torino (Fig. 1). Thanks to the framework modularity, the approach can be easily adapted to other robotic platforms and/or to the use of proper low-cost sensors for local obstacle avoidance instead of the laser range finder.

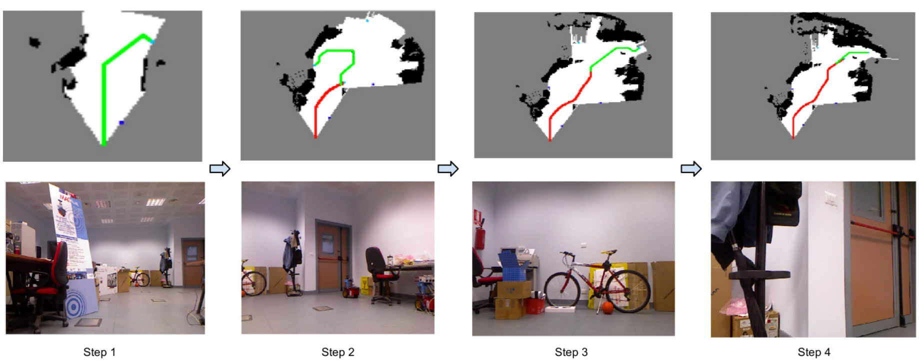

Fig. 1. Autonomous exploration test sequences using P3DX with Kinect and laser sensors

References

1. Engelhard, N., Endres, F., Hess, J., Sturm, J., Burgard, W.: Real-time 3D visual SLAM with a hand-held RGB-D camera. In: RGB-D Workshop on 3D Perception in Robotics at the European Robotics Forum, Vasteras, Sweden (April 2011)
2. Carlone, L., Du, J., Ng, M.K., Bona, B., Indri, M.: An application of Kullback-Leibler divergence to active SLAM and exploration with particle filters. In: IEEE lnt. Conf. on Intelligent Robots and Systems (IROS), pp. 287–293 (2010)