RGB-D Indoor Plane-based 3D-Modeling using Autonomous Robot

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ABSTRACT:

With the advent of Microsoft KINECT, significant effort has been made to create and enhance a dense 3D model of indoor environments. Obtaining 3D model of an indoor environment provides rich information that can facilitate the disambiguation of different places and also boosts the familiarization process to any indoor environment for the remote users.

In this research work, we propose a graph based modeling approach that consists of two algorithms working in parallel: one producing the nodes and the other one generating the edges. The nodes are 3D planar patches, which are described with simple geometric features such as: plane's normal, centroid, etc.). The planar patches are segmented from a range image using region growing technique followed by convex hull method to assign boundaries to the extracted patches. In order to integrate the segmented patches and build a final model we need to merge the extracted patches using graph the edges. This is done by applying the visual odometry algorithm. The visual odometry method estimates the relative pose of the consecutive RGB-D frames through feature extraction and matching techniques with an assumption that the scene remains static. The pose estimated by visual odometry algorithm is then refined using RAndom SAmple Consensus (RANSAC) method followed by iterative closest point (ICP) method. Finally, we add the loop closure for producing consist model of the environment based on the feature labeling and comparing new features with the previous seen features.

There are number of constrains that should be taken into account in order to minimize the error in the merging process of different planar patches. The first parameter is visual appearance, which is a good indicator for classifying nearby patches and merging them as they are highly related to the same object. The second parameter is the geometry, which can be described from the convex shape. The angle between normal vectors of each planar patch is also another useful parameter in the merging process for updating the graph.

Evaluation for testing the robustness of the algorithm is done, through applying a consistency test. The test estimates the adjustment errors of the matched planes derived from the minimization of the cost function, which corresponds to the error in the distance between the centroids of the different merged planes.

The proposed approach has two main advantages: first, the map solution is very compact and second, it is robust against changes in the scene viewpoint as for the indoor scenario the most visible and permanent constant features are planes representing walls, celling and doors while other objects are not completely visible and more likely to be temporary.

The experiments are done with the Seekur Jr robot, which autonomously moves in a corridor collecting data of Kinect sensor placed in the front of the robot. The accuracy of the relative pose extracted from visual odometry algorithm is compared with the robot odometer.

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