Surface Reconstruction for 3D Robotic Mapping

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An important task in mobile robotics is generating consistent environment maps, based on the collected sensor data. In this talk we present a novel method to construct a metric discrete map of the environment, abstracting from the sensor data: The output of a 6D SLAM algorithm is postprocessed to compute a polygonal model. In indoor environments, the model is augmented by an interpretation of the scene. The developed methods enable us to use the resulting polygon maps in different contexts, e.g., for navigation with different robots.

Since manual environment mapping is a tedious job, the robotic mapping problem has drawn a lot of attention in the research community. Recently, the focus shifted from planar 2D maps towards 3D mapping. 3D maps outperform 2D maps for many purposes, such as obstacle avoidance, object recognition and scene understanding.

The rapid development of mobile 3D laser scanners provided the basis for mapping large areas accurately. The resulting 3D maps are point clouds, sampling the surfaces of the environments. Although the sampling density increases, the point clouds do not represent continuous surfaces.

Surfaces are commonly represented by polygonal meshes, particularly triangle meshes, a standard data structure in computer graphics to represent 3D objects. In this community, various automatic mesh generation procedures have been developed. A wide variety of applications apply these algorithms, e.g., model generation for video games or movies, the accurate documentation of architectural heritage and reverse engineering. These algorithms generate highly accurate polygonal models whose appearance has to be as close as possible to the original object, requiring a lot of computation power. In robotics, however, compute power is limited to what fits on a mobile robot. Furthermore, high level of detail is not needed in many robotic algorithms, for instance localization.

Here we present a novel approach to generate automatically 3D polygonal maps from point clouds: Several 3D scans are acquired by a mobile robot and registered into a common coordinate system by our 6D SLAM (simultaneous localization and mapping) algorithm handling 6 DoF robot poses. The globally consistent 3D point cloud serves as input to a modified marching cubes algorithm, transforming the 3D point cloud into a map that contains large closed surfaces. After mapping is done, this compressed representation is used for localization of a team of mobile robots.

Our solution focuses on reducing the computational costs and exploits the inherent structure of scenes scanned by a mobile robot: Common environments for robotic mapping mainly consist of planar surfaces. This planarity constraint is utilized in a modified version of the Marching Cubes algorithm. The main idea is to detect connected planar surfaces in the triangle meshes generated by this algorithm and to extract the boundaries of these areas. The planarity contraint is generally not considered in the computer graphics community since most of their reconstruction methods refer to curved objects with lots of details.

The map generation algorithm has been deployed to map an environment for the LiSA (Life Science Assistant) robot. The LiSA robot uses a 3D map generated by Kurt3D for navigation. The robot control is based on the Player framework, employing particle filter localization. Fig. 1 shows a map used for navigation, extracted from severeal registered laser scans taken by our Kurt3D robot. While navigating LiSA, tilted Hokuyo scanners are used as an additional source of information to improve the pose estimate of the particle filter using the genrated 3D map.

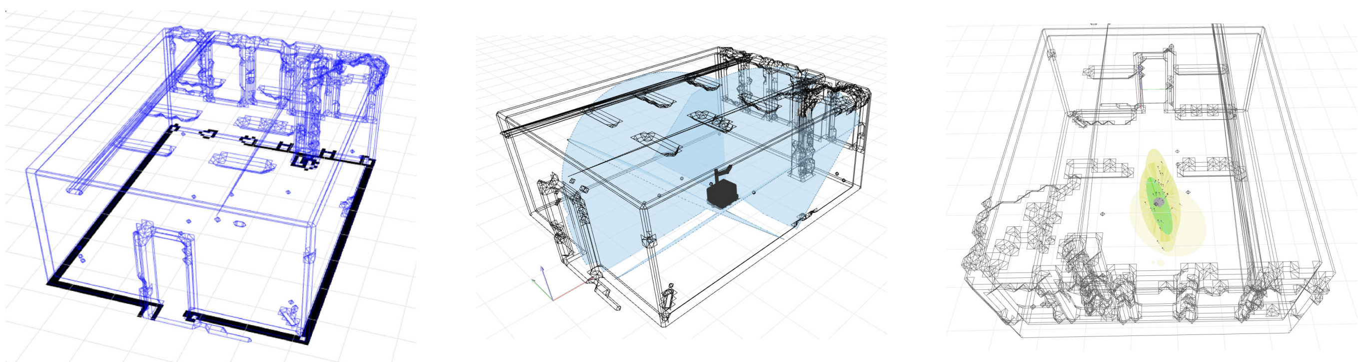

Fig. 1. 3D maps in the Player framework, used for navigating LiSA. Left: The horizontal section marked as thick black line is used for localization with the planar scanners. Note that this is a metric discrete line map. Middle: Measurement ranges of the angled Hokuyo scanners. Right: Particles representing the robot pose.