The use of 3D laser scanner for simultaneous localization and mapping (SLAM) and path planning of mobile robot in rough terrain

Abstract

Development of mobile robots and increasing the areas of their applications, requires finding the effective solutions of navigation, including localization, mapping and path planning for mobile robots of different structures, operating in different conditions and environments.

In this thesis, the methods of mobile robot 6D localization and mapping (6D SLAM) and path planning (PP) were developed. They are designed for the mobile robots operating in non-urbanized areas with significant terrain height differences and roughness. The SLAM and path planning methods use the data from the 3D laser scanner and do not require the data from the global navigation satellite system (GNSS). The typical known methods of localization and mapping based on extraction of the markers from the data sets or multiple comparisons of all data sets are not able to work properly. The INS/GNSS systems which are common in 6D localization sometimes are not available (lack of GNSS signal, multiple vertical obstacles, operation inside buildings etc.). Therefore, the new method of 6D SLAM was developed.

6D SLAM algorithm was developed on the basis of extended Kalman filter (EKF). It uses the two EKF algorithms – for mobile robot pose estimation and for map parameters estimation. The map is organized as a 2.5D grid-type map with terrain height and inclination assigned to each cell. The same map is used in path planning process. The algorithm uses two phases. In the first stage typical graph searching method is applied, while in the second stage – the path is optimized with the use of energy minimization criteria.

The developed SLAM and path planning methods were tested for artificial maps as well as for digital elevation models of real rough terrains. For the purpose of verification of the methods in real-environment experiments the new innovative laser scanner was built (with rotating optical elements – wedge prism and mirror), according to the patent developed at Lodz University of Technology. The device has the unique properties of controlling of the path of laser beam. The point cloud can be gathered from the environment in different sequences.

The simulation tests and real-environment experiments confirmed the correctness of proposed methods. Both methods can be used in mobile robot path planning, in particular for the robots operating in rough terrain, with no access to global navigation signal or when the task of extraction of the markers can require huge computational efforts or can be very time consuming.

23.04.2018 Adam Nieroda