Autonomous Exploration and Mapping of Dynamic Environments in Color

Introduction: The development of autonomous, mobile robots has undergone significant changes due to the availability of open-source software. The approach to tackle the core challenges in mobile robotics, namely localization, mapping and planning, are thereby simplified. This work aims to leverage the tools and algorithms provided by the international robotics community to setup a system capable of exploring and mapping unknown environments autonomously, while adding color to the created map and removing dynamic objects (i.e. People) from it.
Besides showing the reliability and capabilities of the tools, the work further aims to provide a working vertical integration of a quadrupedal robot, a laserscanner and a 360° vision system consisting of four cameras within the Robot Operating System.

Approach / Technology: There are three important aspects to this work that are each expected to fulfill specific requirements that contribute to the system's targeted capabilities.

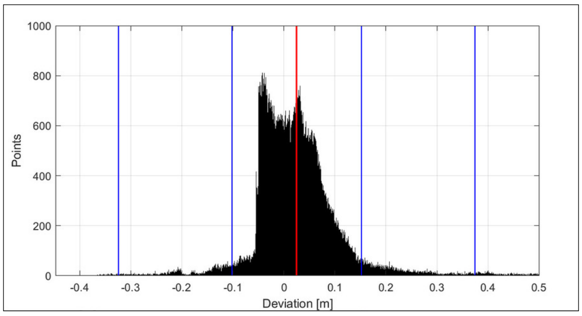
- A mapper that allows creating three dimensional maps in color
- A system that allows removing dynamic objects from the map.
- An interface that allows the integration of available exploration and pathplanning algorithms for autonomy.

To fulfill these requirements a pipeline is established that allows for completely image-based mapping by converting each 360° laserscan into four depth-images that each encode a quarter of the same spatial information. The decision to do so synergizes with the capabilities of real-time appearance based (RTAB) mapping to fulfill the mapper requirements mentioned above.
The image-based approach further allows deploying deep neural networks to detect dynamic objects in RGB image data from the vision system and associating it with the generated depth images from the laserscanner. Dynamic objects can consequentially be removed from depth images based on RGB images.
Based on depth images with removed dynamics and corresponding RGB images, a combination of spatial and color information is provided to map the static part of the environment in which the robot moves.
Based on the generated map pathplanning is conducted using various available algorithms. Two exploration algorithms are further tested to autonomously provide the pathplanner with goals.

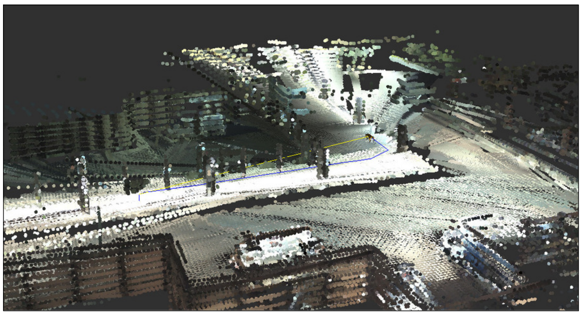
Conclusion: The resulting system is shown to be capable of creating globally consistent maps in circular environments with an overall average deviation from the reference of 5cm. The results further show the reliability of the RTAB mapper and it is shown that the mapper is exploited to the same degree as achieved by its developers.
Shortcomings are detected in the accuracy of the deep neural network and the usefulness of the achieved autonomy due to the available pathplanners and exploration algorithms. Open-source algorithms are shown to be invaluable to quickly setup complex systems, but their shortcomings for specific solutions are clearly shown in the results of this work.

Map of circular indoor environment with visible doors and images on walls. The accuracy is depicted in the image below
Own presentment

Histogram of Deviations from Ground Truth with marked Average (red) and Standard Deviations (blue)
Own presentment



Pointcloud map of outdoor environment in natural lighting conditions.
Own presentment



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