Global Localization using Multiple Hypothesis Tracking: A real-world approach

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Localization and mapping are fundamental problems in service robotics. Knowledge about the robot pose and a representation of the environment are required for a series of high level applications. Due to the lack of GPS/ DGPS/ RTK-GPS in indoor environments it is quite difficult to determine the pose of the robot. In typical service robotic in-door scenarios simultaneous localization and mapping is only used to initially map the environment of the robot. Once the environment is fully mapped there is no need to perform an expensive and fault-prone SLAM algorithm any more. One could take the generated map and localize the robot within, even if the robot is restarted at a different location. The introduced approach will overcome this problem by solving the Global Localization Problem in indoor environments using a visual sensor and a feature-map previously captured by our SLAM approach [1].

Service robots should be designed for life-long and robust operation in dynamic environments. For service robotic applications there is the need of an accurate and reliable method to estimate the position of a robot. Nowadays, typical approaches solving the SLAM problem only lay within the focus of research interest, compare Thrun [2]. For most practical applications however, the combination of SLAM to initially map the environment together with a localization method to estimate a reliable robot pose is much more valuable. Localizing within an already generated static map could be done much more performant and robust, since there is no need to introduce any change in the map. In our localization approach the SLAM algorithm could be switched to a localization only mode, not modifying the map anymore, once the map of the environment is generated. Doing so changes the algorithm from SLAM position tracking to a localization position tracking. This enables a huge performance gain by stopping the introduction of new landmarks to the map. Even if the landmark reduction technique [3] keeps the computational effort achievable, the risk of introducing failure to the map is avoided. We think that an overall localization approach should furthermore be able to deal with the global localization problem. Since, every day usage of a robot requires it to be turned off and on again. It should be able to relocalize itself within the mapped environment. Thus, our approach is able to load a saved SLAM generated feature map and to perform a relocalization procedure until a reasonable pose is found. To cope with the every-day usability there should be no need to correct the SLAM generated map after the online mapping step.

We propose a EKF Multiple Hypothesis Tracking based solution, similar to the laser ranger based approach of Jensfeld [4, chap 4]. The used feature map is online SLAM generated and no further human interaction to adapt the map is

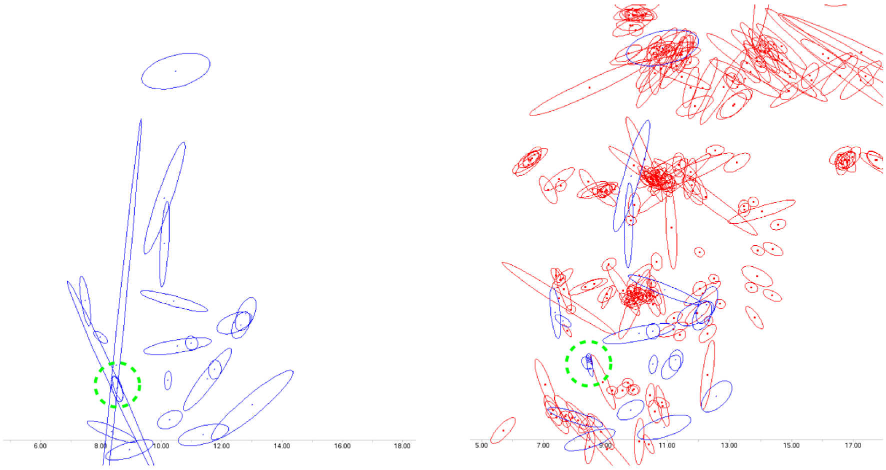

Figure 1: left: Initially generated hypotheses with their poses and the two sigma covariance ellipse. right: The same hypotheses after three update steps. Particularly those hypotheses representing the correct robot poses (marked green), have been updated. The uncertainty of those poses have been reduced heavily. The landmarks with there estimated pose and uncertainty are colored red.

necessary. Initially starting with the observed features in the image of the current camera view, we compute several hypotheses. Each hypotheses is composed from a combination of three bearing only measurements and their corresponding landmark poses estimated in the EKF and the corresponding feature map. The usage of SURF features reduces the amount of false data association decisions. However even with such strong visual features, false positives occur, since initially no position validation of the observed features can be performed. Thus, the proposed approach generates an initial pose for a hypotheses using every combination of detected features (see figure 1). Once the hypotheses has been generated the question, how to determine the correct one raises. We propose a measure combining the quality and quantity of validated feature observations for each hypotheses. Furthermore, we use a threshold discarding hypotheses with to large uncertainty, measured using the eigenvalues of the robot pose covariance matrix.

The theoretical basis for our system will be discussed in detail in the paper. Within real-world experiments we demonstrate the performance of our approach. These experiments are performed on a P3DX-platform (see figure 2) using an omnidirectional camera. The bearing-only localization approach uses two types of sensors, odometry and an omnidirectional camera. The experiments show that the proposed approach is capable to globally localize the robot using a bearing only SLAM generated feature map. In the experiments section we test the capability of the methods to relocalize the robot without any knowledge of its pose. The SLAM generated feature map is used to solve the Global Localization Problem. The generated hypotheses will be analyzed and evaluated concerning their capablilty to distingwish correct from false pose hypotheses.

Life-long and robust operation are important goals, service robots have to

Figure 2: P3DX-platform with omnidirectional camera.

solve on the way to everyday usability. Our integrated approach to handle the localization problem within every part of a robots life is a further step towards life-long operation. In particular the possibility to switch between SLAM and global localization and hence to cope with the resource limitation of real systems is a step towards robust service robotic applications.

References

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