Interval-based Global Localization in Building Maps

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Introduction

Global localization in large maps in the absence of GPS data is one of the key challenges that need to be solved in the context of autonomous driving. In particular urban canyons make global positioning using such systems very challenging. As a result, local sensory needs to be used to localize the robot on a map. Our goal is to localize the robot in an arbitrary building map. A building map may have repetitive symmetrical structures due to which the localization may be ambiguous. A prominent solution to this problem is the Monte Carlo Localization (MCL) [1,2]. However, the major drawback of MCL approaches is that the quality of the solution heavily depends on the number of samples. If the uncertainty is very large, a large number of particles may be required to cover the solution space and therefore can become computationally heavy. Further, due to random sampling of the particles, an unfortunate sequence of samples can cause a wrong convergence of the method.

We introduce a novel global localization method using intervals that copes with ambiguous localization and overcomes the aforementioned problems. We assume (i) that we know the building map of the environment in which the robot is moving, (ii) that the robot can never be inside a building, and in the scope of this abstract (iii) that the orientation of the robot is known (from a compass for instance). Exploiting the assumptions and by only using the robot's odometry information, our method can narrow down the feasible set of poses of the vehicle along the trajectory without using any exteroceptive sensors such as laser scanners. Desrochers and Jaulin [3] solve a similar problem to ours, but with the major difference, that they use sonar range measurements and restrict the local measurements to always see parts of the map. In contrast to probabilistic approaches as [1,2], our method does not need an association step of local sensor data to the map which is often error-prone. As a result, our method maintains integrity. On the downside, our approach cannot provide as accurate results as classical methods do. Nonetheless, we believe that our approach can be used to effectively reduce the search space for other methods and to find inconsistencies in the used map.

Method

In the 2D case, the pose consists of two translation and one orientation parameter. According to assumption (iii) the orientation angle is known. Hence, the global localization problem simplifies to determining the translation. As the initial position is unknown, according to assumption (i) the robot can be placed everywhere on the map. Assumption (ii) reveals, that the robot cannot be placed within buildings. That means, the position of the robot can be described by a set of positions on the map, that has an empty intersection with the buildings described by polygons. The set of feasible robot positions is represented by subpavings. When the robot moves, the subpavings are updated according to the measured odometry. Those updated subpavings that lie within a building polygon are discarded from the feasible set of positions. Subpavings that intersect but do not fully lie within a building polygon are further bisected and evaluated in a SIVIA approach. Fig. 1 illustrates our method.

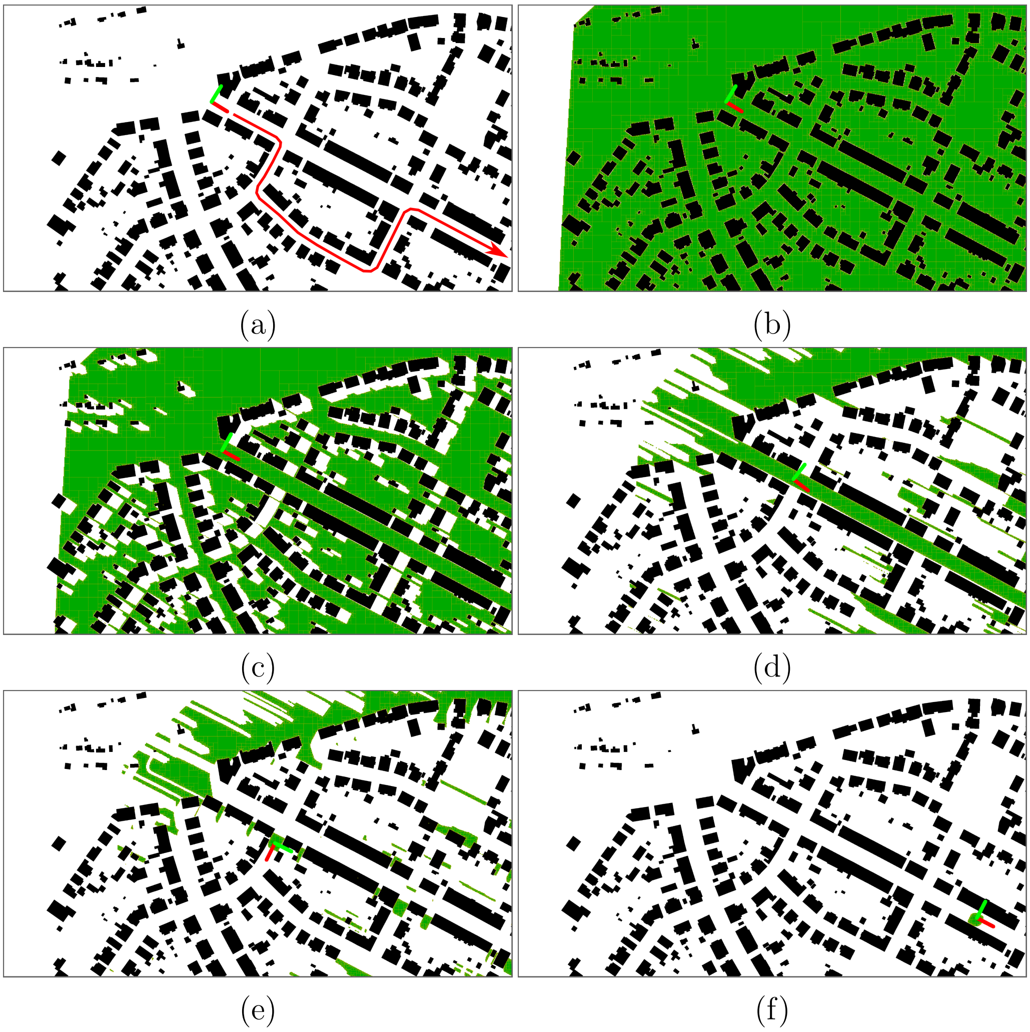
(a) (b) (c) (d) (e) (f)

Figure 1: Global Localization on the KITTI 0027 dataset [4].

First results

We experimetally evaluate our method with the KITTI 0027 dataset [4]. Fig. 1a shows the building map of a part of Karlsruhe, Germany. The trajectory is marked red. The ground truth pose of the robot is represented by the green-red coordinate frame. The feasible set of robot positions is visualized in Fig. 1b to 1f in green. Initially, the robot can be everywhere on the map besides within the buildings as shown in Fig. 1b. In Fig. 1c the vehicle has driven forward and the buildings enable us to carve out infeasible positions of the vehicle. From Fig. 1b to 1f the feasible position set is gradually narrowed down along the trajectory. In Fig. 1e multiple disconnected regions for the position remain. In Fig. 1f the robot is localized unambiguously at the end of the trajectory.

In future work, we plan to extend our method in such a way that we can withdraw assumption (iii) by also estimating the orientation. Therefore, we divide the initial orientation interval into multiple subpavings and apply our method to each of them. Those initial orientation subpavings that lead to empty sets for the feasible set of positions can be discarded and the initial orientation can be narrowed down by exclusion.

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