Qualitative Measure for Particle Clustering and Object Classification in Context of the World Modeling for a Mobile Robot

Extended Abstract

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Many tasks of a mobile robot, e.g., navigation, require the knowledge of the positions of the objects in the surrounding environment. This task is especially challenging for the robots which perception is based on a directed visual system, e.g., a camera with a limited view angle. The incomplete and noisy sensor information leads to the uncertainty in the robots belief of the world. An appropriate model of the world may enable the robot to make plans and to realize complex behavior.

The most state of the art modeling methods use probabilistic approaches. A very common approach is the *Bayes-Filtering* which estimates the state as a probabilistic *expected value* integrating all possibilities weighted with their corresponding probabilities. The resulting hypothesis is also called the *Bayes hypothesis*. However, the integration of all possibilities may turn out to be computationally very expensive, e.g., if the observations are ambiguous which may lead to a highly multi-modal probability distribution. The most implementations tackle this issue by approximating the actual probability function by a best fitting simplified version, e.g., Gaussian or particles.

The context of *RoboCup*, where teams of autonomous mobile robots have to play soccer (cf. [1]), provides a very good environment to examine modeling approaches for mobile robots. In particular, the problem of the *self-localization*, e.g., estimation of the robot's position on the field, is one of the actual problems in mobile robotics. In our example the robot is able to perceive its environment by a camera with a limited range of view. In particular, the robot is able to detect lines, goals etc. in the image and estimate their relative positions on the ground. Thereby, the field lines provide valuable information which is necessary to determine the robot's position on the field. However, this measurements, e.g., distance and angle to a seen line, are highly ambiguous, since there are numerous lines on the field.

To approach this problem of self-localization we use a particle based implementation of the Bayes-Filter. In this paper we discuss how the problem of ambiguous measurements can be treated in this context. Here, each particle represents a possible position of the robot. If a line is perceived, each particle is

CONCURRENCY, SPECIFICATION AND PROGRAMMING
M. Szczuka et al. (eds.): Proceedings of the international workshop CS&P 2011
September 28-30, Pułtusk, Poland, pp. 361-362

weighted by the line which would be most likely observed if the robot would be situated at the position represented by this particle respectively.

Ambiguous observations may lead to multi-modal hypothesis distribution, i.e., several heaps of particles in our case. Usually, a clustering method based on a distance measure is used to estimate the actual position of the robot. In some cases it may lead to a position outside of any heap, e.g., when two equally sized heaps which are not far from each other are clustered together. In this paper we propose an alternative *qualitative* measure for the clustering of the particles. Thereby, two particles are treated as similar which believe to have observed, i.e., have been updated by, the same objects, e.g., the same line. Further, we explore the possibilities to use these measures for classification of the seen objects, i.e., what line exactly has been seen by the robot.

In our experiment we could show that this way of clustering outperforms methods based on spatial measures in certain situations. We also show, that the object classification based on this approach may provide more stable results. We present results of the experiments performed both in simulation and on a real robot.

References

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