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Jos Elfring, Sjoerd van den Dries, René van de Molengraft, Maarten Steinbuch
Eindhoven University of Technology
P.O. Box 513, 5600 MB, Eindhoven, The Netherlands
Email: J.Elfring@tue.nl

1 Introduction

Domestic robots are typically confronted with a complex, dynamically changing and unstructured environment. In such environments, robots must be able to perform a wide variety of tasks, *e.g.*, safe navigation, object manipulation, including many different objects. An important prerequisite for successfully accomplishing these tasks is the availability of an accurate description of the environment the robot is operating in. In this work, such a description of the environment will be referred to as world model. A world model usually contains 3D-positions of uniquely labeled objects. In dynamic scenarios, dynamic object attributes such as velocities are included as well [1] and depending on the tasks any other object attribute can be added. The robot perceives the world using a perceptual system possibly containing multiple sensors such as cameras and laser scanners. The perceptual system generates measurements, *i.e.*, time-stamped features, that can be anything from colored blobs in a camera image [2] to labeled object positions [1]. These measurements are the input for the algorithm that constructs the world model.

2 Requirements

The world modeling algorithm should link measurements from the perceptual system to semantically meaningful labeled objects in the world model. Creating and maintaining this link is called *anchoring* [3]. Updating the object attributes based on measurements is a non-trivial task due to the uncertainties the robot will be confronted with and measurement noise in the input data. Therefore, a proper *data association* algorithm is required. In addition, *model-based object tracking* can be used (i) for estimating attributes that can not be measured directly and (ii) to do predictions. Finally, the algorithm should allow *real-time execution* on a robot with limited computational resources.

3 Probabilistic Multiple Hypothesis Anchoring

A probabilistic multiple hypothesis anchoring (PMHA) algorithm was developed meeting these requirements. It is inspired on anchoring as described in [3] with an explicit data association algorithm based on multiple hypothesis tracking (MHT) [4]. The MHT algorithm solves the data association problem by considering all possible measurement to object associations. Each set of associations is called a hypothesis and gets a probability of being correct. Unlikely hypotheses are pruned in order to allow real-time execution. The main advantage of the MHT is the ability to correct previous decisions based on new measurements. By incorporating a multiple model tracker [5], any kind of prior knowledge can be exploited, *e.g.*, "John arrives at work at 8 am" or "humans approximately move according to a constant velocity motion model".

The research leading to these results has received funding from the European Union Seventh Framework Program FP7/2007-2013 under grant agreement n^{o}248942 RoboEarth.

4 Results

The PMHA algorithm is implemented on our AMIGO robot and experiments have shown:

- Successful anchoring of measurements to objects.
- Probabilistic data association using MHT. As a result, new measurements can be used to correct previous decisions.
- Multiple model tracking exploiting any kind of prior knowledge that is available.
- Real-time execution at tens of Hertz in scenarios with many objects.

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