Sheet 9

Topic: Simultaneous Localization and Mapping
Submission deadline: July 1, 2013
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Exercise 1: Features for Landmark-based SLAM

Robots operate in many different environments. In each environment different types of landmarks may be useful. For each of the following three environments: office, outdoor and underwater think of five different types of landmarks that might be well suited.

How useful are your landmarks in combination with the following sensors: sonar, laser, monocular vision, and stereo vision? Please submit your ratings \(^1\) (“++” very useful, “+” useful, “−” not useful, “−−” not possible) in tabular form with short explanations for not-obvious ratings.

Exercise 2: Bearing-only SLAM

Bearing-only SLAM refers to the SLAM problem when the sensors can only measure the bearing of a landmark but not its range. One problem in bearing only SLAM with EKFs concerns the initialization of landmark location estimates, even if the correspondences are known. Discuss why, and devise a technique for initializing the landmark location estimates (means and covariances) that can be applied in bearing only SLAM.

\(^1\)Please note, that different ratings can be possible under different assumptions (e.g. lighting-conditions). The optimal choice of landmarks is still an open research question.
Exercise 3: Data Association

Features extracted from an observation can be interpreted as matches with features in the map, new previously unobserved features, or false alarms (noise).

Consider two features \( z_1^t \) and \( z_2^t \) extracted from an observation \( z_t \), and a map \( m_t = \{l_1, l_2\} \) with two features. An assignment \( \psi \) associates each observed feature \( z_i \) to a map feature \( l_j \), or marks it as a false alarm or as a new feature.

(a) Write down all possible assignments for the two observed features \( z_1^t \) and \( z_2^t \), and the two map features \( l_1 \) and \( l_2 \). Note that in an assignment an observed feature can be associated to one map feature at the most.

(b) Suppose now that for a given assignment, every observed feature marked as a new feature is added to the map, and every map feature without a matching observed feature is removed from the map. How many new assignments are generated from the set of assignments computed in the previous exercise if at time \( t + 1 \) a single feature \( z_{t+1}^1 \) is extracted?