

## Sheet 10

Topic: Simultaneous Localization and Mapping

Submission deadline: July 17, 2014

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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 <sup>1</sup> (“++” 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 EKF's 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.

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<sup>1</sup>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  $z_t^1$  and  $z_t^2$  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  $z_t^1$  and  $z_t^2$ , 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?