6.6.2 Landmark Measurements

In many robotics applications, features correspond to distinct objects in the physical world. For example, in indoor environments features may be door posts or windowsills; outdoors they may correspond to tree trunks or corners of buildings. In robotics, it is common to call those physical objects *landmarks*, to indicate that they are being used for robot navigation.

LANDMARKS

The most common model for processing landmarks assumes that the sensor can measure the range and the bearing of the landmark relative to the robot's local coordinate frame. Such sensors are called *range and bearing sensors*. The existence of a range-bearing sensor is not an implausible assumption: Any local feature extracted from range scans come with range and bearing information, as do visual features detected by stereo vision. In addition, the feature extractor may generate a *signature*. In this book, we assume a signature is a numerical value (e.g., an average color); it may equally be an integer that characterizes the type of the observed landmark, or a multi-dimensional vector characterizing a landmark (e.g., height and color).

RANGE AND BEARING SENSOR

SIGNATURE OF A LANDMARK

If we denote the range by r, the bearing by ϕ, and the signature by s, the feature vector is given by a collection of triplets

$$f(z_t) \quad = \quad \{f_t^1, f_t^2, \ldots\} \quad = \quad \{\begin{pmatrix} r_t^1 \\ \phi_t^1 \\ s_t^1 \end{pmatrix}, \begin{pmatrix} r_t^2 \\ \phi_t^2 \\ s_t^2 \end{pmatrix}, \ldots\} \tag{6.38}$$

The number of features identified at each time step is variable. However, many probabilistic robotic algorithms assume conditional independence between features

$$p(f(z_t) \mid x_t, m) \quad = \quad \prod_i p(r_t^i, \phi_t^i, s_t^i \mid x_t, m) \tag{6.39}$$

Conditional independence applies if the noise in each individual measurement $(r_t^i \quad \phi_t^i \quad s_t^i)^T$ is independent of the noise in other measurements $(r_t^j \quad \phi_t^j \quad s_t^j)^T$ (for $i \neq j$). Under the conditional independence assumption, we can process one feature at a time, just as we did in several of our range measurement models. This makes it much easier to develop algorithms that implement probabilistic measurement models.

Let us now devise a sensor model for features. In the beginning of this chapter, we distinguished between two types of maps: *feature-based* and *location-based*. Landmark measurement models are usually defined only for feature-based maps. The reader may recall that those maps consist of lists