MOMENTS PARAMETERIZATION

CANONICAL PARAMETERIZATION

the *moments parameterization*. This is because the mean and covariance are the first and second moments of a probability distribution. In this chapter, we will also discuss an alternative parameterization, called *canonical parameterization*, or sometimes *natural parameterization*. Both parameterizations, the moments and the canonical parameterizations, are functionally equivalent in that a bijective mapping exists that transforms one into the other. However, they lead to filter algorithms with somewhat different computational characteristics. As we shall see, the canonical and the moments parameterizations are best thought of as duals: what appears to be computationally easy in one parameterization is involved in the other, and vice versa.

This chapter introduces the two basic Gaussian filter algorithms.

- Chapter 3.2 describes the Kalman filter, which implements the Bayes filter using the moments parameterization for a restricted class of problems with linear dynamics and measurement functions.

- The Kalman filter is extended to nonlinear problems in Chapter 3.3, which describes the extended Kalman filter.

- Chapter 3.4 describes a different nonlinear Kalman filter, known as unscented Kalman filter.

- Chapter 3.5 describes the information filter, which is the dual of the Kalman filter using the canonical parameterization of Gaussians.

3.2 The Kalman Filter

3.2.1 Linear Gaussian Systems

Probably the best studied technique for implementing Bayes filters is the *Kalman filter*, or *(KF)*. The Kalman filter was invented by Swerling (1958) and Kalman (1960) as a technique for filtering and prediction in *linear Gaussian systems*, which will be defined in a moment. The Kalman filter implements belief computation for continuous states. It is not applicable to discrete or hybrid state spaces.

The Kalman filter represents beliefs by the moments parameterization: At time t, the belief is represented by the the mean μ_t and the covariance Σ_t.

GAUSSIAN POSTERIOR

Posteriors are *Gaussian* if the following three properties hold, in addition to the Markov assumptions of the Bayes filter.