mapped sigma points $\mathcal{Y}^{[i]}$ according to

$$(3.69) \qquad \begin{aligned} \mu' &= \sum_{i=0}^{2n} w_m^{[i]}\, \mathcal{Y}^{[i]} \\ \Sigma' &= \sum_{i=0}^{2n} w_c^{[i]}\, (\mathcal{Y}^{[i]} - \mu')(\mathcal{Y}^{[i]} - \mu')^T. \end{aligned}$$

Figure 3.8 illustrates the dependency of the unscented transform on the uncertainty of the original Gaussian. For comparison, the results using the EKF Taylor series expansion are plotted alongside the UKF results.

Figure 3.9 shows an additional comparison between UKF and EKF approximation, here in dependency of the local nonlinearity of the function g. As can be seen, the unscented transform is more accurate than the first order Taylor series expansion applied by the EKF. In fact, it can be shown that the unscented transform is accurate in the first two terms of the Taylor expansion, while the EKF captures only the first order term. (It should be noted, however, that both the EKF and the UKF can be modified to capture higher order terms.)

3.4.2 The UKF Algorithm

The UKF algorithm utilizing the unscented transform is presented in Table 3.4. The input and output are identical to the EKF algorithm. Line 2 determines the sigma points of the previous belief using Equation (3.66), with γ short for $\sqrt{n+\lambda}$. These points are propagated through the noise-free state prediction in line 3. The predicted mean and variance are then computed from the resulting sigma points (lines 4 and 5). R_t in line 5 is added to the sigma point covariance in order to model the additional prediction noise uncertainty (compare line 3 of the EKF algorithm in Table 3.3). The prediction noise R_t is assumed to be additive. Later, in Chapter 7, we present a version of the UKF algorithm that performs more accurate estimation of the prediction and measurement noise terms.

A new set of sigma points is extracted from the predicted Gaussian in line 6. This sigma point set $\bar{\mathcal{X}}_t$ now captures the overall uncertainty after the prediction step. In line 7, a predicted observation is computed for each sigma point. The resulting observation sigma points $\bar{\mathcal{Z}}_t$ are used to compute the predicted observation $\hat{z}_t$ and its uncertainty, S_t. The matrix Q_t is the covariance matrix of the additive measurement noise. Note that S_t represents