Algorithm UKF_localization($\mu_{t-1}, \Sigma_{t-1}, u_t, z_t, m$):

Generate augmented mean and covariance

$$M_t = \begin{pmatrix} \alpha_1 v_t^2 + \alpha_2 \omega_t^2 & 0 \\ 0 & \alpha_3 v_t^2 + \alpha_4 \omega_t^2 \end{pmatrix}$$

$$Q_t = \begin{pmatrix} \sigma_r^2 & 0 \\ 0 & \sigma_\phi^2 \end{pmatrix}$$

$$\mu_{t-1}^a = (\mu_{t-1}^T \quad (0\ \ 0)^T \quad (0\ \ 0)^T)^T$$

$$\Sigma_{t-1}^a = \begin{pmatrix} \Sigma_{t-1} & \mathbf{0} & \mathbf{0} \\ \mathbf{0} & M_t & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & Q_t \end{pmatrix}$$

Generate sigma points

$$\mathcal{X}_{t-1}^a = (\mu_{t-1}^a \quad \mu_{t-1}^a + \gamma\sqrt{\Sigma_{t-1}^a} \quad \mu_{t-1}^a - \gamma\sqrt{\Sigma_{t-1}^a})$$

Pass sigma points through motion model and compute Gaussian statistics

$$\bar{\mathcal{X}}_t^x = g(u_t + \mathcal{X}_t^u, \mathcal{X}_{t-1}^x)$$

$$\bar{\mu}_t = \sum_{i=0}^{2L} w_i^{(m)} \bar{\mathcal{X}}_{i,t}^x$$

$$\bar{\Sigma}_t = \sum_{i=0}^{2L} w_i^{(c)} (\bar{\mathcal{X}}_{i,t}^x - \bar{\mu}_t)(\bar{\mathcal{X}}_{i,t}^x - \bar{\mu}_t)^T$$

Predict observations at sigma points and compute Gaussian statistics

$$\bar{\mathcal{Z}}_t = h(\bar{\mathcal{X}}_t^x) + \mathcal{X}_t^z$$

$$\hat{z}_t = \sum_{i=0}^{2L} w_i^{(m)} \bar{\mathcal{Z}}_{i,t}$$

$$S_t = \sum_{i=0}^{2L} w_i^{(c)} (\bar{\mathcal{Z}}_{i,t} - \hat{z}_t)(\bar{\mathcal{Z}}_{i,t} - \hat{z}_t)^T$$

$$\Sigma_t^{x,z} = \sum_{i=0}^{2L} w_i^{(c)} (\bar{\mathcal{X}}_{i,t}^x - \bar{\mu}_t)(\bar{\mathcal{Z}}_{i,t} - \hat{z}_t)^T$$

Update mean and covariance

$$K_t = \Sigma_t^{x,z}\ S_t^{-1}$$

$$\mu_t = \bar{\mu}_t + K_t(z_t - \hat{z}_t)$$

$$\Sigma_t = \bar{\Sigma}_t - K_t\ S_t\ K_t^T$$

$$p_{z_t} = \det(2\pi S_t)^{-\frac{1}{2}} \exp\left\{-\frac{1}{2}\ (z_t - \hat{z}_t)^T S_t^{-1} (z_t - \hat{z}_t)\right\}$$

return μ_t, Σ_t, p_{z_t}

Table 7.4 The unscented Kalman filter (UKF) localization algorithm, formulated here for a feature-based map and a robot equipped with sensors for measuring range and bearing. This version handles single feature observations only and assumes knowledge of the exact correspondence. L is the dimensionality of the augmented state vector, given by the sum of state, control, and measurement dimensions.