pendent noise ε_{b^2} with zero mean and variance b^2:

$$\hat{\delta}_{\text{rot1}} = \delta_{\text{rot1}} - \varepsilon_{\alpha_1 \delta^2_{\text{rot1}} + \alpha_2 \delta^2_{\text{trans}}} \tag{5.37}$$

$$\hat{\delta}_{\text{trans}} = \delta_{\text{trans}} - \varepsilon_{\alpha_3\ \delta^2_{\text{trans}} + \alpha_4\ \delta^2_{\text{rot1}} + \alpha_4\ \delta^2_{\text{rot2}}} \tag{5.38}$$

$$\hat{\delta}_{\text{rot2}} = \delta_{\text{rot2}} - \varepsilon_{\alpha_1 \delta^2_{\text{rot2}} + \alpha_2 \delta^2_{\text{trans}}} \tag{5.39}$$

As in the previous section, ε_{b^2} is a zero-mean noise variable with variance b^2. The parameters α_1 to α_4 are robot-specific error parameters, which specify the error accrued with motion.

Consequently, the true position, x_t, is obtained from x_{t-1} by an initial rotation with angle $\hat{\delta}_{\text{rot1}}$, followed by a translation with distance $\hat{\delta}_{\text{trans}}$, followed by another rotation with angle $\hat{\delta}_{\text{rot2}}$. Thus,

$$\begin{pmatrix} x' \\ y' \\ \theta' \end{pmatrix} = \begin{pmatrix} x \\ y \\ \theta \end{pmatrix} + \begin{pmatrix} \hat{\delta}_{\text{trans}} \cos(\theta + \hat{\delta}_{\text{rot1}}) \\ \hat{\delta}_{\text{trans}} \sin(\theta + \hat{\delta}_{\text{rot1}}) \\ \hat{\delta}_{\text{rot1}} + \hat{\delta}_{\text{rot2}} \end{pmatrix} \tag{5.40}$$

Notice that algorithm **sample_motion_model_odometry** implements Equations (5.34) through (5.40).

The algorithm **motion_model_odometry** is obtained by noticing that lines 5-7 compute the motion parameters $\hat{\delta}_{\text{rot1}}$, $\hat{\delta}_{\text{trans}}$, and $\hat{\delta}_{\text{rot2}}$ for the hypothesized pose x_t, relative to the initial pose x_{t-1}. The difference of both,

$$\delta_{\text{rot1}} - \hat{\delta}_{\text{rot1}} \tag{5.41}$$

$$\delta_{\text{trans}} - \hat{\delta}_{\text{trans}} \tag{5.42}$$

$$\delta_{\text{rot2}} - \hat{\delta}_{\text{rot2}} \tag{5.43}$$

is the *error* in odometry, assuming of course that x_t is the true final pose. The error model (5.37) to (5.39) implies that the probability of these errors is given by

$$p_1 = \varepsilon_{\alpha_1 \delta^2_{\text{rot1}} + \alpha_2 \delta^2_{\text{trans}}}(\delta_{\text{rot1}} - \hat{\delta}_{\text{rot1}}) \tag{5.44}$$

$$p_2 = \varepsilon_{\alpha_3\ \delta^2_{\text{trans}} + \alpha_4\ \delta^2_{\text{rot1}} + \alpha_4\ \delta^2_{\text{rot2}}}(\delta_{\text{trans}} - \hat{\delta}_{\text{trans}}) \tag{5.45}$$

$$p_3 = \varepsilon_{\alpha_1 \delta^2_{\text{rot2}} + \alpha_2 \delta^2_{\text{trans}}}(\delta_{\text{rot2}} - \hat{\delta}_{\text{rot2}}) \tag{5.46}$$

with the distributions ε defined as above. These probabilities are computed in lines 8-10 of our algorithm **motion_model_odometry**, and since the errors are assumed to be independent, the joint error probability is the product $p_1 \cdot p_2 \cdot p_3$ (c.f., line 11).