Sheet 2
Motion Models and Robot Odometry

Group 4
Urs Borrmann, Caner Hazirbas, FangYi Zhi

May 12, 2013

Exercise 1

c) Group Picture

d) Graph Visualization

e) Specify the odometry model

Exercise 2

d) Kalman Filter Covariance Ellipse Secreenshot

e) Kalman Filter with Higher Noise Screenshots

f) Noise Prediction for Experimental Setup

g) Observation Function and Its Jacobian

Observation Function

Observed marker pose is calculated with function $h(x)$ (eq. 1). This $h(x)$ observation function predicts the marker pose z_{pre} given x, estimated robot world state(eq 2), and z_g ,the marker pose in global frame(eq. 3).

1.
$$z_{pre} = h(x)$$
$$z_{pre} = (x_{pre} \quad y_{pre} \quad \psi_{pre})^T$$

2.
$$x = (x_w \quad y_w \quad \psi_w)^T$$

3.
$$z_g = (x_g \quad y_g \quad \psi_g)^T$$

In order to find the observation, we need to transform the global marker pose to local frame.

If X is homogeneous transformation matrix of x, robot pose,

$$X = \begin{pmatrix} R & t \\ 0 & 1 \end{pmatrix} = \begin{pmatrix} \cos\psi_w & -\sin\psi_w & x_w \\ \sin\psi_w & \cos\psi_w & y_w \\ 0 & 0 & 1 \end{pmatrix}$$

then we can transform any local frame to global frame as follows;

$$\vec{t_g} = X t_p \vec{re}$$

We want to transform from global to local. In order to do that we should take inverse of X transformation matrix;

$$X^{-1} = \begin{pmatrix} R^{-1} & -R^{-1}t \\ 0 & 1 \end{pmatrix} = \begin{pmatrix} \cos\psi_w & \sin\psi_w & -x_w\cos\psi_w - y_w\sin\psi_w \\ -\sin\psi_w & \cos\psi_w & x_w\sin\psi_w - y_w\cos\psi_w \\ 0 & 0 & 1 \end{pmatrix}$$

Now we can compute the local marker position from global marker position;

$$\vec{t_g} = \begin{pmatrix} x_g \\ y_g \end{pmatrix}$$

$$\tilde{t_{pre}} = X^{-1}\tilde{t_w} = \begin{pmatrix} (x_w - x_l)\cos\psi_w + (y_w - y_l)\sin\psi_w \\ -(x_w - x_l)\sin\psi_w + (y_w - y_l)\cos\psi_w \\ 1 \end{pmatrix}$$

Since yaw angle is always in the global frame, observed yaw angle is

$$\psi_{pre} = (\psi_w - \psi_g)$$

At the end we get following observation function

$$h(x) = \begin{pmatrix} (x_w - x_g)\cos\psi_w + (y_w - y_g)\sin\psi_w \\ -(x_w - x_g)\sin\psi_w + (y_w - y_g)\cos\psi_w \\ (\psi_w - \psi_g) \end{pmatrix}$$

i) Trajectory

j) Drift on Pose Estimation