EKF for Roomba Filter

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4 Jun 2018

State is $(x, y, \theta, \dot{\theta})^T$
Timestep is τ
Transition function is

$$x = x_0 + v\left(\frac{\cos\theta_0 \sin(\dot{\theta}_0\tau)}{\dot{\theta}_0} + \frac{\sin\theta_0}{\dot{\theta}_0}(\cos(\dot{\theta}_0\tau) - 1)\right)$$

$$y = y_0 + v\left(\frac{\sin\theta_0 \sin(\dot{\theta}_0\tau)}{\dot{\theta}_0} - \frac{\cos\theta_0}{\dot{\theta}_0}(\cos(\dot{\theta}_0\tau) - 1)\right)$$

$$\theta = \theta_0 + \dot{\theta}_0\tau$$

$$\dot{\theta} = \dot{\theta}_0$$

Its derivatives are

$$\frac{\partial x}{\partial x_0} = 1$$

$$\frac{\partial x}{\partial \theta_0} = v\left(\frac{-\sin\theta_0 \sin(\dot{\theta}_0\tau)}{\dot{\theta}_0} + \frac{\cos\theta_0}{\dot{\theta}_0}(\cos(\dot{\theta}_0\tau) - 1)\right)$$

$$\frac{\partial x}{\partial \dot{\theta}_0} = v\left(\cos\theta_0\left(\tau\frac{\cos(\dot{\theta}_0\tau)}{\dot{\theta}_0} - \frac{\sin(\dot{\theta}_0\tau)}{\dot{\theta}_0^{\,2}}\right) + \sin\theta_0\left(\tau\frac{-\sin(\dot{\theta}_0\tau)}{\dot{\theta}_0} - \frac{\cos(\dot{\theta}_0\tau) - 1}{\dot{\theta}_0^{\,2}}\right)\right)$$

$$\frac{\partial y}{\partial y_0} = 1$$

$$\frac{\partial y}{\partial \theta_0} = v\left(\frac{\cos\theta_0 \sin(\dot{\theta}_0\tau)}{\dot{\theta}_0} + \frac{\sin\theta_0}{\dot{\theta}_0}(\cos(\dot{\theta}_0\tau) - 1)\right)$$

$$\frac{\partial y}{\partial \dot{\theta}_0} = v\left(\sin\theta_0\left(\tau\frac{\cos(\dot{\theta}_0\tau)}{\dot{\theta}_0} - \frac{\sin(\dot{\theta}_0\tau)}{\dot{\theta}_0^{\,2}}\right) - \cos\theta_0\left(\tau\frac{-\sin(\dot{\theta}_0\tau)}{\dot{\theta}_0} - \frac{\cos(\dot{\theta}_0\tau) - 1}{\dot{\theta}_0^{\,2}}\right)\right)$$

$$\frac{\partial \theta}{\partial \theta_0} = 1$$

$$\frac{\partial \theta}{\partial \dot{\theta}_0} = \tau$$

$$\frac{\partial \dot{\theta}}{\partial \dot{\theta}_0} = 1$$