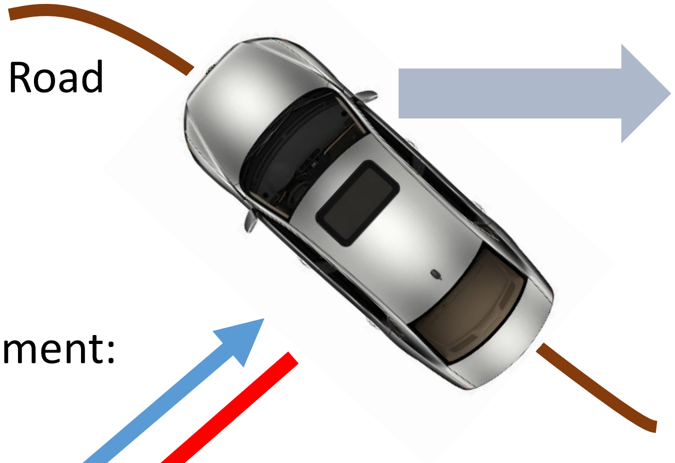
A target tracking example:

A nearly constant velocity motion model for the car:

$$\begin{bmatrix} x_k \\ \dot{x}_k \\ y_k \\ \dot{y}_k \end{bmatrix} = \begin{bmatrix} 1 & T & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & T \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x_{k-1} \\ \dot{x}_{k-1} \\ y_{k-1} \\ \dot{y}_{k-1} \end{bmatrix} + \begin{bmatrix} v_1 \\ v_2 \\ v_3 \\ v_4 \end{bmatrix}$$



To understand the noise term: the unknown acceleration causes the uncertain for position (x_k, y_k) and velocity $(\dot{x}_k, \dot{y}_k)$, and this effect is modeled by a zero mean Gaussian random vector with an assumed structured convariance matrix.

Initial Measurement:
distance r_k
angle θ_k

Sensor/Radar

Convert to

Converted measurement: coordinates

$$x_{\mathrm{m},k}, y_{\mathrm{m},k}$$

Measurement model for the car's state:

$$\begin{bmatrix} x_{\mathrm{m},k} \\ y_{\mathrm{m},k} \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix} \begin{bmatrix} x_k \\ \dot{x}_k \\ y_k \\ \dot{y}_k \end{bmatrix} + \boldsymbol{w}_k$$

Noise of the measurement

Every time we have the measurement $(x_{\mathrm{m},k}, y_{\mathrm{m},k})$, we can estimate the current position and velocity of the car by the Kalman filter.