Probabilistic Robotics Course

EKF Scenarios

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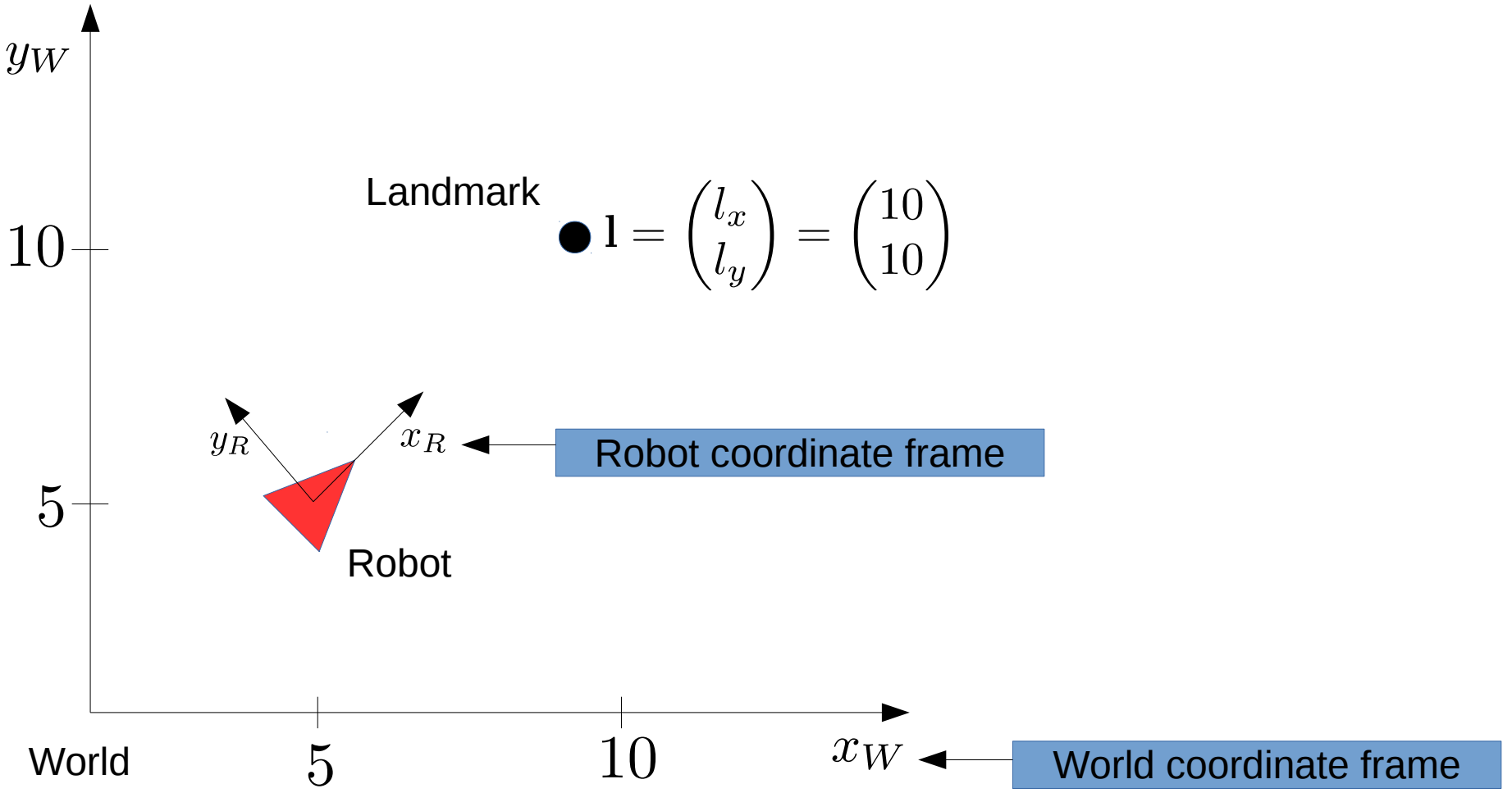
EKF Localization

- The map (i.e. the landmarks) is known to the robot!

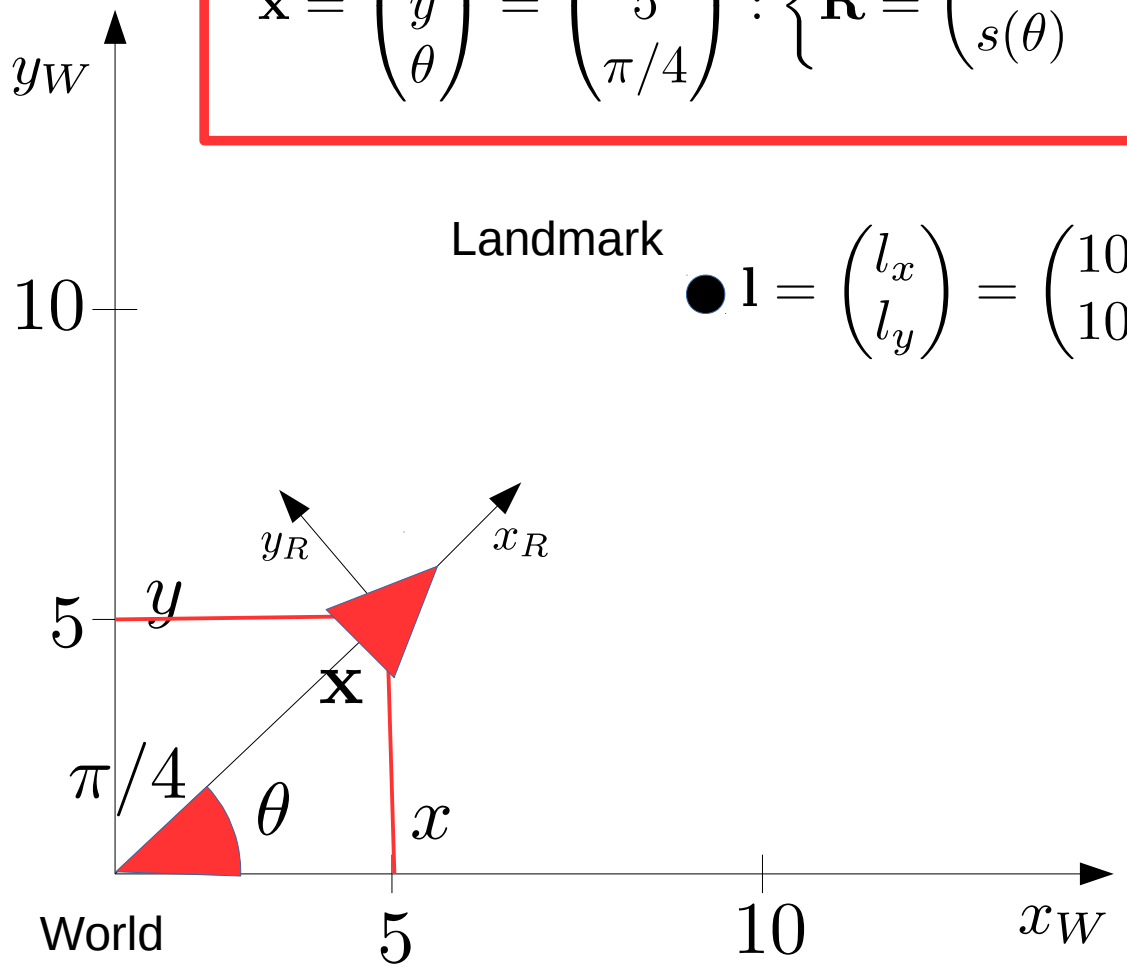


EKF Localization

- The robot doesn't know if its state $\mathbf{x}$ is true.

$$\mathbf{x} = \begin{pmatrix} x \\ y \\ \theta \end{pmatrix} = \begin{pmatrix} 5 \\ 5 \\ \pi/4 \end{pmatrix} : \left\{ \mathbf{R} = \begin{pmatrix} c(\theta) & -s(\theta) \\ s(\theta) & c(\theta) \end{pmatrix}, \mathbf{t} = \begin{pmatrix} x \\ y \end{pmatrix} \right\}$$

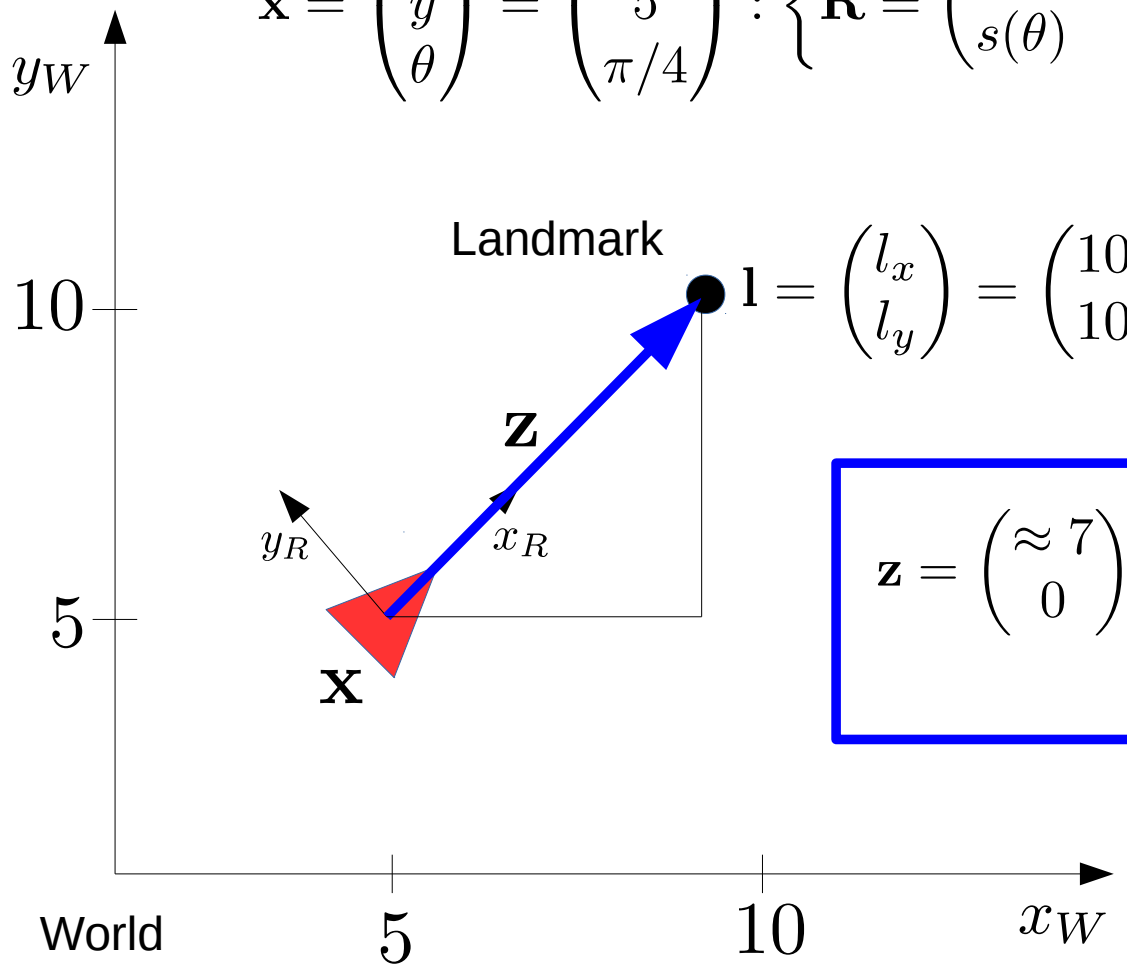
State



EKF Localization

- The robot obtains relative measurements!

$$\mathbf{x} = \begin{pmatrix} x \\ y \\ \theta \end{pmatrix} = \begin{pmatrix} 5 \\ 5 \\ \pi/4 \end{pmatrix} : \left\{ \mathbf{R} = \begin{pmatrix} c(\theta) & -s(\theta) \\ s(\theta) & c(\theta) \end{pmatrix}, \mathbf{t} = \begin{pmatrix} x \\ y \end{pmatrix} \right\}$$



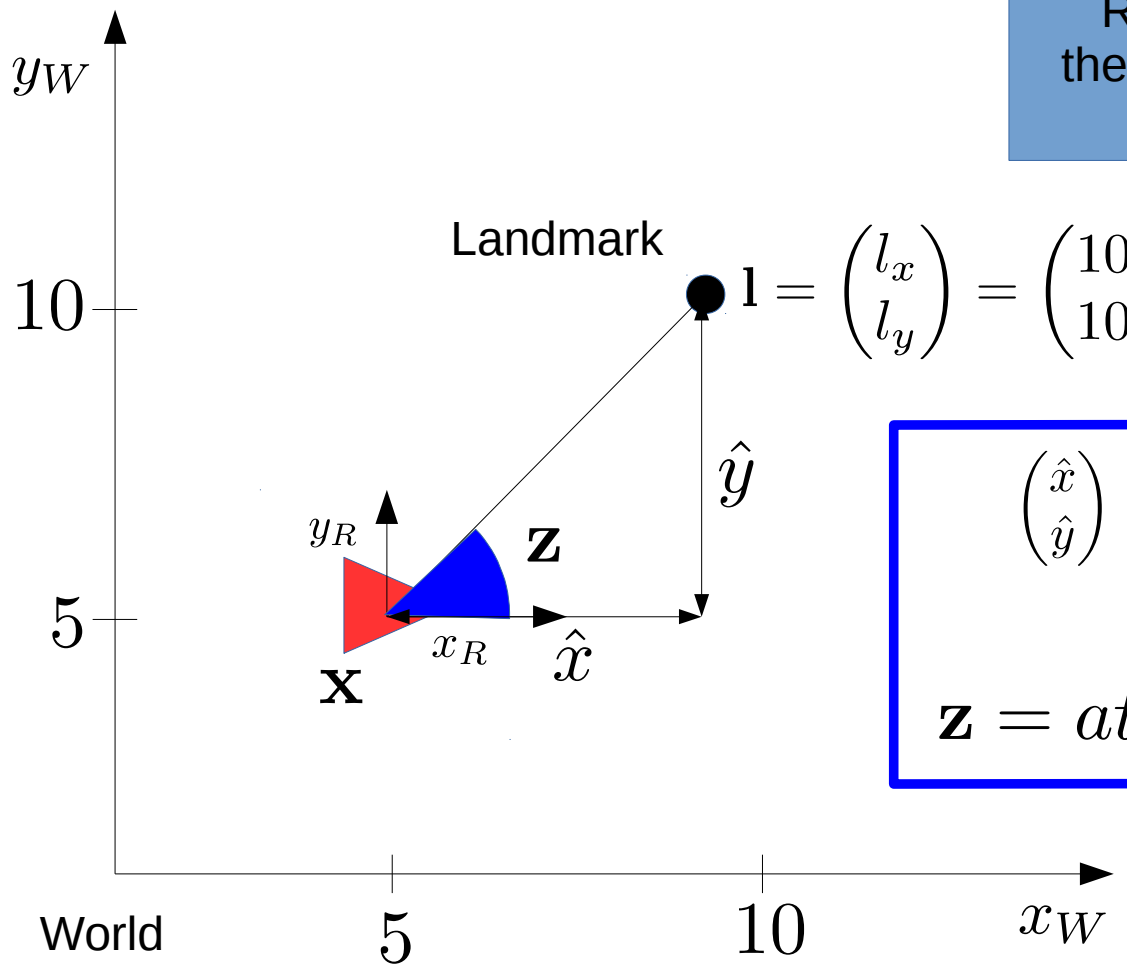
$$\approx 0.7$$

$$\mathbf{z} = \begin{pmatrix} \approx 7 \\ 0 \end{pmatrix} = \underbrace{\begin{pmatrix} c(\pi/4) & s(\pi/4) \\ -s(\pi/4) & c(\pi/4) \end{pmatrix}}_{\mathbf{R}^\top(\theta)} \underbrace{\begin{pmatrix} 10-5 \\ 10-5 \end{pmatrix}}_{(\mathbf{l}-\mathbf{t})}$$

Measurement: a vector

EKF Localization Bearing-only

- The map is still known, but we only measure bearings (angles to landmarks)



Relative coordinates to the landmark, the robot can perceive them only through the bearing angle!

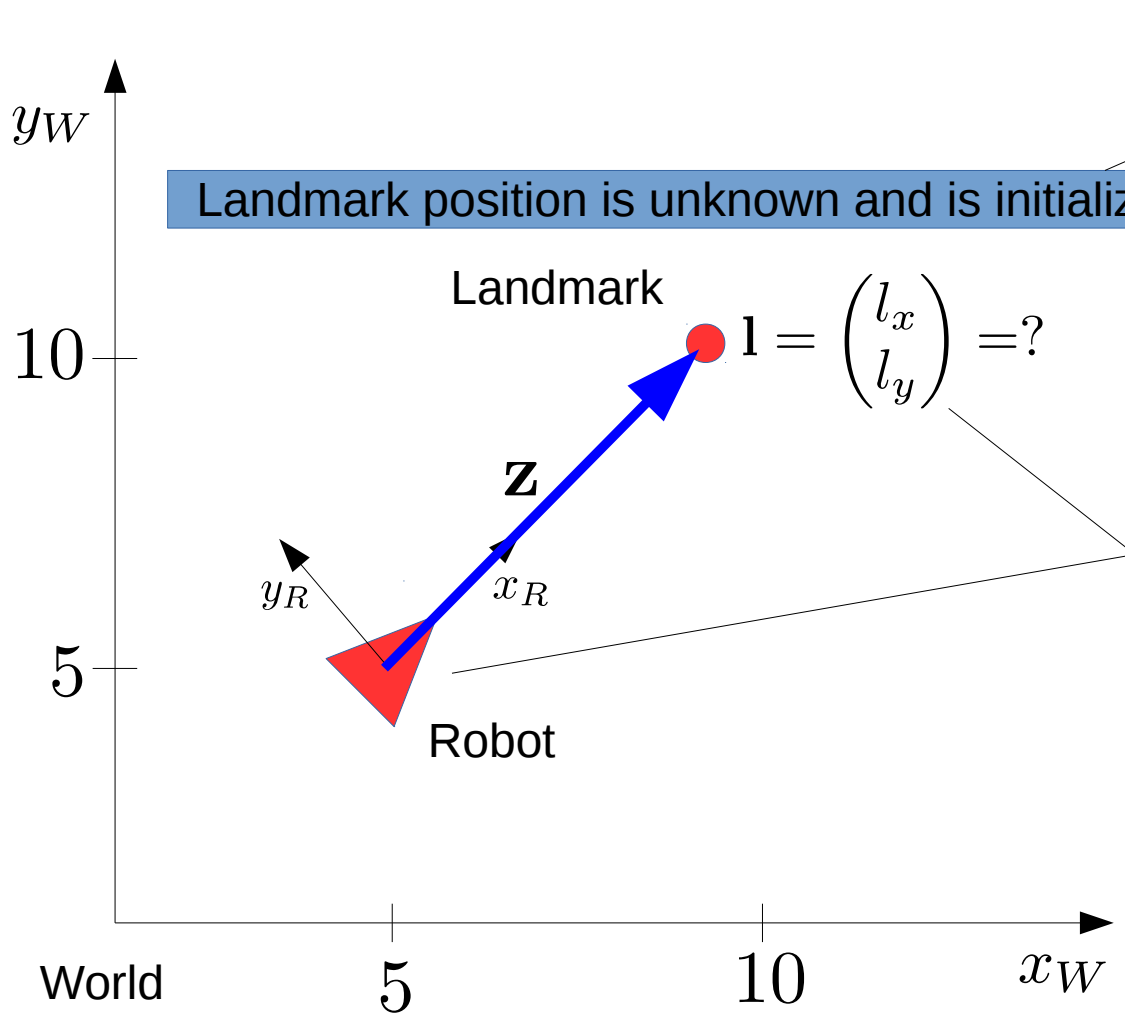
$$\begin{pmatrix} \hat{x} \\ \hat{y} \end{pmatrix} = \begin{pmatrix} 5 \\ 5 \end{pmatrix} = \underbrace{\begin{pmatrix} c(0) & s(0) \\ -s(0) & c(0) \end{pmatrix}}_{\mathbf{R}^\top(\theta)} \underbrace{\begin{pmatrix} 10-5 \\ 10-5 \end{pmatrix}}_{(\mathbf{l}-\mathbf{t})}$$

$$\mathbf{z} = atan(\hat{y}/\hat{x}) = atan(1) = \pi/4$$

Measurement: a scalar

EKF SLAM

- The map is unknown, so the robot also has to estimate the positions of the landmarks



$$\begin{pmatrix} l_x \\ l_y \end{pmatrix} = \begin{pmatrix} x \\ y \end{pmatrix} + R\mathbf{z}$$

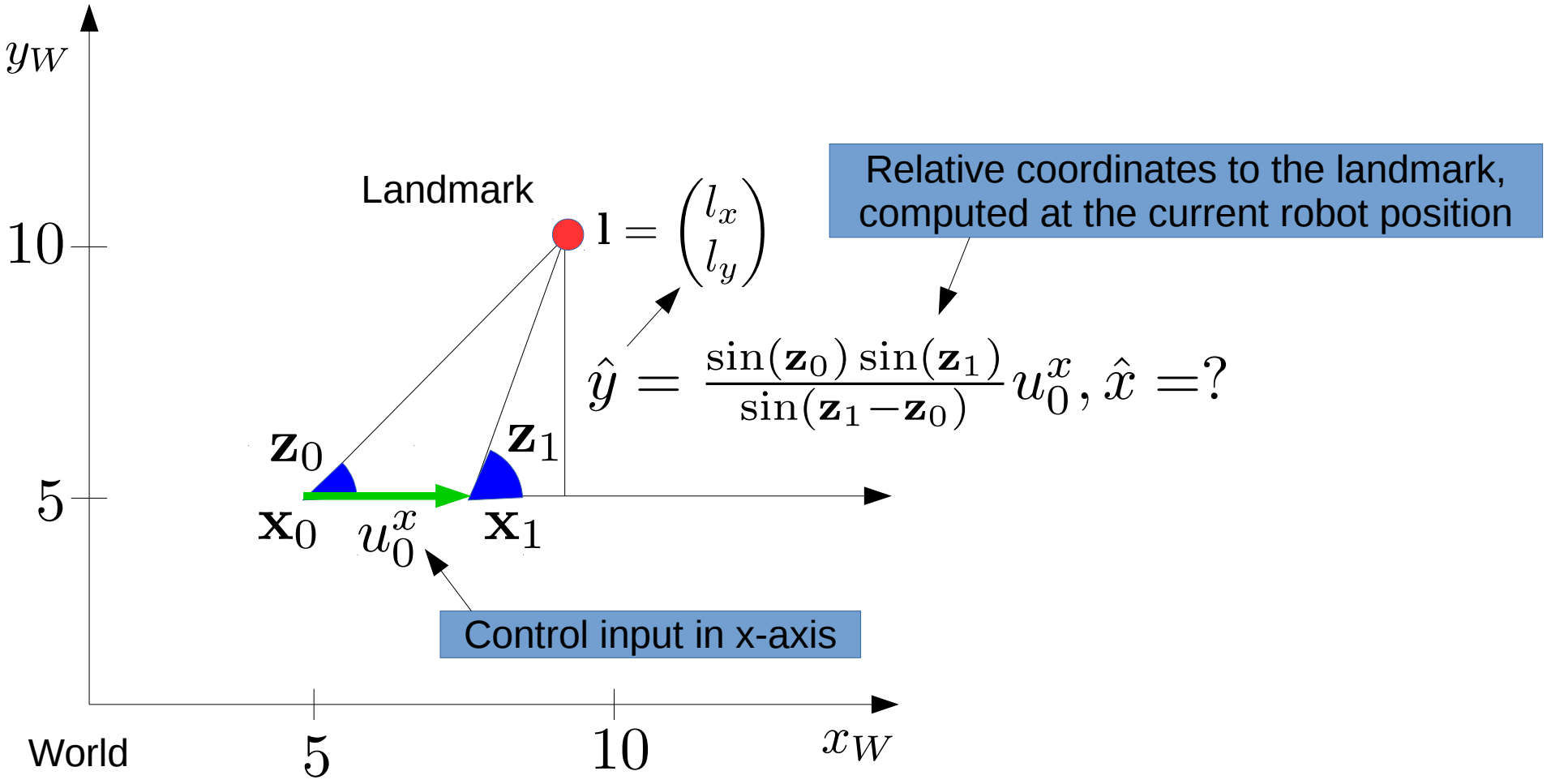
Landmark position is unknown and is initialized with the first measurement

$$\mathbf{x} = \begin{pmatrix} x \\ y \\ \theta \\ l_x \\ l_y \end{pmatrix} = \begin{pmatrix} 5 \\ 5 \\ \pi/4 \\ 10 \\ 10 \end{pmatrix}$$

Augmented state,
contains all estimated landmarks

EKF SLAM Bearing-only

- How to compute the landmark position $\mathbf{l}$ based on two measurements $\mathbf{z}_0, \mathbf{z}_1$?



EKF Mapping

- What’s different with respect to SLAM?
- What’s different with respect to classical Localization?