LAB5: EKF-SLAM/DATA ASSOCIATION NOTES

ECEN 633: Robotic Localization and Mapping

Slides courtesy of Michael Kaess

LAB3 – EKF-SLAM

Three Tasks

▶ **Task 1:** EKF-SLAM Simulator – Known Data Association

▶ **Task 2:** EKF-SLAM Simulator – Unknown Data Association

▶ **Task 3:** EKF-SLAM on Victoria Park

State Augmentation of Belief

▶ Before

$$\mu_t = \begin{bmatrix} \mu_r \\ \mu_L \end{bmatrix} \qquad \Sigma_t = \begin{bmatrix} \Sigma_{rr} & \Sigma_{rL} \\ \Sigma_{Lr} & \Sigma_{LL} \end{bmatrix}$$

▶ After

$$\mu_{t_{\mathrm{aug}}} = \begin{bmatrix} \mu_r \\ \mu_L \\ \mu_{\ell_i} \end{bmatrix} = \begin{bmatrix} \mu_r \\ \mu_L \\ \mathbf{g}(\mu_r, \mathbf{z}_t^i) \end{bmatrix}$$

$$\Sigma_{t_{\mathrm{aug}}} = \begin{bmatrix} \Sigma_{rr} & \Sigma_{rL} & \Sigma_{r\ell_i} \\ \Sigma_{Lr} & \Sigma_{LL} & \Sigma_{L\ell_i} \\ \Sigma_{\ell_i r} & \Sigma_{\ell_i L} & \Sigma_{\ell_i \ell_i} \end{bmatrix} \qquad \begin{aligned} \Sigma_{\ell_i r} &= \Sigma_{r\ell_i}^\top = G_r \Sigma_{rr} \\ \Sigma_{\ell_i L} &= \Sigma_{L\ell_i}^\top = G_r \Sigma_{rL} \\ \Sigma_{\ell_i \ell_i} &= G_r \Sigma_{rr} G_r^\top + G_\delta Q_t^i G_\delta^\top \end{aligned}$$
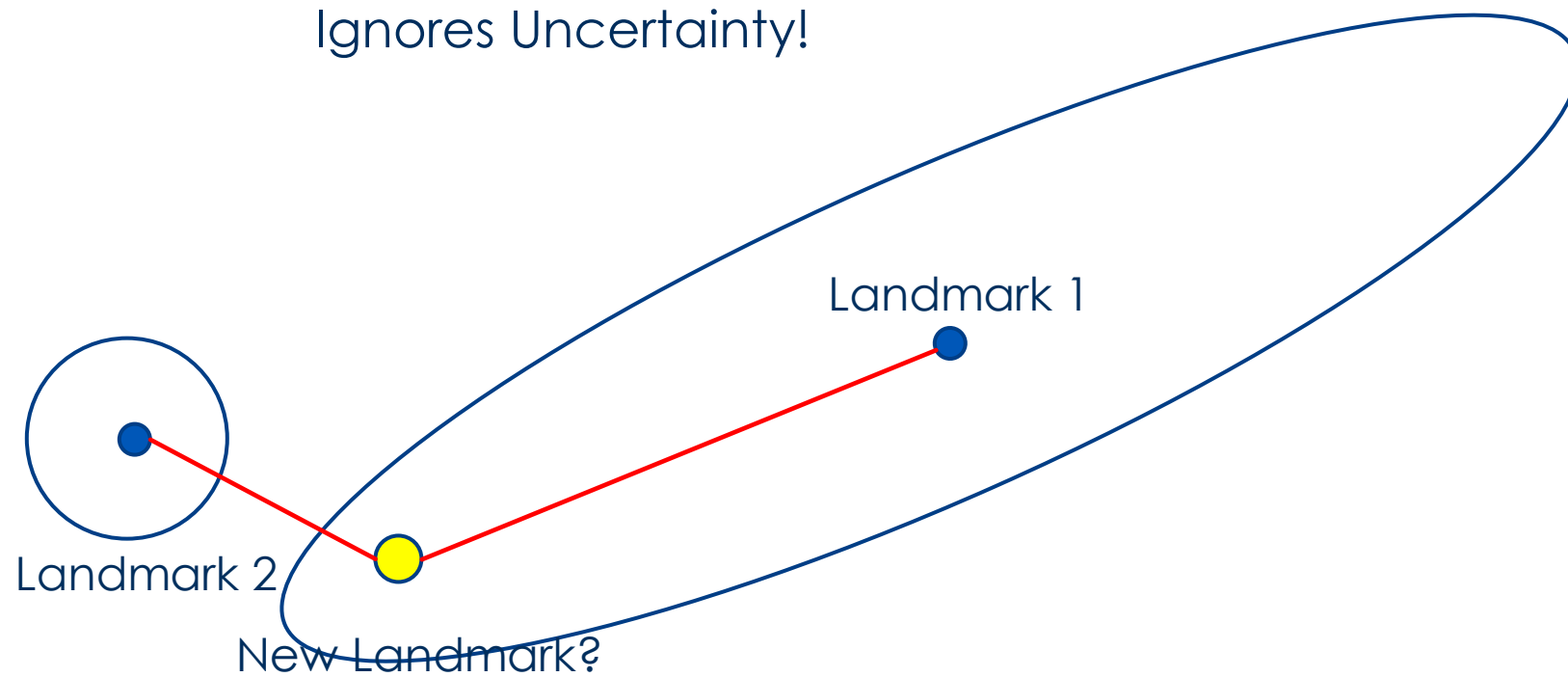
See Slides from Lecture on EKF SLAM for more on this!

Data Association

▶ Nearest Neighbor (Euclidean Space)

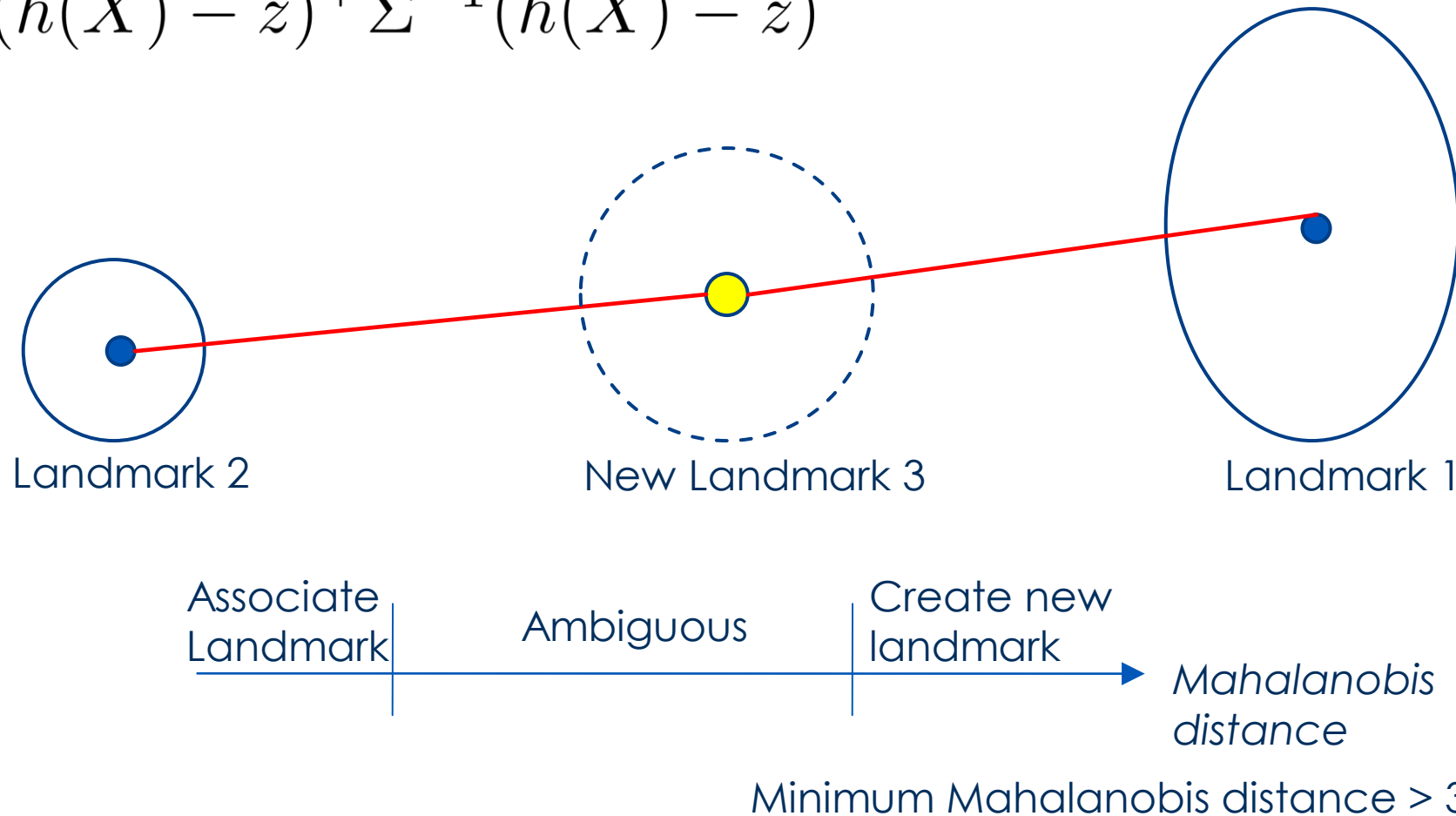▶ Nearest Neighbor (Mahalanobis Distance)

▶ Joint Compatability

Nearest Neighbor Euclidean Distance

Ignores Uncertainty!

Landmark 1

Landmark 2

New Landmark?

Nearest Neighbor – Mahalanobis Distance

▶ Mahalanobis distance

$$K^2 = (h(X) - z)^\top \Sigma^{-1} (h(X) - z)$$

Landmark 2

New Landmark 3

Landmark 1

Associate
Landmark

Ambiguous

Create new
landmark

Mahalanobis
distance

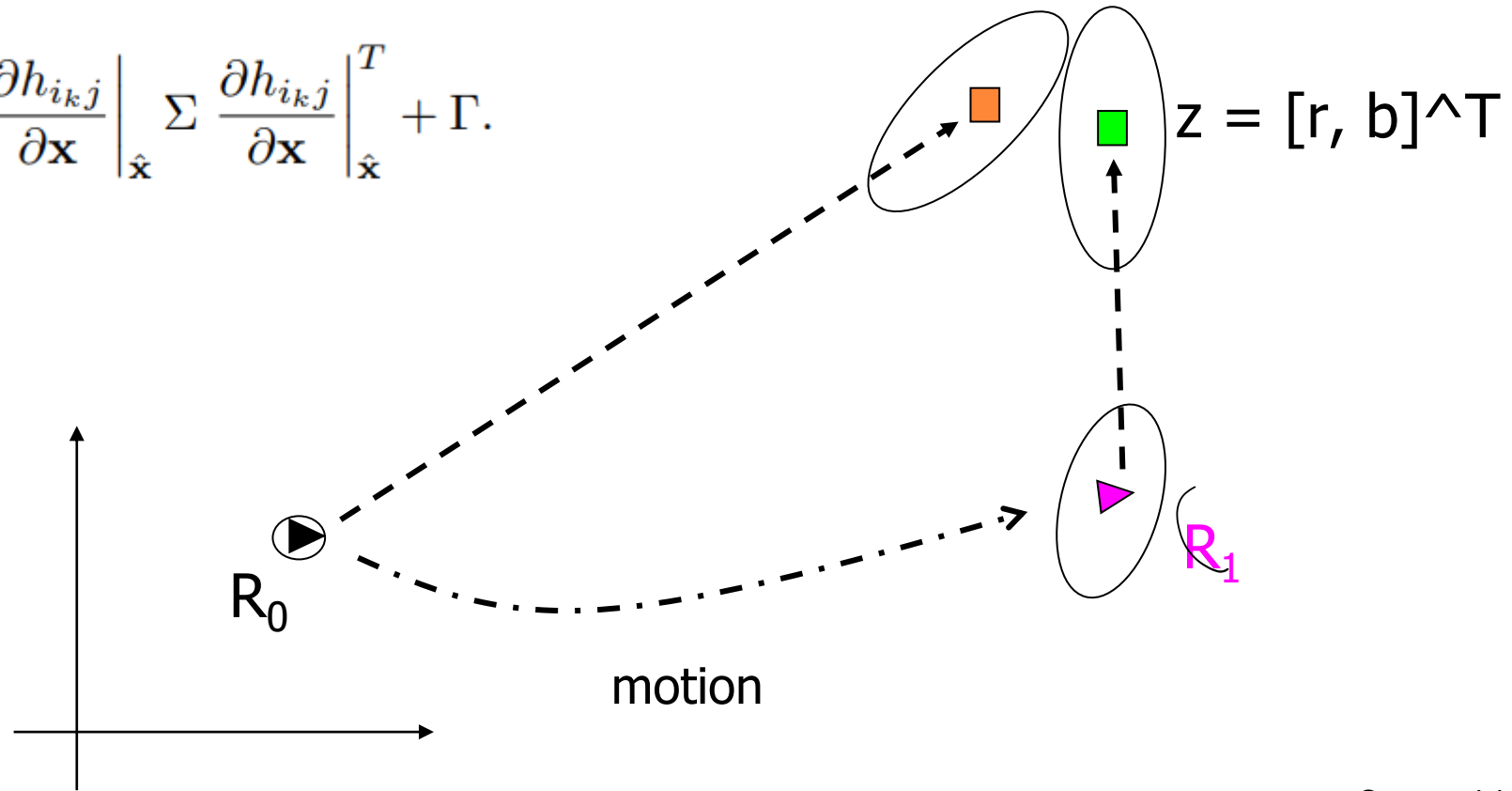Minimum Mahalanobis distance > 3

Nearest Neighbor – Mahalanobis Distance

▶ Mahalanobis distance

$$K^2 = (h(X) - z)^\top \Sigma^{-1}(h(X) - z)$$

$$\Sigma := \left.\frac{\partial h_{i_k j}}{\partial \mathbf{x}}\right|_{\hat{\mathbf{x}}} \Sigma \left.\frac{\partial h_{i_k j}}{\partial \mathbf{x}}\right|_{\hat{\mathbf{x}}}^T + \Gamma.$$

z = [r, b]^T

R_0

R_1

motion