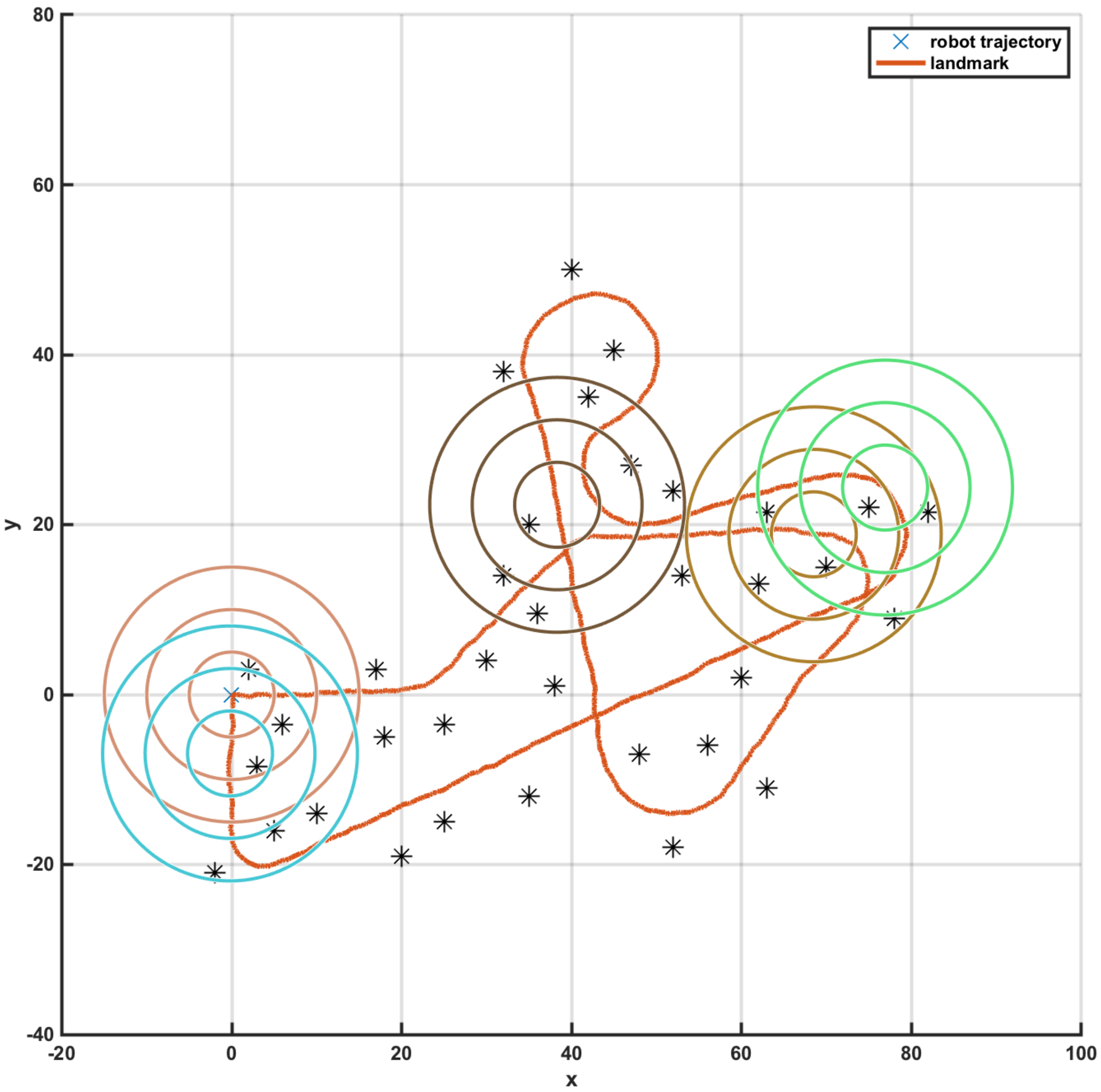
Probabilistic robot localization project.

Consider the unicycle robot whose motion is described in the Matlab code TrueRobotWorld.m which moves in a 2D space where there are 35 landmarks in the environment. The robot can take relative range and bearing measurements from any of these landmarks when the landmark is in the robot's circular measurement zone. See the figure on the right for couple of cases of visualizing the robot measurement zone for 3 cases with radii 5,10, and 15 meters at some selected time instances. Suppose that there is a data association/detection function on the robot that allows the robot to uniquely identify what landmark it is taken measurement from. Suppose that the unique id of a landmark is a unique label from {1,…,35} that is assigned to it. The objective of this project is to conduct beacon-based localization and range/bearing SLAM.



For beacon-based localization, the robot knows the location of the landmarks. Therefore, when it detects a landmark it knows both the id of the landmark and its location.
Simulate 3 case studies defined by the measurement zones of radii 5,10, and 15 meters. Plot the estimated trajectories for each of these cases on top of the true robot trajectory (overlay the 4 plots that you you will obtain on top of each other).
For each case plot what landmark is detected at what time (TrueRobotWorld.m contains the code to obtain this plot).

In practice, because we do not know the actual trajectory of the robot, a performance metric that is used in evaluating the performance of localization filters is **loop-closure**. In loop-closure, the robot starts from a known initial condition and returns back to it at the end of the experiment. The loop-closure error is the difference between the known start location and the estimated final return point. Report the loop-closure error for each of your case studies. Explain the deference you observe. For loop-closure study, use the random noises that are provided with the TrueRobotWorld.m code (load the process noises that gets added to the true system model from w_x.mat, w_y.mat,w_theta.mat)

Think about how would you do a performance analysis for if you are working with a simulated true robot model. What kind of plots you will use to demonstrate and compare the estimation performance of your estimator. Show your work and discuss the plots and the differences you observe in your plots for the 3 case studies discussed above.

The process noise covariance for the robot is

$$Q_{Robot} = \begin{bmatrix} (0.4\delta_t)^2 & 0 & 0 \\ 0 & (0.4\delta_t)^2 & 0 \\ 0 & 0 & (0.05\delta_t)^2 \end{bmatrix}$$

The measurement noise covariance with respect to each landmark is

$$R_i = \begin{bmatrix} (0.1)^2 & 0 \\ 0 & \left(\frac{3\pi}{180}\right)^2 \end{bmatrix}, i \in \{1, \dots, 35\}$$

For SLAM localization, the robot does not know the location of the landmarks. Therefore, when it detects a landmark it only knows the id of the landmark. Along with its own states the robot should estimate the location of the landmark. Repeat the same study as the one described for the beacon-based localization.