Principles of Robot Autonomy I
Homework 4 SOLUTIONS

Problem 1

(a) One way to draw the graph is below. There are many ways to draw the factor graph. Color is not required, but the labeling is required.

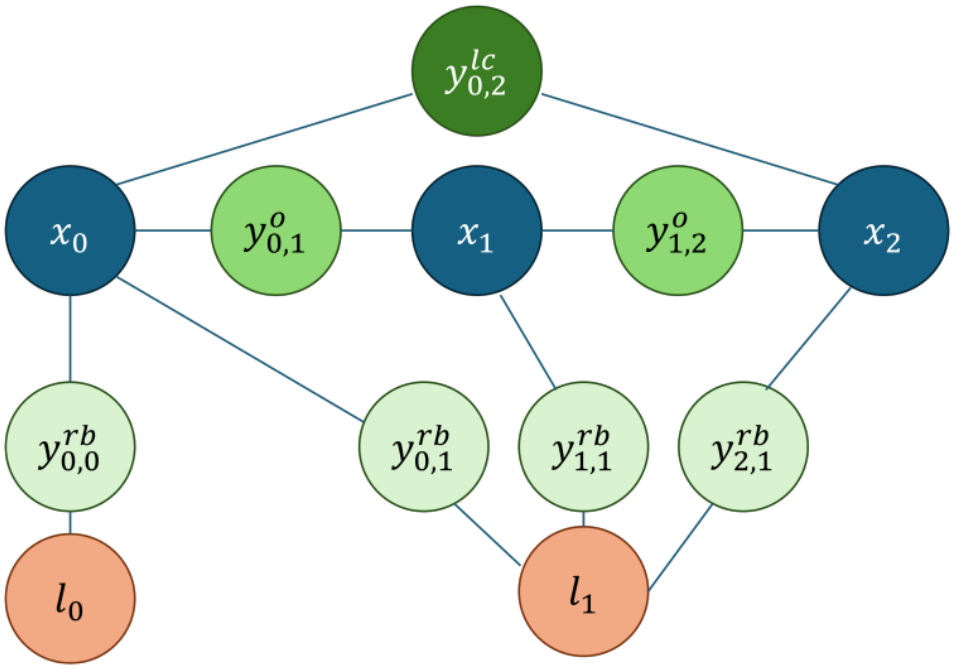

Figure 1: Simple factor graph

(b) N/A

(c) We expect 60 factors, we encourage students to check if their answer makes sense from the data provided (i.e., you can count the factors directly from the data).

(d)

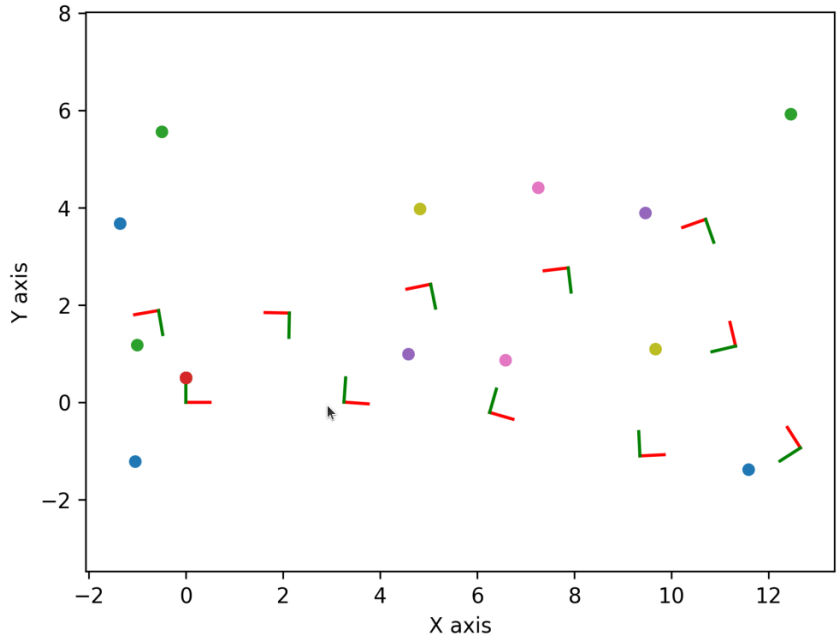

Figure 2: GTSAM Initialization

(e)

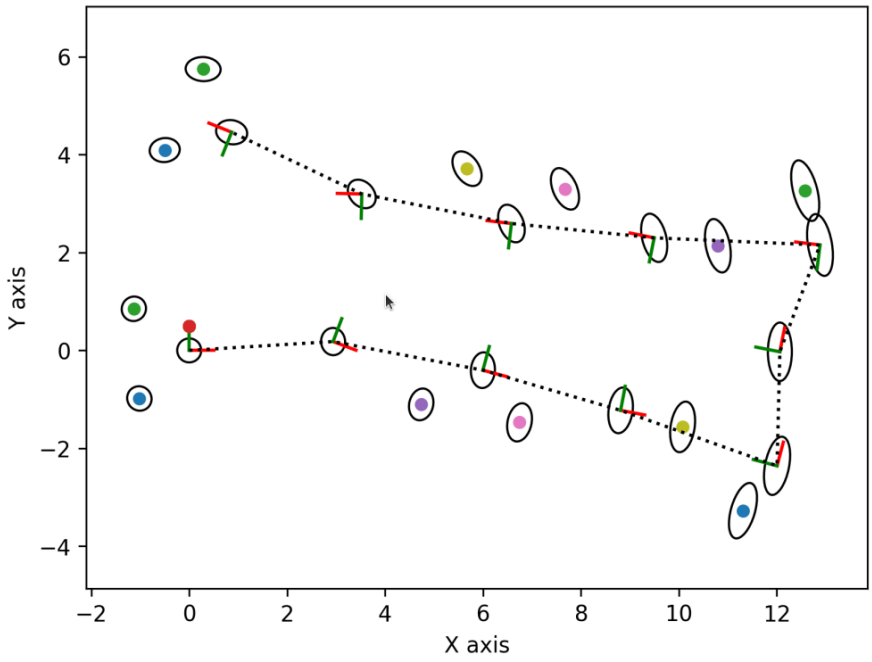

Figure 3: GTSAM Optimized

(f) We expect a discussion that includes the following: • Overall rotation due to uncorrected odometry drift. The whole system is invariant under rotation except for the prior pose. • The error ellipses are elongated in the $\hat{\theta}$ direction with respect to a polar coordinate system about the origin. Again, this is due to odometry. We reduce the uncertainty in the states adjacent to the loop closure constraint. • The error ellipses are generally tighter at the start and end. The start is well constrained by the initial pose and the end is well constrained by the landmarks near the initial pose.

(g) We expect 32 factors in the 3-unit range case. We expect 114 factors in the 10-unit range case.

(h) The one with a 3-unit range will struggle since the graph is too sparse. The optimizer finds a local minimum and cannot recover. The one with a 10-unit range should look practically perfect since the rover can connect terms across the scene.

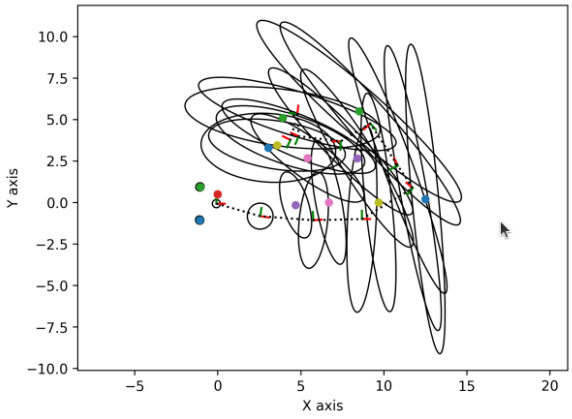

Figure 4: 3 unit sensor range

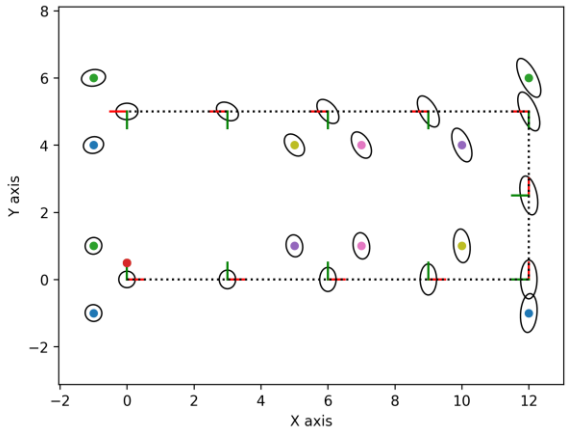

Figure 5: 10 unit sensor range

Problem 2

(i) Solution in code.

(ii) Solution in code.