7.1.

a) 22 possible assignments

| $f1$ | $f2$ |
|---|---|
| L1 | L2 |
| L1 | L3 |
| L1 | False |
| L1 | New |
| L2 | L1 |
| L2 | L3 |
| L2 | False |
| L2 | New |
| L3 | L1 |
| L3 | L2 |
| L3 | False |
| L3 | New |
| New | L1 |
| New | L2 |
| New | L3 |
| New | False |
| New | New |
| False | L1 |
| False | L2 |
| False | L3 |
| False | False |
| False | New |

b)

$$m_{t+1} = (L1, L2, L3) \rightarrow f3 \Rightarrow L4 = L1 \vee L2 \vee L3 \vee New \vee False$$

$$m_{t+1} = (L1, L2, L3, L4) \rightarrow f3 \Rightarrow L5 = L1 \vee L2 \vee L3 \vee L4 \vee New \vee False$$

$$m_{t+1} = (L1, L2, L3, L4, L5) \rightarrow f3 \Rightarrow L1 \vee L2 \vee L3 \vee L4 \vee L5 \vee New \vee false$$

And so on…

7.2.

**Intro to problem:**

In bearing-only SLAM, where only inexpensive sensors are used such as a monocular (single) camera, direct distance to the landmarks would not be provided, since it can only measure bearing of the landmarks. And this causes initialization of landmarks to be harder.

Previously, most approaches used Gaussian PDFs, but this paper made a more efficient method using EKF to fuse the data obtained by the laser beam to obtain Range and Bearing EKF-SLAM instead of Bearing only.

Naive way for landmark initialization is done by taking two frames where in both a specific landmark appears. And then using feature extraction, matching and triangulation, the 3D location of the point could be obtained. The problem with this is when both frames are taken from same angle, only difference in distance to the landmark. In such case, applying triangulation is quite hard. After applying triangulation, uncertainties are considered, and the result is a Gaussian, where the mean is the nominal solution, and the covariance is obtained by transforming the robot and measuring uncertainties via Jacobians of the observations function.

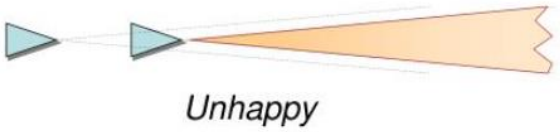



*Figure 2: Bad scenarios for Triangulation*

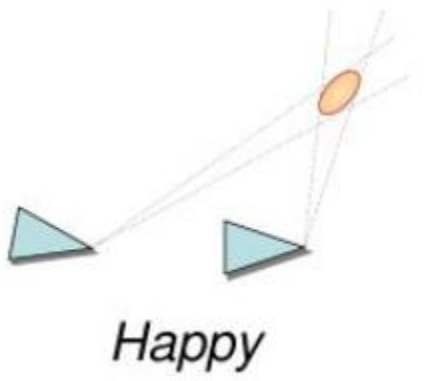


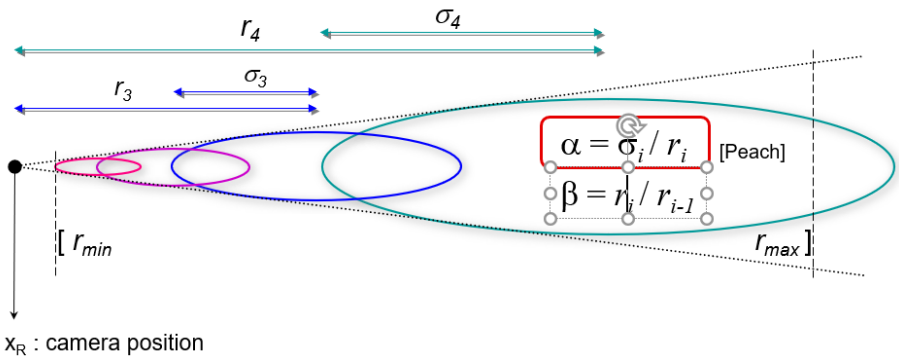

*Figure 1: Good scenarios for Triangulation*

**Solution:**

There are two methods mentioned in this paper for the un-delayed landmark representation.

1. First method is an offline method called the multi-map algorithm that uses Geometric Ray.

Say the laser beam has two readings, rmin and rmax. Then we fill the distance between these two with gaussians, using different ranges for each gaussian, and keeping the linearization constraint.




Then we have a logarithmic number of terms which are a relatively small number that can be easily handled with EKF. These terms initialize different maps, each with different mean and covariance for the gaussian of the landmark. Then, as the robot moves and obtains more frames, and measuring likelihood of landmarks, the maps with more unlikely landmark locations are pruned, till only one map is remained with the right landmark member. And that remained member is Gaussian.

2. Second algorithm is online, called The Federated Information Sharing (FIS) algorithm, which could be done in real-time.
   In this algorithm, the difference is all observations are obtained in the same map, along with subsequent observations. Then this map is continuously updated to do the member pruning. Till one member is left for each landmark.