

An HMM Lab Exercise (Catching the Ghost):

In these Corona days, an invisible ghost takes shelter in your room. You are also passing good time with him/her during day time. Since the ghost is creating problems at night time by making weird noises, you prefer to catch him/her and put it in a bottle for the whole night. However, it is not easy to locate the ghost since it is invisible and the ghost is moving randomly in your room. Assume that the ghost has a map of your room that can be considered as a grid of size 9×9 . He/She can randomly move one position in any of the four directions (up, down, left, right) with equal probabilities (e.g., 0.24). He/She may also move in a random direction (diagonal one position) or stay in place with small probabilities. You have a sensor that can sense how far the ghost is from a given position of the sensor (using Manhattan distance). Based on the distance of the sensor from the ghost, the sensor shows three colors: red if it is close by, orange if it is at medium distance, and green if it is far away.

To model the above problem using HMM, you have to define initial probability distribution $P(X_1)$, transition probability distribution, $P(X_t|X_{t-1})$ and emission probability distribution $P(R_{ij}|X_t)$. You can consider $P(X_1)$ as uniform distribution, $P(X_t|X_{t-1})$ as the transition probability distribution due to the mobility of the ghost, and $P(R_{ij}|X_t)$ as the probability distribution of sensing red/orange/green of different cells given the host at a position of the grid.

- A) Design a system that updates the probabilities of the ghost being in a grid cell as the time elapses and a sensor measurement observed. To advance a time to the next time stamp, you will press a button and see the change of probabilities in the grid. Then when you press on a cell to get the sensor measurement it will display the color of the grid cell based on the distance to the ghost, and update the probability distribution of all grid cells accordingly. Finally when you are almost sure about the ghost location (the cell with the highest probability, you can hit the cell to catch the ghost. Use the HMM filtering technique to do the task.
- B) Do the above task using Particle filtering.