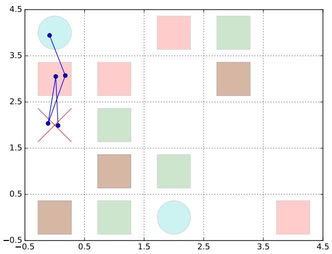
Lab: Probabilistic Reasoning and Decision Making

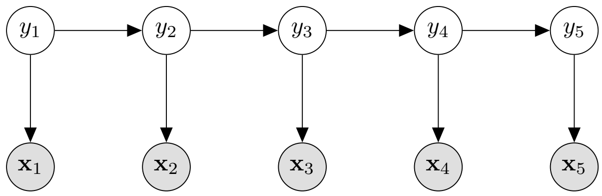
INF581: Advanced Topics in Artificial Intelligence

The task is to design a virtual cat-like agent to catch rats in a specific scenario. The agent models the scenario as a 5×5 set of equi-sized tiles, shown in the grid of Figure (a). The agent remains motionless at the tile marked by $\times$. It assumes that the target (the rat) moves exactly 1 tile (either horizontally or vertically, i.e., taxicab-distance) per time step. The challenge of this scenario is that it is dark, and the target cannot be seen. However, the agent is certain that at time $t = 1$ a rat enters the scenario, and that there are only two possible points of entry, denoted in Figure (a) by blue circles. Also according to its beliefs, it will hear a rustling sound with probability 0.9 if the target passes on one of certain tiles (denoted as green squares), and hear it with probability 0 otherwise (i.e., if not on one of those tiles). Furthermore, the agent believes it will hear a crinkling sound with probability 0.8 if an object passes on certain tiles (marked by red squares), and 0 otherwise. A brown square (green + red) denotes a tile where either a rustle or crinkle sound (or both) may be heard. The blue line shows an example path.

The agent waits for 5 steps, (i.e., until $t = 5$; it accumulates observations $\mathbf{x}_1, \ldots, \mathbf{x}_5$) then makes a decision whether to pounce in an attempt to catch the target (rat), knowing that it can only pounce distance 2 (again, taxicab distance). Figure (b) shows a graphical model representation, where shaded nodes $\mathbf{x}_t \in \{0, 1\}^2$ indicate the two possible observations ($x_1 = 1$ if rustling is heard, $x_2 = 1$ if crinkling) and $y_t \in \{0, \ldots, 24\}$ the position. The agent is rewarded with payoff 10 for catching the rat, 1 for missing it, and 3 for a non-attempt. The probability of catching the rat given a pounce within range is 0.85.



(a) Example scenario playout:
$y_{1:5} = 4, 3, 2, 3, 2$; i.e.,
path: (0, 4), (0, 3), (0, 2), (0, 3), (0, 2)



(b) Graphical model representation; Note:
$y_t = 0 \Leftrightarrow$ tile $(0, 0)$; $y_t = 4 \Leftrightarrow$ tile $(0, 4)$; $y_t = 24 \Leftrightarrow$ tile $(4, 4)$.

The Task: Design an agent, such that given a sequence of 5 observations $\mathbf{x}_1, \ldots, \mathbf{x}_5$, it:

1. Explores all possible paths $y_1, \ldots, y_5$ that the target may take,
2. Estimates the most likely position of the target at y_5, and
3. Decides whether to pounce or not, under utility function $U(q) = \sqrt{q}$ given payoff q.

Hints: Write out the joint distribution from Figure (b) and use it (with the description above) to guide your design of functions of movement and observation, and to explore all possible paths the target may take by $t = 5$. Note that a path is only possible if the probability mass remains above 0. Make assumptions and simplifications as you see suitable (e.g., sound is heard equally probably across the scenario). Write your code into run_task.py where indicated by TODO. The path taken is determined by the random seed (Figure (a) shows the true path for the default seed). A function explore_paths is sketched out as a suggestion (to use recursion). You may find it useful to use the functions in utils.py to convert between representation $y_0 \in \{0, \ldots, 24\}$ and a coordinate representation $(\text{tile}_x, \text{tile}_y) \in \{0, \ldots, 4\}^2$.