

Actions:

The actions(A) available to the agent are: Up, Down, Left, and Right.

State-Space:

We can divide the game environment into a grid 'G' of cells. Each cell in the grid can be identified by its row number and the column number. Each cell can contain only one of the following elements:

1. Wall
2. Dot
3. Large Dot
4. Empty

In this game, the agent and the ghosts continue to move in a certain direction until they hit a wall. The agent stops after hitting the wall while the ghosts randomly change their direction on hitting the wall. The agent's direction can be controlled by the actions mentioned above. We can identify the location of the four Ghosts and the Agent on the grid by specifying the coordinates of the cell they are in. Let us represent the coordinates of the Pac-Man (the Agent) by ' C_A ' (Agent's Coordinates) and the coordinates of the four Ghosts can be represented by G_R (Red Ghost), G_B (Blue Ghost), G_P (Pink Ghost), and G_O (Orange Ghost). Thus, the locations of the ghosts can be given by a set $C_G = \{G_R, G_B, G_P, G_O\}$. Also, each ghost moves in a certain direction. The directions of each ghosts can be given by a set $D = \{D_R, D_B, D_P, D_O\}$. Also, when the agent consumes the Large Dot, the ghosts become vulnerable for a certain time; we can denote this by 'T'. For the time duration T, after eating the Large Dot the agent can consume the ghosts.

Thus, a state(S) in Pac-Man game could consist of:

1. The location of the Pac-Man (Agent) denoted by C_A .
2. The locations of the four ghosts given by the set C_G .
3. The directions in which the ghosts move denoted by the set D.
4. The Grid G.
5. Are ghosts vulnerable or not? (vulnerable ghosts can be eaten). Or the time T during which the ghosts are vulnerable.

Transition Function:

In the start state, the game appears to be frozen. As soon as the agent takes one of the four actions, i.e. when the agent moves to new location (C_A'), the state of the game is changed i.e. ghosts are introduced in the game (C_G'), each ghost has a new direction defined by D' , the Grid G' has empty cells as the agent eats the Dots.

Agent's new location:

The new location of the agent is given by $C_A' = C_A$ if there is wall at $G(C_A')$. i.e. the agent stays at the same location. Otherwise, $C_A' =$ next cell in the direction the agent is moving.

$$\text{i.e. } C_A' = \begin{cases} \text{Row} + 1, \text{Column} & : \text{if Action} = \text{Up} \\ \text{Row} - 1, \text{Column} & : \text{if Action} = \text{Down} \\ \text{Row}, \text{Column} + 1 & : \text{if Action} = \text{Right} \\ \text{Row}, \text{Column} - 1 & : \text{if Action} = \text{Left} \end{cases}$$

Ghosts new location and direction:

The new locations for each of the four ghosts is given by $C_G' = \{G_R', G_B', G_P', G_O'\}$. These new locations also depend upon the current location of the ghost and its direction. It is normally the next cell in the given direction. When the ghost hits the wall, it randomly chooses a new direction D' . The ghosts start at the centre of the grid when it is eaten by the agent.

The new Grid G' :

The Grid G' is same as the previous Grid G . Except the cells with the Dots and Large Dots are replaced by empty cells if the agent has passed over those cells (i.e. the agent eats those Dots and Large Dots).

The ghost vulnerability period T' :

If all the levels of the game are similar, the time T is set to 5 seconds as soon as the agents eats a Large Dot. Until this T becomes 0, the agent can eat the ghosts.

The directions of the ghosts are non-deterministic and the probability of choosing a direction is $\frac{1}{4}$. All the other state elements are deterministic. The agent's location is dependent on the actions it takes.

Reward Function:

$$R(S) = \begin{cases} 1000, & \text{for reaching the goal state} \\ 1, & \text{for eating a dot} \\ 100, & \text{for eating a vulnerable ghost} \\ 0, & \text{for dying} \end{cases}$$

The goal state is one with no Dots remaining. If the locations of the Agent and one of the ghosts is same i.e. C_A belongs to the set C_G , the agent dies.