6CCS3AIN, Tutorial 01 (Version 1)

1. Write down an example of an intelligent agent, either from the fictional world (from a book, a play, a film, a television show and so on) or from the real world.

   Write a few lines to describe this example, and say:

   (a) what kind of sensors it uses;

   (b) what actions it can carry out; and

   (c) what environment it operates in.

2. Classify the environment from the previous question.

   You should classify the environment in the way that we described in the lecture — accessible or inaccessible, static or dynamic, and so on. Explain *why* you give the answer that you do.

3. Come up with another example agent that operates in a *different* kind of environment. Classify that environment also.

4. Figure 1 (next page) shows an agent situated in an environment. We can think of the environment E being made up of 36 states:

   $$e_{0,0}, e_{0,1}, \ldots$$

   where the subscript of each e indicates a square in the grid.

   Thus the agent, sitting in the bottom lefthand corner, is in state $e_{0,0}$, while if the agent were at the goal, in the top righthand corner, it would be in state $e_{5,5}$. $e_{0,0}$ is the initial state of the environment.

   The filled squares indicate obstacles — the agent cannot be in these states.

   The agent can move north, south, east or west, which we write as:

   $$\alpha_n, \alpha_s, \alpha_e, \alpha_w$$

   and these have the effects you would expect. If the agent is in state $e_{0,0}$ and takes action α_n, it will end up in state $e_{0,1}$, while if the agent is in state $e_{3,2}$ and takes action α_e it will end up in $e_{4,2}$. If the agent tries to move outside the grid then it does not move (for example if the agent is in $e_{0,5}$ and tries to do α_n then it stays in $e_{0,5}$).

   If the agent enters the state $e_{5,5}$, marked with the word goal, then it gets a reward of 10. If it enters state $e_{1,4}$, marked with a dark circle, it gets a reward of -10 (ie it takes a loss).

   (a) Write down a run of the agent that takes it from $e_{0,0}$ to $e_{1,4}$.

   (b) Consider the following control program:

   while(not in state $e_{5,5}$){
       randomly pick either α_n or α_e (each with probability 0.5)
       execute the action that was selected
   }

   Write down two runs that the agent might carry out when executing this program.

   (c) If the agent executes the program, can it ever reach $e_{5,0}$? Why?

   (d) What is the maximum and minimum reward that the agent can get running this program? Why?

   (e) How likely is it that when the agent runs the above program it will get the reward of -10?

   (Hint: There is a precise probability that the agent will get to the relevant state. You should work out how to calculate this.)

5. Suppose the vacuum world from the lecture (the one from the slides from lecture 1) contains obstacles which the agent has to avoid, and that the agent has a sensor to detect the obstacles. That is, there are squares that are blocked because they are simply inaccessible (such as a wall) and other squares where there are obstacles (e.g., a human foot). Write down a new control program for the agent.

   Explain what, if any, guarantees you can make for your solution about its ability to make the room clean, and justify your answer.

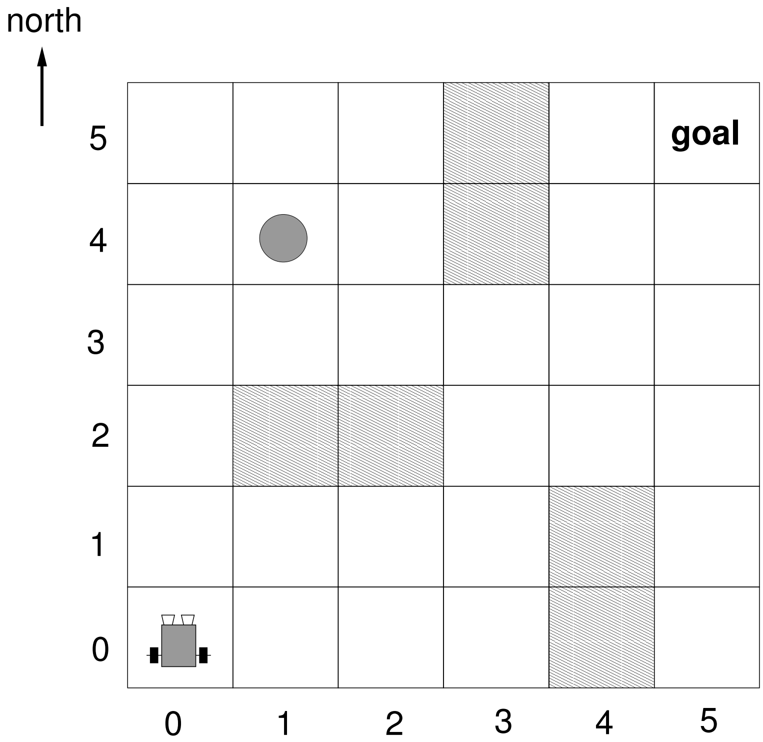

Figure 1:

6. Suppose that the vacuum world agent's sensors — the one from the lecture that sees the dust, and the new one from Question 5 that can see obstacles — are now *noisy* so they only give the right answer 80% of the time.

   (You can interpret this to mean that if there is dust or an obstacle, the relevant sensor will say that it is there 80% of the time. You can assume when there is no dust or obstacle, the sensor always correctly reports this.)

   How does this change the logic-based control program? Assume that if the agent tries to move into a square that contains an obstacle, it does not move.

   Explain what, if any, guarantees you can make for your solution about its ability to make the room clean, and justify your answer.

6CCS3AIN, Tutorial 01 Answers(Version 1)

1. One example is a robocup football playing robot, a nao communication robot.

   (a) It has many different kinds of sensors: microphones, camera, tactile sensors, sonars (to detect things in front of it), wifi so can take input from the web....

   (b) Make noise, eyes change colour to express emotions, prehensile hands to grip things, motors that move its limbs with many degrees of freedom....

   (c) Operates in the physical world. We might think specifically about the robocup environment.

2. The physical robocub environment is:

   - Partially accessible: the nao robot only ever "sees" a small part of the environment — the bit in its (quite narrow) field of view, and within the range of the camera and microphones. It may also have to make decisions about what to process from the input it does get — for example it may take up too much resources to process all the sound input it receives.
   - Non-deterministic: errors in the motors might mean a particular action isn't performed successfully. Also, if you're only perceiving/modelling the world to a certain degree of granularity, then differences that are imperceptible to you may make a difference to the outcome of your actions.
   - Episodic or sequential - depends what level of granularity you think about it at. If you think about a tournament as an episode, you might argue that your actions within the tournament are unlikely to affect its performance in any future tournament. Although you might also argue that what you do will affect others' model of you, and so may mean they perform differently against you. If you're thinking of a game as a sequence of episodes, then the environment is sequential, since the choices the robot makes (particularly if you think about how it interacts with its team and the assumptions it makes about them) can affect its performance later in the game. Or if you're thinking of the robot as something that learns based on its experience, or that its building up a model of its opponents and team mates based on its experience, then sequential.
   - Dynamic: There are lots of other agents and processes acting on the environment.
   - Continuous: The motors can turn through any number of degrees and can be combined in many different ways. The touch sensors can (in principle) record a continuous range of pressures. But you might argue it's likely to be treated as discrete.

   It's important to justify your answers and make clear what assumptions you're making!

3. A companion robot that helps care for an elderly person. It's environment is the physical world, specifically the person's home.

   - Inaccessible: the robot does not know what's going on in other rooms, but also cannot know for sure what's going on the person's mind, or with their health.
   - Non-deterministic: often the outcome of their actions might also depend on the person. For instance, think about communicative actions: the robot might make a noise with the intention of cheering the person up, but this might not always have the desired effect.
   - Sequential: it needs to think about past and future actions when deciding what to do. For instance, when deciding whether to recharge its battery, it ought to think about whether this will prevent any important future actions. Or when deciding whether to remind the person to take their pills it might think about how many times it's already done this and how annoyed it normally makes the person.
   - Dynamic: the person also acts on the environment, but also things like central heating system, weather, other agents.
   - Continuous: any number of noises or movements the robot can make, any number of inputs that can be recorded. But in practice likely treated as discrete.

4. (a) One possibility:

$$e_{0,0}, \alpha_n, e_{0,1}, \alpha_n, e_{0,2}, \alpha_n, e_{0,3}, \alpha_e, e_{1,3}, \alpha_n, e_{1,4}$$

   Another possibility:

$$e_{0,0}, \alpha_n, e_{0,1}, \alpha_n, e_{0,2}, \alpha_e, e_{0,2}, \alpha_e, e_{0,2}, \alpha_n, e_{0,3}, \alpha_e, e_{1,3}, \alpha_n, e_{1,4}$$

(b) Some possibilities:

$$e_{0,0}, \alpha_e, e_{1,0}, \alpha_e, e_{2,0}, \alpha_n, e_{2,1}, \alpha_e, e_{3,1}, \alpha_e, e_{3,1}, \alpha_e, e_{3,1}, \alpha_n, e_{3,2},$$
$$\alpha_e, e_{4,2}, \alpha_n, e_{4,3}, \alpha_e, e_{5,3}, \alpha_e, e_{5,3}, \alpha_n, e_{5,4}, \alpha_e, e_{5,4}, \alpha_n, e_{5,5}$$

$$e_{0,0}, \alpha_n, e_{0,1}, \alpha_n, e_{0,2}, \alpha_e, e_{0,2}, \alpha_n, e_{0,3}, \alpha_e, e_{1,3}, \alpha_n, e_{1,4}, \alpha_n, e_{1,5}$$

(c) No. Since it can only go east and north, it cannot get over the obstacle in column 4 and then down to $(5, 0)$.

(d) The maximum value is 10 if it gets to the goal (which it can reach as above).
The minimum value it can get is -10, which it gets if it goes through the circle. Though this is not a terminal point, the agent cannot pass through the circle more than once (because it can only move north and east).

(e) There are two obvious routes: α_n, α_n, α_n, α_n,α_e, and α_n, α_n, α_n, α_e, α_n.
However, because of the obstacle in $(1, 2)$ any sequence like:

$$\alpha_n, \alpha_n, \alpha_e, \ldots \alpha_e, \alpha_n, \alpha_e, \alpha_n$$

or

$$\alpha_n, \alpha_n, \alpha_e, \ldots \alpha_e, \alpha_n, \alpha_n, \alpha_e$$

will also work and so, we have two possible routes, each of which has between 5 and ∞ steps.
Since each transition has a probability of 0.5 of occurring, the total probability of all these runs will be:

$$2 \cdot \sum_{n=0}^{\infty} 0.5^{5+n} = 2 \cdot \sum_{n=5}^{\infty} 0.5^n \tag{1}$$

There is a simple formula to calculate the sum of an infinite geometric series (knowledge of this wouldn't be expected in the exam):

$$\sum_{k=m}^{\infty} a.r^k = \frac{a.r^m}{1-r}$$

Applying this, we get the total probability as:

$$\begin{aligned} 2 \cdot \sum_{n=5}^{\infty} 0.5^n &= 2 \cdot \left(\frac{0.5^5}{1-0.5} \right) \\ &= 4 \cdot 0.5^5 \\ &= 0.5^3 \\ &= 0.125 \end{aligned}$$

Note that the important bit here is figuring out what the set of possible runs are and thus what the probability calculation would look like. Actually doing the calculation (and knowing what the sum of the geometric series is) is much less important. In other words, getting to eqn (1) is what you need to be able to do.

5. If we assume that the vacuum cannot enter a square with an obstacle, then we have:

function vacuum_agent(Location, Dirty, Obstacle).
    if Dirty = Yes then Suck
    elseif Location = A and Obstacle = No, then Right
    elseif Location = B and Obstacle = No, then Left.

In the absence of obstacles this will move from room to room sucking up dust, and therefore clean the rooms. However, once there are obstacles, we have no guarantees of cleanliness since the vacuum may not be able to reach the dust.

6. When sensors only report correctly 80% of the time, the vacuum can not "see" dust that is there, meaning that it may leave rooms dirty. Repeatedly checking rooms (as in the program above) means that the probability of not seeing dust and so not sucking it, tends to zero the longer that the program runs, but will be non-zero for any finite run. You might consider changing the program so the agent always does Suck, without bothering to check whether it thinks it's dirty or not.

   Obstacles are less of a problem in the sense that if the vacuum doesn't "see" one and so tries to move when it shouldn't, all that happens if the vacuum doesn't move (we ignore the possibility of damage when hitting the obstacle). The vacuum can even figure out that there is an obstacle from its failure to move.