VI51: Virtual Life Simulation - Final Exam P2015

Duration: 2h.
No document nor calculator nor smart phone nor touchpad allowed.
English recommended, French accepted.
Malus of 1 point for dirty sheets.
Each part must be written on separated sheets.

Part 1: Markov Models (5 points)

In this problem, you will use HMM to decode a simple DNA sequence. It is well known that a DNA sequence is a series of components from $\{A, C, G, T\}$. Now let's assume there is one hidden variable S that controls the generation of DNA sequence. S takes 2 possible states $\{S_1, S_2\}$. Assume the following transition probabilities for HMM :

$P(S_1|S_1) = 0.8$, $P(S_2|S_1) = 0.2$, $P(S_1|S_2) = 0.2$, $P(S_2|S_2) = 0.8$

Emission probabilities as following:

$P(A|S_1) = 0.4$, $P(C|S_1) = 0.1$, $P(G|S_1) = 0.4$, $P(T|S_1) = 0.1$
$P(A|S_2) = 0.1$, $P(C|S_2) = 0.4$, $P(G|S_2) = 0.1$, $P(T|S_2) = 0.4$

And start probabilities as following:

$P(S_1) = 0.5$, $P(S_2) = 0.5$

Question 1.1:

What's the meaning of HMM? Sketch the mathematical formalisation of it.

Question 1.2:

Draw the Markov Chain of the variable S.

Question 1.3:

What is the purpose of the Forward algorithm?

Question 1.4:

Assuming that the observed sequence is $x = CGTCAG$, calculate the most likely path that leads to this observation sequence.

Part 2: Agent Simulator (15 points)

Question 2.1: (2 points)

Write a small class diagram that relates the four concepts: `Agent`, `Body`, `WorldObject`, and `Environment`. The meanings of these concepts should guide you for writing the class diagram.

Question 2.2: (1 points)

Explain, in a couple of sentences, the principle of the model, that is based on the use of repulsive forces, for the computation of the motion of an agent body.

Question 2.3: (2 points)

You want to write an environment model for a 3D first-person shooter game based on the priniples of a virtual environment simulation. What is(are) the best data-structure(s) to represent this environment model. Explain your choices.

Exercise 2.4: (6 points)

You want to write the behaviour a beach soccer player which want to wine a game against another team. Each team consists of two players (there is no goalkeeper). Each player want to shoot the ball in the goal of the other team. In parallel, each player want to avoid the ball for entering in his/her goal.

a) What are the possible actions (3 actions max)?

b) What are the possible perceptions?

c) Write the state machine for a single player.

Exercise 2.5: (4 points)

You want to write a perception algorithm with occlusion culling (occluded objects must not be seen). The considered environment is 2D and continuous. The objects in the environments are only circles. You must assume that frustum culling (obtain the set of objects inside a field of view) is done by the function:
`frustumCulling() :  List<Circle>`
Each `Circle` is defined with its center coordinates `centerx`, `centery`, and its `radius`.

a) Propose an occlusion culling algorithm. If you have made several design hypothesis, you must quickly explain them.