VI51: AI for Games and Vir. Env. - Final Exam P2016

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

Part 1: Markov Models (10 points)

Question 1.1: HMM (2 points)

What is a HMM? What are the main algorithms? What are their purposes? Give an example.

Exercise 1.2: What is behind google page rank (8 points)

The problem of a page ranking algorithm can be summarized like this: Given n interlinked webpages, rank them in order of "importance." Each accessible page n has got an importance score labeled $x_n > 0$. What we want to do is to compute each x_i using the link structure of the web to determine their importance. (tips: a link to a page is like a vote for its importance)

Question 1.2.1: First idea

Let consider the following example. A, B, C, D and E are webpages linked as illustrated by Figure 1,

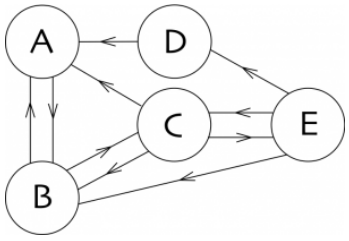

Figure 1: Example of Page Links

In this first attempt, we decided to consider x_k being equal to the number of links to page k. Compute x_k for each page in the example. What is the obvious limit of this solution?

Question 1.2.2: A first improvement

Let consider now that x_k is equal to the sum of the importance scores of all pages linking to page k. Is this solution overcoming the limit of the first proposal? Apply this solution to the example. What are the problems raised by this new solution?

Question 1.2.3: Brin and page solution

Let x_k be equal to the sum of x_j/n_j where the sum is taken over all the pages j that link to page k and n_j is the number of outgoing links from page j. Compute for each state the value x_k relatively to all x_j. Express this using a matrix representation.

Question 1.2.4: Travelling through a Markov chain

Let now consider P a matrix which represents a probability transition matrix from one website to others, and illustrated by Figure 2.

$$P = \begin{array}{c} \begin{matrix} A & B & C & D & E \end{matrix} \\ \begin{pmatrix} 0 & 1/2 & 1/3 & 1 & 0 \\ 1 & 0 & 1/3 & 0 & 1/3 \\ 0 & 1/2 & 0 & 0 & 1/3 \\ 0 & 0 & 0 & 0 & 1/3 \\ 0 & 0 & 1/3 & 0 & 0 \end{pmatrix} \end{array} \begin{matrix} A \\ B \\ C \\ D \\ E \end{matrix}$$

Figure 2: P matrix

Each column represents the departing page and each row the arriving page. Complete the Markov Chain figure of the example using these probabilities.
Let consider p_{ij} the conditional probability representing that we are on the i-th page at step $n+1$, knowing that we were on the j-th page at the preceding time step. Considering that we are in a Markovian world, compute the matrix P^2 that allow to express the transition probability from time n to time $n+2$.
Using the same strategy, compute the probability matrix from time n to time $n+32$. What can we conclude on this algorithm?

Part 2: Star Collector (4 points)

Consider the following 3x3 gridworld if Figure 3.

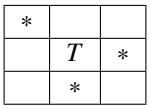

Figure 3: 3x3 gridworld

The agent's goal is to collect as many stars as possible, before going to the cell T. The agent can move up, down, left and right. Carrying out an action that leads the agent out of the gridworld results in staying in the cell. When an agent reaches a cell containing a star, it takes it from the cell. Otherwise, it reveives a reward of -1. We assume $\gamma = 0.9$.

Question 2.1:

Model this task by an oriented graph, where each node represents a state and each edge a transition between states. On each edge is indicated the action to take to go from one state to another one and the reward received from going from one state to the next one.

Question 2.2:

Recall the algorithm Q-Iteration.

Question 2.3:

Apply 3 iterations of the Q-iteration method and show the final matrix of the Q-values.

Question 2.4:

What is the greedy policy assuming the Q-values obtained after 3 iterations?

Part 3: Agent Simulator (6 points)

Question 3.1: (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 3.2: (2 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 3.3: (2 points)

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