Exam

Course Data Mining for Networks

2019-2020

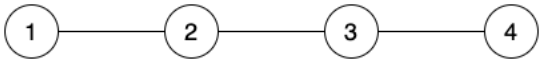
Part 1 : Graph Kernels (9 points)

I. General questions about the course (4.5 points)

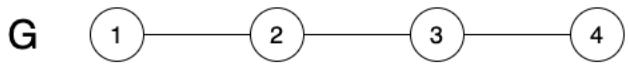
1. Is the graph edit distance is an efficient measure to compare a large number of graphs? Compare it with other methods presented during the course. Discuss algorithmic complexity. (Max 10 lines)
2. Explain what is the kernel trick in general and for the random graph kernel. (figures + max 10 lines).
3. Describe how to compute a shortest path kernel. Provide an example with a graph of at least 4 vertices, different from the ones of the course (figures+max 20 lines of text).
4. Discuss the advantages and drawbacks of signature-based Detection vs anomaly-based detection to mitigate network attacks. (figures+max 10 lines of text).

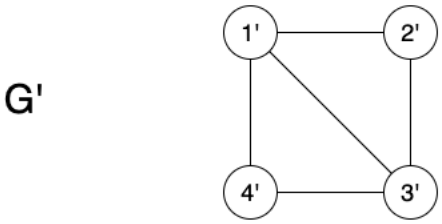
II. Random Walk Kernels (4.5 points)

1. Compute the number of walks of length 1, 2, 3 of the following graph using matrix multiplication.



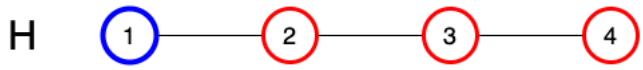
2. Build the direct product G x G' of the two following graphs G and G'.

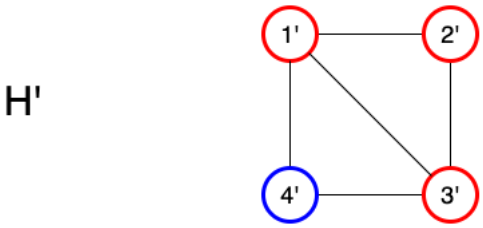




3. How many walks are there in the direct product graph G x G' between the vertices (2,1') and (3,3') of lengths 1, 2, 3, 4, 5? Exhibit them.

4. Build the direct product H x H' of the two following labeled graphs H and H'. Nodes have 2 labels: Red or blue. Edges do not have labels





5. How many matching walks are there in the direct product graph H x H' between the vertices (2,1') and (3,3') of lengths 1, 2, 3, 4, 5? Exhibit them.

Part 2 : Reinforcement Learning (11 points)

I. General questions about the course (3 points)

1) How would you define reinforcement learning? How is it different from traditional supervised or unsupervised training? (max 10 lines of text)
2) For Q learning, explain why a model of the environment is not necessary. (max 10 lines of text)
3) When the environment is not known, what phases should be balanced to learn from it? (max 5 lines of text)

II. Q-Learning Algorithm (3 points)

Assume we are an agent in a 3x2 grid-world, as shown in the figure below. We start at the bottom left node (1) and finish in the top right node (6).
When node 6 is reached, we receive a reward of +10 and return to the start for a new episode. On all other actions that not lead to state 6, the reward is -1.

4	5	**finish** 6
start 1	2	3

In each state we have four possible actions: up, down, left and right. For each action we move deterministically in the specific direction on the grid. Assume that we cannot take actions that bring us outside the grid.

The current estimates of *Q(s; a)* are given in the below table:
Note that the (action)-value of a terminal state is 0.

Q(1,up)=4			Q(1,right)=3
Q(2,up)=6		Q(2,left)=3	Q(2,right)=8
Q(3,up)=9		Q(3,left)=7	
	Q(4,down)=2		Q(4,right)=5
	Q(5,down)=6	Q(5,left)=5	Q(5,right)=8

We have sampled the following episode: 1 - right - 2 - up - 5 - right - 6, after which the program ended. Update the corresponding *Q(s; a)* entries (take $\alpha = 0.2$; $\Upsilon = 0.8$) .

III. Analyzing a research paper (5 points)

The next questions are about the research paper you had to read before the exam:
Yu Lin, Tianyu Wang, and Shaowei Wang, **"UAV-Assisted Emergency Communications: An Extended Multi-Armed Bandit Perspective"**, in IEEE Communications Letters, vol. 23, n. 5, May 2019.

The paper addresses the problem of finding the optimal path planning of an Unmanned Aerial Vehicle (UAV) under limited battery capacity, to maximize the number of served users.

1) Introduce the research topic of the paper (real life application, technology involved, …) (max 10 lines of text)
2) Given the formulation of the path planning problem as a Multi-Armed Bandit (MAB) problem, how many arms are considered in the paper?
3) What arises here at the end of each time slot that does not appear in classical MAB algorithms?
4) Discuss the two action selection policies proposed in the paper. (max 20 lines)
5) Assume a small example of 4 grids numbered 1, 2, 3, 4 with current values of the different equations presented in the paper in the following table:

	1	2	3	4
Eq. (3)	12.2	6.8	4.47	8.5
Eq. (4)	0.1	0.49	0.67	0.5
Eq. (5)	6.2	4.3	2.0	10.1

What will be the next action selected by the UAV in the first "greedy" policy?
What will be the next action selected by the UAV in the α-greedy policy in case of exploration? And in case of exploitation?