HIT

Homework/Assignment

Course: *Artificial Intelligence Technologies and Applications in Computer Vision 2025 –*
Professor: *Prof. David Suter/Prof. Qince Li*
Due date: *XXXX*

Note: the due date has been left unspecified. Prof. Qince Li will advise of the due date.

The questions are not allocated marks. Prof. Qince Li will decide how to assess this work. (My own view is to have a very coarse grading - perhaps pass or fail, perhaps pass, fail and distinction.)

In any case it would seem that some questions (associated with projects are):

1. Much more "person hours than other questions"
2. Not universally "attemptable" by all (it depends on programming background, access to computing etc.)

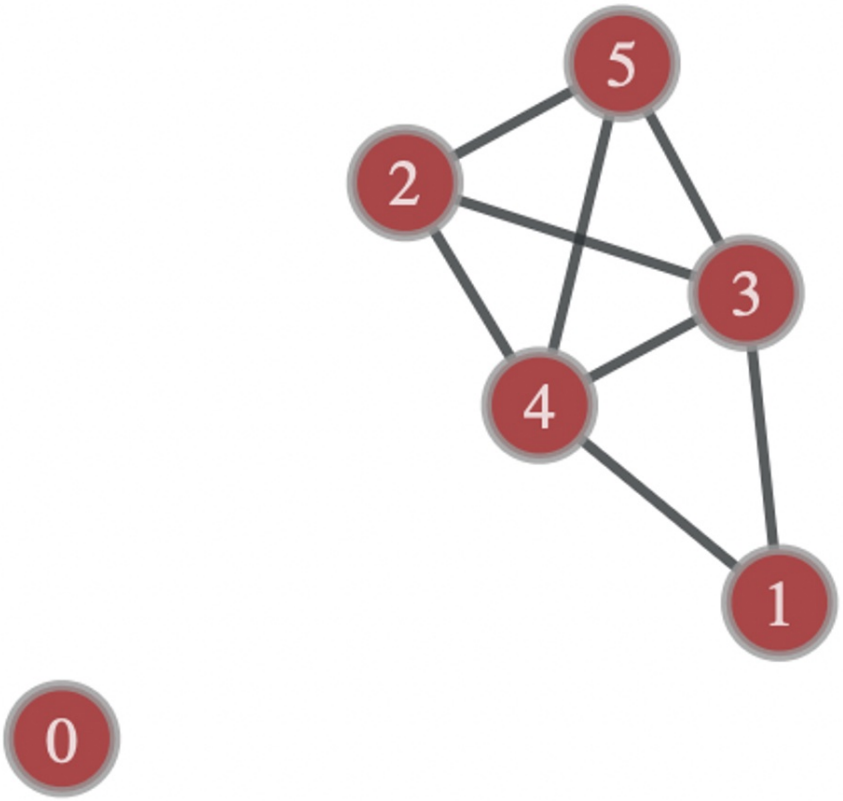
so my view is that programming exercises should either be extra "optional work" and used for distinction grading of students; or students should be given the choice of choosing a programming exercise or all pen and paper exercises.

Answers should be given with working, or at least with an explanation of *how the answer was worked out*.

(DS 11/07/25).

Question 1

What are the independent sets of the following graph?



Question 2

What are the vertex covers of the graph given in question 1?

Question 3

What is the maximum clique of the graph in question 1?

Question 4

Viewing the graph in question 1 as a simplicial complex:

- *(a) what are all of the maximal faces*
- *(b) for each maximal face - give all the subfaces that make up that simplex*

Question 5

Consider the simplicial complex that could be drawn as the graph in question 1 but colouring in the triangles $\{2,3,4\},\{2,3,5\},\{2,4,5\},\{3,4,5\}$*,, to signify the interiors belonging to the simplicial complex:*

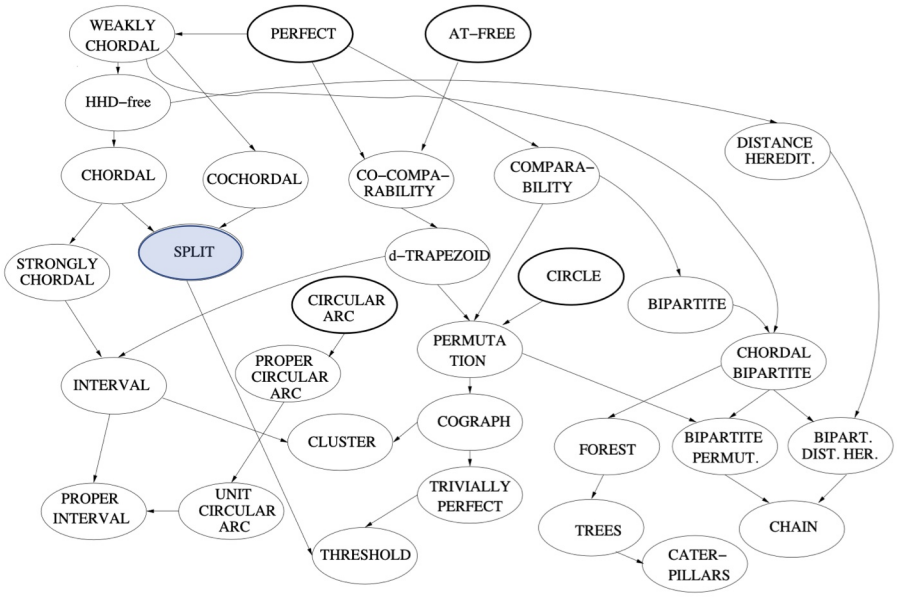
- *(a) what are all of the maximal faces*
- *(b) for each maximal face - give all the subfaces that make up that simplex*

Question 6

Draw the simplicial complex with maximal faces: $\{1,2,3\}\{3,4,5\}\{1,6\}$*. What are the minimal sized non-faces of this complex (on the ground set* $\{1,2,3,4,5,6\}$*)*

Question 7

Consider the class inclusions given in the figure:



where an arrow from class A to B represents that B is a (proper) subset of A.

- *(a) Is the class threshold in the intersection of classes split and cograph? (Explain)*
- *(b) Is it possible that class weakly-chordal is contained in class threshold? (Explain)*
- *(c) For a given problem is it possible that this problem is easier to solve, for all instances of class split, than for all instances of class threshold? (explain)*

Question 8

Construct (draw it and give the sets of edges) the $0,1^*$*-constructible graph given by the construction string* 0101*. Is it a threshold graph?*

Question 9

Is the graph in question 8 a split graph? If so, give the split of vertices that identify it as a split graph? Is it an unbalanced split graph? If so give at least one swing vertex.

Question 10

The independent sets of the graph in question 8 form a simplicial complex. Define the (monotone) boolean function $f(x)$ *to be 0 if* $x \in \{0,1\}^4$ *is in the simplicial complex (with the i'th bit of x corresponding to whether vertex* of the threshold graph *i is in the set associated with that vertex* of the boolean cube*). Otherwise* $f(x) = 1$*. Draw the 4-dimensional boolean cube (Hasse diagram), distinguish the members of the indpendence complex of the graph in question 8 by placing an "overbar" on top of them. Colour the edges* of the boolean cube/Hasse diagram *using the following scheme (black for edges not pivotal pivotal, red edges associated with inclusion/exclusion of vertex 1. Likwise, blue for vertex 2, green for vertex 3, and brown for vertex 4.*
Count the pivotal edges of each type and hence give the Influences of the variables associated with each vertex of the threshold graph in question 8.

Question 11

Construct (give the sets of edges) the $0,1^*$*-constructible 3-uniform hypergraph given by the construction string* 00101.

The following are suggested programming exercises. You should choose at most one. They are somewhat open ended. They depend heavily on your programming experience, access to computing etc. You wilkl have to use a lot of judgement as to how hard things will be for *YOU* to undertake these and how ambitious you should be. We can't offer a service to help you debug or to help you install software - sorry....

You need to be embarking on programming because you are confident you have the skills and you *interested* in doing so. It will probably be more work than the pen and paper exercises!

Question 12

Programming/Experimental Exploration (Mini-project) Eight Puzzle.

The eight puzzle can be encoded using tiles numbered 0..8 with 0 representing the vacant space. The only valid moves are interchanging a time that is adjacent (directly above below, immediately to the left right) with the space. Each move costs one unit. Write an A program to solve the eight puzzle given some starting configuration (specified by the user in a file or typed in a run time). The search space of all possible configurations of 0..8 on a 3x3 grid actually breaks into 2 connected components. So to ensure your input is such that the goal state is reachable, you need to either "run random moves away from the goal state" to derive a feasible start state or test inputs using the parity rule (you can find discussions of this on the web).*

You should implement at least TWO admissible heuristics and compare the performance (counts of states expanded in the planning) using each heuristic separately or using their combination with Max(h1,h2).

You should write a short report, including output/graphs etc of what you have done. You should give web links to every tutorial/examples that helped you - and also document where the code for libraries comes from (unless it is a standard package for - say Rstudio install or whatever environment you use - in which case you only need to state which packages you installed).

Merely repeating the steps of an online tutorial is not enough - you should look to try something at least slightly different/extended from what you have found as examples.

Question 13

Programming/Experimental Exploration (Mini-project) A or RL MaxCon.*

Zhipeng Cai (you might find his current webpage interesting! https://zhipengcai.github.io) has code for A for MaxCon: https://github.com/ZhipengCai/MaxConTreeSearch This is in Matlab.*

If you can't get access to matlab or not familiar with using it, you really only need to have the code for "L-infinity fitting". Giang Truong made his RL code (in python) available: github.com/hagianga21/MaxCon_RL/tree/main/minMaxSolver and it contains an implementation of this subroutine (well it actually calls, from python, another package you can install...). The L-infinity fitting is common to whether you are doing RL Maxcon of A Maxcon.*

You are free to choose what to do. One "extreme" is to write A from scratch, applied to maxCon. Using for example only the above sub-routine for the main part that actually interrogates the data (feasibility test and get the basis). Then you should try it on some smallish examples of line fitting, of if more adventurous, homography estimation or fundamental matrix estimation, or plane fitting in 3D....*

Another extreme is to take the complete package of either Zhipeng's matlab code or Giang's python cuda RL github.com/hagianga21/MaxCon_RL/tree/main - you will need a GPU to to do RL of anything other than trivial sizes of problems and limited learning.

You should write a short report, including output/graphs etc of what you have done. You should give web links to every tutorial/examples that helped you - and also document where the code for libraries comes from (unless it is a standard package for - say Rstudio install or whatever environment you use - in which case you only need to state which packages you installed).

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