PROBLEM SET 5

DATA STRUCTURES AND ALGORITHMS 2 - FALL 2023

yourid

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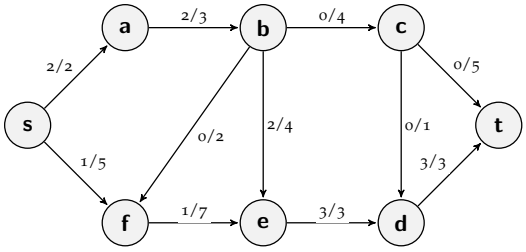
Collaboration Policy: You are encouraged to collaborate with up to 4 other students, but all work submitted must be your own *independently* written solution. List the computing ids of all of your collaborators in the `collabs` command at the top of the tex file. Do not share written notes, documents (including Google docs, Overleaf docs, discussion notes, PDFs), or code. Do not seek published or online solutions for any assignments. If you use any published or online resources (which may not include solutions) when completing this assignment, be sure to cite them. Do not submit a solution that you are unable to explain orally to a member of the course staff. Any solutions that share similar text/code will be considered in breach of this policy. Please refer to the syllabus for a complete description of the collaboration policy.

Collaborators: list your collaborators

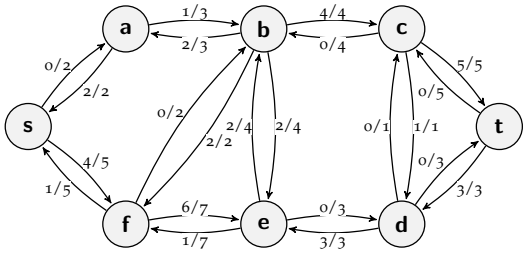
Sources: list your sources

PROBLEM 1 *Max Flow*

Given the following Flow Network G and Residual Graph G':



Flow Network G



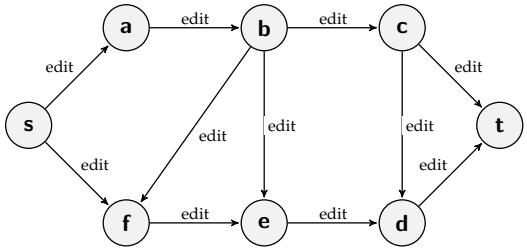
Residual Graph G'

1. Find an augmenting path in the graph G'. List the nodes in the path you found in order (e.g., $s \to a \to b \to c \to d \to t$).

   Solution:

2. Update the Flow Network G above. You **must** edit the graph below (do not upload a picture).

   Solution:



3. Find the min cut of the graph. List the nodes on each side of the cut.

   Solution:

PROBLEM 2 *Element Uniqueness Reduction*

Reduce Element Uniqueness to Mode in $O(n)$ time. Element Uniqueness is defined as: given a list of numbers, return true if no number appears more than once (i.e., every number is distinct). Mode is defined as: given a list of numbers, return one of the numbers which appears most frequently in the list; i.e. if everything was unique it will return an arbitrary element.

Solution:

PROBLEM 3 *Reading and Evaluating Proofs*

Generative AI systems are exciting – *and scary*. They can answer many questions, but how much can we trust the results?

For this problem you will choose an generative AI system (e.g., ChatGPT, Bing (inside of Edge)) and ask it to do a proof for an algorithm we've studied in this unit—specifically, the proof that the reduction of Bi-Partite Matching to Max-Flow is correct. You'll then carefully read the proof it gives you and compare it to the version of that proof in our textbook, noting any issues or significant differences.

Here's a suggested prompt to give the system. You may use this unchanged, or alter it to try to get a better result.

Answer this question as if you were a computer scientist. Formally prove that the Bi-Partite Matching algorithm using a max-flow algorithm is correct (i.e, it always find the optimal matching between nodes in the bi-partite graph).

In your solution, provide the following;

1. Give the name and version number of the generative AI system you've used.

   Solution:

2. In a sentence, describe the proof strategy used by the AI.

   Solution:

3. Study the textbook's proof of this algorithm, Lemma 24.9 in Section 24.3 of the 4th edition of the textbook. In no more than 5 or 6 sentences, describe any issues or problems you see in the AI's result or how it differs from the textbook's proof. *Your answer might address the following questions: Do you think it successfully proves correctness? Are there gaps or odd logical jumps in the proof it provides? How different is it from the proof in the textbook? (If there are no issues to report, just say that.)*

   Solution:

4. Copy the prompt you gave the AI below.

   Solution:

5. Copy the AI's response (the proof) below.

   Solution:

PROBLEM 4 *Algorithms and Society: Ethical and Social Issues*

In society the term *algorithms* is frequently used for what some call *algorithmic decision systems*. These are systems that rely on large amounts of data and algorithms that use AI or machine learning to make decisions in a wide range of important issues in society.

https://en.wikipedia.org/wiki/Automated_decision-making

While these systems are different in nature that almost all the algorithms topics we've studied in this course, some kind of algorithmic process is at the heart of such systems. It is appropriate for a computing student studying algorithms to be aware of this use of the term and to understand examples of such systems and the social and ethical challenges they pose.

Below is a list of articles, etc., that touch on algorithm-based systems and social or ethical issues in society. Choose one article that interests you, and answer the following questions.

1. List the title of the of the reading that you chose.

   Solution:

2. In no more than five or six sentences, summarize how one algorithmic decision system discussed in the reading may lead to negative or undesirable consequences for individuals or societies. (The reading may discuss more than one, but you only need to write about one.)

   Solution:

3. In a few sentences, what actions do you think the computing personnel or organizations that create such systems could do to reduce possible negative or undesirable consequences? (Keep your answers brief!)

   Solution:

Readings (choose one):

1. *Bias in AI-based models for medical applications: challenges and mitigation strategies*
   https://www.nature.com/articles/s41746-023-00858-z
2. *Machine Bias* (This is a longer article on risk assessments in criminal sentencing that got a lot of national attention.)
   https://www.propublica.org/article/machine-bias-risk-assessments-in-criminal-sentencing
3. *Why colleges are using algorithms to determine financial aid levels*
   https://www.highereddive.com/news/colleges-enrollment-algorithms-aid-students/692601
4. *Designing Ethical Self-Driving Cars*
   https://hai.stanford.edu/news/designing-ethical-self-driving-cars
5. *Algorithms that Run the World, an interview with Cathy O'Neil* (author of the book "Weapons of Math Destruction")
   https://thedecisionlab.com/podcasts/algorithms-that-run-the-world-with-cathy-oneil