國立臺灣大學
National Taiwan University

Recitation Week 14
PA3 Explanation & Hint

EE4033 Algorithms, Fall 2022

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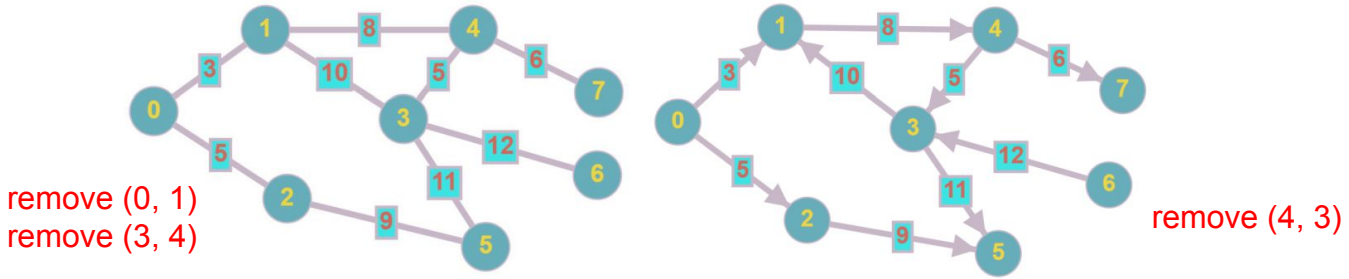
2022/12/5

Outline

- Problem Formulation
- I/O Format
- Important Assumptions
- Command Lines : PA3 / Checker / Submission Checker
- Evaluation
- Submission
- Tips
- Q & A

Problem Formulation: Cycle Breaking

- Given
  - A graph G = (V, E) which may contain cycles
  - V: vertice
  - E: edges with weights
- Objective
  - Remove some edges to make the graph acyclic and connected with minimum total cost (weight)
  - Cycle Breaking Problem / Cycle Removal Problem



(a) weighted undirected graph (b) weighted directed graph

Problem Formulation: Three Types of Graph Instances

- Unweighted undirected graph - find optimal solution
  - All edges weights equal to 1

- Weighted undirected graph - find optimal solution
  - General case
  - Including positive/negative/zero edge weights

- Weighted directed graph - no need to find optimal solution
  - Edges are directional
  - Minimum feedback arc set problem
  - NP-hard problem

Input Format

- 1st line
  - ‘u’ : undirected graph
  - ‘d’ : directed graph
- 2nd line
  - an integer *n* of the total number of vertices
  - the indice of vertices are from *0* to *n - 1*
- 3rd line
  - an integer *m* of the total number of edges
- The following *m* lines
  - three integers *i, j, w*
  - an edge from *vertex i* to *vertex j* with *weight w*
  - w : -100 ~ 100
- A single 0 at the end of input

Sample Input 1	Sample Input 2
u	d
8	8
9	9
0 1 3	0 1 3
0 2 5	0 2 5
1 3 10	1 4 8
1 4 8	2 5 9
2 5 9	3 1 10
3 4 5	3 5 11
3 5 11	4 3 5
3 6 12	4 7 6
4 7 6	6 3 12
0	0

Output Format

- 1st line
  - The total weight of removed edges to make the input graph acyclic
- The following lines
  - A list of these removed edges and their weights
  - The order of *i* and *j* can be different from the input for undirected graph
  - The output edges can be in arbitrary order
- If the input graph has no cycles,
  you should output a line with single “0” (zero)

Sample Output 1	Sample Output 2
8 0 1 3 3 4 5	5 4 3 5

Important Assumptions (2022/11/29 updated)

- The input graph has only one connected component
- The output graph (after removing all reported edges) should remain connected
- For undirected graph instances
  - $1 \le n \le 10,000$
  - $1 \le m \le 20,000,000$
- For directed graph instances
  - $1 \le n \le 5,000$
  - $1 \le m \le 10,000$

Command Line - PA3

- The executable binary should be named as cb
- Command format:

  ./cb [input_filename] [output_filename]
- Example:

  ./cb public_case_1.in public_case_1.out

Command Line - Checker

- To verify your results
  - A binary file that can be executed on Linux systems
  - It checks
    - if the output edges are from the input set
    - if the resulted graph is acyclic and connected

- Usage:

  ./pa3_checker [input_filename] [output_filename]

- Example:

  ./pa3_checker public_case_1.in public_case_1.out

Command Line - Submission Checker

- Create a directory named <studentID>_pa3 (e.g. r10943109_pa3/)
  - src/<all your source code>
  - bin/cb
  - doc/report.pdf
  - makefile
  - README

- Compress your directory into a *tgz* file named <studentID>_pa3.tgz

  tar --exclude='*puts*' -zcvf <studentID>_pa3.tgz <studentID>_pa3/

- Usage:

  bash checkSubmitPA3.sh <studentID>_pa3.tgz

Evaluation

- Runtime limit for each case : 60 seconds

- 2 cases for unweighted undirected graph (12%)
  - 6 pts for correctness per case
- 3 cases for weighted undirected graph (18%)
  - 6 pts for correctness per case
- 4 cases for weighted directed graph (40%)
  - 2 pts for correctness and 8 pts for performance per case
- README (10%)
- Report (10%)
- Submission Format (10%)

Submission

- Submit your to <studentID>_pa3.tgz NTU COOL before

【1pm, December 28, 2022 (Wed.)】

- Penalty for late submission: 20% per day

- All submissions will be subject to duplication checking

【Do Not Plagiarize】

Tips

- Key words
  - cycle breaking problem, cycle removal problem
  - breadth-first search, depth-first search
  - minimum spanning tree

- How to deal with difficult optimization problems?
  - Develop efficient heuristics
  - Greedy/local search methods

- For directed graph, perhaps…
  - Treat it as undirected graph first
  - Then optimize the solution

Q & A

Please email TA Shiuan-Yun Ding at r10943109@ntu.edu.tw for any questions