

CompSci 260P Winter 2020 Project 2: Greedy Approximations

Due **Sunday, February 23**, 6:29PM, although late submissions are allowed.

Note that the due date is 24 hours (plus one minute) prior to your second exam.

Getting Started

Before you begin work on this project, there are a couple of chores you'll need to complete on your VM to get it set up to proceed.

Refreshing your CompSci 260P VM environment

Even if you previously downloaded your CompSci 260P VM, you will probably need to refresh its environment before proceeding with this project. Log into your VM and issue the command `compsci260p version` to see what version of the CompSci 260P environment you currently have stored on your VM. If it does not indicate that project 1 (or a later project) is posted, you need to run `compsci260p refresh`.

If you're unable to get outgoing network access to work on the VM — something that afflicts a handful of students each quarter — then the refresh command won't work, but an alternative approach is to download the latest environment from the link below, then to upload the file to your VM using SCP. (See the Project #0 write-up for more details on using SCP.) Once the file is on your VM, you can run the command **`compsci260p refresh_local NAME_OF_ENVIRONMENT_FILE`**, replacing **`NAME_OF_ENVIRONMENT_FILE`** with the name of the file you uploaded; note that you'd need to be in the same directory where the file is when you run the command.

The file is linked from the “public” CompSci 260P page; click this link and enjoy the amazing web design skill that put it together: <https://www.ics.uci.edu/~mikes/compsci260p/>

Creating your project directory on your CompSci 260P VM

A project template has been created specifically for this project, containing a similar structure to the basic template you saw in Project #0.

Decide on a name for your project directory, then issue the command **`compsci260p start YOUR_CHOSEN_PROJECT_NAME project1`** to create your new project directory using the project1 template. (For example, if you wanted to call your project directory proj1, you would issue the command `compsci260p start proj2 project2` to create it.) Now you're ready to proceed!

Reviewing related material

Review the last lecture before the first exam, as that covers Minimum Spanning Trees and the first part of Wednesday of week six's lecture, as that covers using a MST to approximate a traveling salesperson journey. I encourage you to review the material from weeks six and seven, as that covers greedy algorithms and greedy approximations (especially Wednesday of week six), and should give you better context for this assignment.

Choosing a project partner

You *have the option* to work with a second person for this assignment. If you do so, I expect you to work via pair programming. That is, you **may not** split the assignment, such as by having one person implement the minimum spanning tree while the other person implements the part that finds the journey given the tree, and the two are stitched together later. I reserve the right to ask one or both project partners about the implementation and adjust the score accordingly.

Similarly, any academic dishonesty arising from a group will be treated as an offense by both partners.

Both partners must fill out the following survey to register the partnership. It is not enough for one to do so. Be sure to include your UCINetID and your partner's UCINetID. Failure to do so may cause one person to not get credit. Fill this out even if you are the same partnership you had in project 1.

https://docs.google.com/forms/d/e/1FAIpQLSc7n2cvAknWDVCu5PziXSKcPUsPJEiYj_4-YR6fpNeqkyZNcA/viewform

Requirements

You are required to implement the functions `compute_mst`, `computeTSPJourney`, `costOfJourney` and `waste` in `proj2.cpp`; these are defined in `proj2.hpp`.

For this project, you have a few requirements:

- You must implement the functions in `proj2.cpp`.
- You must use the MST to compute a valid TSP journey. Remember that the original graph was complete, so any given pairs of vertices have an edge between them. You need to compute a depth-first traversal of the graph and consider the vertices in the order in which you *first* see them.

- Your program must run in under three minutes¹ on a reasonably modern computer. Test cases that take longer than this to run may be deemed to be incorrect. Note that this means you will need to think a little about efficiency in your program. It also imposes a restriction on me: I cannot give you a very large test case. Of course, “very large test case” has grown since projects 0 and 1. For example, the largest provided test case, `BigSampleTests.TSPJourney_n100`, takes 12ms on my computer (with my “speed run”² solution).
- You may assume all inputs are valid; for example, in `costOfJourney`, the second parameter will always be a permutation of the unsigned ints in the range of $[0, n-1]$, where n is the number of vertices in the given graph. You do not need to do bounds checking or the like.

You *may* use standard libraries as appropriate, unless there is one that makes solving this problem trivial. I am unaware of any such part of the library. The standard priority queue class lives in `<queue>` for some reason. However, it is by default a *max priority queue* while you want a *min priority queue* if you are implementing Prim’s Algorithm. For this reason, the default `<` operator for `Edge` class has been overwritten to be a greater-than instead. Of course, if you want to use `std::sort`, you’ll then need to either reverse the result or call `sort` with your own comparator. **Do not modify the `Edge` class.**

You are **explicitly permitted** to use C++ standard library container classes (`std::vector`, `std::set`, etc). You are welcome to ask anything you want about these libraries, or to look up material about them online. Information about how to use an explicitly-permitted library may always be shared among classmates, but refrain from telling one another how you solved a problem in the assignment with them. For example, answering “how do I check if an element is in a `std::set`?” is great and encouraged, while answering “what did you use `std::set` for in your project?” is not.

A good reference for the STL container classes (such as those listed above, including `std::map`) is <http://www.cplusplus.com/reference/map/map/> .

If you would like to reuse some or all of *your code* (not that of someone else) from project 0 or project 1 for part of this project, you are welcome to do so. If you have a partnership, you may take code from either or both partners’ versions of project 0 or project 1, but not from anyone else’s. If you take from a previous version, please leave a comment saying whose and which project.

¹ Technically, I use processor minutes for this, so (a) if I have something else running, it doesn’t count against you when it’s on the processor, and (b) someone cannot get around this by spinning up extra threads. You can use `timeout 180s ./run gtest --gtest_filter=SimpleTests.MSTn10` to test that particular test case, with a timeout of 3 minutes, on your own machine if you want.

I also run test cases when I don’t have other things running though.

² This refers to my desire to implement it as quickly as I could, as opposed to my desire to make the fastest implementation I could. Comparing your code to your professor’s best isn’t my goal here.

Remember that the purpose of this project isn't to *find* an implementation of TSP, but rather to code it yourself. Submitting work that isn't yours (for any reason) is a decidedly bad idea and one of the very few ways to do poorly in this class. If I find that you submitted code you found online, your grade will be worse than if you hadn't turned in this project at all.

Deliverables

After using the gather script in your project directory to gather up your C++ source and header files into a single **project2.tar.gz** file (as you did in Project #0), submit that file (and only that file) to Checkmate. Refer back to Project #0 if you need instructions on how to do that. This time, it should give you the correct file name, insert innocent-looking face emoji here.

You will submit your project via Checkmate. Keep in mind that that you're responsible for submitting the version of the project that you want graded. We won't regrade a project simply because you submitted the wrong version accidentally. (It's not a bad idea to look at the contents of your tarball before submitting it; see Project #0 for instructions on how to do that.)

Which partner should submit?

If you are working as a partnership, **exactly one** of you should submit the project. Do not forget to submit it, and also, I do not want to have the situation where both partners submit it. If two people both submit it, there may be a grade penalty assessed.

Can I submit after the deadline?

Yes, it is possible, subject to the late work policy for this course, which is described in the section titled Late work in the course reference and syllabus. The short story is, the longer after the deadline, the less credit you get, and after 99 hours post-deadline, no credit. Note that the second exam is less than 99 hours post-deadline and you cannot move the exam in order to make time to do this project.

Grading

The grade that will be emailed to the submitting partner is your "raw score" based solely on correctness : we will run some number of test cases for your code and, based on how many and which ones you get correct, you will earn some number of points between 0 and 10 (inclusive, and might not be integer-valued). Each is worth some number of points and is graded based on whether or not your code correctly determines if the puzzle has a solution, and if so, what it is. If it is determined that your program does not make an attempt to solve the problem at hand, you will not get these points, regardless of the result from testing. The tests will look a lot like the tests in your Google Test starting directory for this assignment; if you pass those, you're off to a good start, but it's not a guarantee.

The grade emailed does not include late penalties.

If we review your code and find your style to be sufficiently bad, we reserve the right to deduct points based on this, proportional to how bad the style is. If we do so, we will alert you to both the penalty and the reason. Here are some guidelines to follow when submitting your code:

- Include a reasonable level of comments. Do not comment every line, but do not omit comments either. A decent guideline is that if you were asked to explain your code six months from now, your comments should guide you to be able to do so.
- Use meaningful variable names where appropriate. Loop counters need not have a long name, but if you declare a `std::set`, give it a name reflecting what is in the set, not “mySet.”
- Use proper scoping for variables. Avoid global variables except in rare circumstances. Pass parameters appropriately.
- Indent appropriately. While C++ does not have Python’s indentation requirements for writing usable code, the guidelines of *readable* code are an issue here.
- Avoid vulgarity in your code and comments. Variable names, output statements, and the like should not make reference to topics that are not discussed in polite company.
- Remove debug output as appropriate; rather than commenting it out, delete it if it is unnecessary. If you think you might want to return to those debug statements, enclose them instead. Write something like this as a global variable (this is a case where such is acceptable):

```
const bool DEBUG_OUT = true;
```

Then, when you need a debug statement, enclose it:

```
if( DEBUG_OUT )
{
    std::cout << "Set has been successfully declared!" << std::endl;
}
```

When you want to remove the debug output, you can change the declaration to set the variable to false. You may wish to have multiple variables to control debug in various functions, either globally or having them local to functions.

Similarly, if you keep your debug output lines in the file you turn in, having meaningful output statements is better than “code is here!” or “aaaaa.” This is also true if you are going to ask someone (like your professor, for example) for help with debugging.