Assignment 8

Project Introduction Essay

At this stage of the course you should have a good understanding of what is the central problem we are working on and how we plan to approach it. As such, you should know write an essay about the project that should answer the following questions:

1. What problem are you trying to solve?
2. Why is this problem important/useful?
3. What prior work is known on this problem?
4. How are you proposing to approach this problem? How is this an improvement or different from other approaches?

Your essay should have two parts. The first should be a 250 word abstract summarizing the project following the ISEF format, which you can read more about here: `https://www.societyforscience.org/isef/how-to-write-an-isef-abstract/`. The second part should be a more complete description of the project answering all the above questions. It doesn't have a word limit, but don't write more than 2 pages.

You might want to read more about some of the reference past work that this project is based on, so here a couple of links with relevant information:

- Deep Mind Blog Post: goes over the GA+LLM approach that was designed in the paper below.
- FunSearch Paper: the paper where the technique this project is based on was first introduced. It's pretty readable, but it's not recommended that you read more than the Introduction section.
- Lecture Notes on GA: some notes with a more detailed description of GAs.

You might want to do some of your own research on the history of genetic algorithms, but the links above will provide you with most of what you need.

Some rules to this assignment:

- You can/should refer to any of the information in the slides or prior videos from the class.
- You can look up information online about any of the things we discussed, but you can't copy paste anything! All text should be written by you.

- Do not use AI to generate any text. This includes using chatGPT/Gemini/Claude or any of the known large language models.

Capacitated Autonomous Robot Routing

Here is a formal description of the problem we saw in class.

A charging depot at location 0 dispatches a fleet of K identical autonomous robots to perform N spatially–distributed tasks located at vertices $1, \ldots, N$. Moving a robot from location i to location j incurs a non–negative travel cost C_{ij}. Each task has to be executed once, and a robot can execute at most L tasks before returning to the depot.

Parameters

- N - number of task locations.
- K - number of available robots.
- L - capacity limit (maximum tasks per robot tour).
- C_{ij} - travel cost from location i to location j.

Constraints

1. (*Start/End rule*) Each route starts and ends at location 0.
2. (*Capacity*) Every robot visits performs at most L tasks.
3. (*Task coverage*) The routes form a partition of $\{1, \ldots, N\}$: each task location appears in *exactly one* route.

Objective Minimize the total travel cost incurred by all robots:

Think about how you would approach this problem using a genetic algorithm. Namely, how would you represent a state? What would your scoring function be? How would you crossover two states? How would you mutate a state?