IOWA STATE UNIVERSITY
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Developing a Beginner's Guide to the ACM International Collegiate Programming Competition

Introduction

The ACM International Collegiate Programming Competition (ICPC) is a yearly programming and problem solving competition involving some of the best universities and collegiate programmers worldwide.

RANK	TEAM		SCORE	
1	Northern Eurasia	Moscow State University	10	1531
2	North America	Massachusetts Institute of Technology	9	1191
3	Asia Pacific	The University of Tokyo	9	1386
4	Europe	University of Warsaw	8	891

Figure 1: ICPC World Finals Results 2019

Reasons to participate in the ICPC:

- Resume and job interview preparation
  - Competitive programming is great practice to stand out during technical interviews with a potential employer
- Apply problem solving and programming techniques beyond the classroom
  - Read problem and translate it to the computer science domain
  - Determine best algorithms/data structures to solve the problem
  - Create a test plan to validate the correctness of the solution
  - Consider performance issues: runtime complexity, data sizes
  - Debug incorrect solutions; only told right/wrong output, and not allowed to see test cases used for judging

Objective

In this project, my goal was to take the knowledge I had gathered during my experience in the competition and compile it into a guide which would help new students get up to speed more quickly by explaining common issues and providing tips. I also solved problems from several past years' regionals and wrote explanation sketches for the solutions.

Methods

Past Regional Analysis:

- Solve past regional problems, checking with an online judge where possible and directly against judge data otherwise
- Note data structures, algorithms used in solution
- Compile results from actual regional competition

Beginner's Guide:

- Work with students during weekly practice sessions
- Survey of current problem solving members
- Draw from my own experience of two competitions

Sample Problem and Solution – Lost Map (2017)

This problem appeared in the 2017 North Central North America ICPC regional qualifier. Of the 207 teams competing, 131 attempted the problem and only 17 solved it, making it a moderately difficult problem.

A remote collection of villages has commissioned you to create a map of the road network connecting them and a table of the shortest distances between each pair of villages. Unfortunately, you have lost the map and now have only the table. Given that the villages have constructed the minimum distance of roads to connect them, can you reconstruct the map?

The naïve way to approach this problem is to view it as a reverse all-pairs shortest path problem. A solution which can reconstruct the map is as follows:

For each village i, each other village j, and each village which could be between them k: if the distance from i to j is the same as the distance from i to k plus the distance from k to j, then there is not a road directly from i to j.

However, the runtime complexity of this solution is $O(N^3)$, where N is the number of villages. Since N can be as large as 2500, this solution would require over 15 billion operations to complete, which is not feasible inside the time limits of the problem.

The correct solution is to realize that this is a minimum spanning tree problem, and to use an a MST algorithm such as Prim's Algorithm, which runs in $O(ElogV) = O(N^2logN)$ time. This solution is efficient enough to be accepted.

Beginner's Guide to the ICPC

My goal in writing this guide was to supplement the solutions and explanations from past regional problems with a set of instructions and examples to help explain the ICPC and make it easier for students new to the competition to begin solving problems. My guide covers the following topics, among others:

Overview of the Competition and Teamwork

One challenging aspect of the competition is how to share one computer between a team of three. My guide gives an overview of how to maximize points and work efficiently as a team.

Proper Input and Output Handling

It can be confusing to understand exactly how input cases are sent to the program and output cases should be displayed. Handling input improperly can even result in the program getting stuck in an infinite loop, making it appear that the solution is not efficient enough.

Helpful Practice Tools

A number of helpful tools exist to supplement programming practice and make it easier to find and solve problems while learning new techniques. However, I found that most participants at ISU were unaware of these tools or did not use them. While it is not good to depend on these tools too much, since they are not available during contests, they can be very helpful during practice sessions.

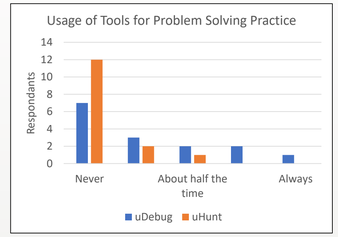

Figure 2

Debugging Rejected Solutions

When a solution is rejected, there is no information about why the solution provided the wrong output. I provided some common issues and places to start when a problem is rejected. Usually it comes down to either a minor programming mistake or incomplete testing before submitting the solution.

Past Regional Analysis

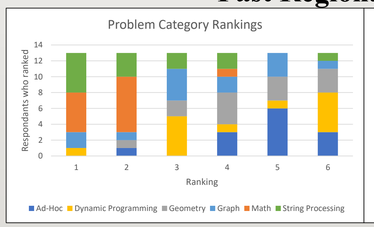

Figure 3

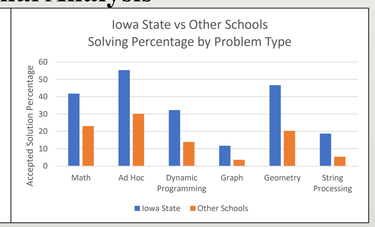

Figure 4

The biggest result that I found from past regional analysis is that student perceptions of problem categories do not line up with the results from past regionals. By focusing practice in areas where Iowa State students perform relatively worse, Iowa State teams can be more successful and solve more problems during the regional competitions.

Conclusions

There are certainly areas where Iowa State teams can improve and compete at a higher level in the ACM ICPC. I hope that the guide I have written will help new students get involved and enable them to be more successful with competitive programming.

References

"Home." *ACM North Central North America Regional | Nebraska*, University of Nebraska – Lincoln, 27 Sept. 2018, ncna-region.unl.edu.

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