CS201 Course Project (Optional)

2024 Spring Semester
Due: Jun. 21th, 2024, please submit through Blackboard

1 Project Introduction

Please choose one of the following projects:

1. Look up some of the incorrect proofs of famous open questions and open questions that were solved since 1970 and describe the type of error made in each proof. Your score will depend on the depth of your analysis and discussions.

2. Look up the definition of a transcendental number. Explain how to show that such numbers exist and how such numbers can be constructed. Which famous numbers can be shown to be transcendental and for which famous numbers is it still unknown whether they are transcendental? Real-world applications of these numbers? Can you suggest additional applications and explain why and how? Your score will depend on the depth of your analysis and discussions.

3. Describe six different NP-complete problems. Demonstrate how one of the NP-complete problems can be reduced to the satisfiability problem. Come up your own real-world problem formulation and formally prove the problem is NP-complete. Your score will depend on whether your problem is interesting and novel, the depth of your problem formulation, whether your proof is rigorous or not.

4. Explain why it would not be suitable to use p, where p is a large prime, as the modulus for encryption in the RSA cryptosystem. That is, explain how someone could, without excessive computation, find a private key from the corresponding public key if the modulus were a large prime, rather than the product of two large primes. Come up a *new* potential application of RSA cryptosystem. Describe the motivation, novelty, and rationale.

5. Discuss some of the various methodologies used to establish the correctness of programs and compare them to Hoare's methods. Explain how the ideas and concepts of program correctness can be extended to prove that operating systems are secure.

6. Describe some of the earliest uses of the pigeonhole principle by Dirichlet and other mathematicians. Come up with your real-world problem formulation and discuss how the problem can be solved using pigeonhole principle. Your score will depend on whether your problem is interesting and innovative and the depth of your problem formulation and solution.

7. Describe the use of dynamic programming in economics including its use to study optimal consumption and saving. Based on the discussions, come up with your real-world problem formulation and discuss how the problem can be solved using dynamic programming. Your score will depend on whether your problem is interesting and innovative and the depth of your problem formulation and solution.

8. Explain what is meant by a modular lattice. Describe some of the properties of modular lattices and describe how modular lattices arise in the study of projective geometry. Based on the discussions, come up with your real-world problem formulation and discuss how the problem can be solved using modular lattice. Your score will depend on whether your problem is interesting and innovative and the depth of your problem formulation and solution.

9. Explain how graph theory can help uncover networks of criminals by studying relevant social and communication networks. The discussions may cover various aspects, e.g., algorithms for detecting criminals, the degree of criminals, mechanisms for prohibit criminals, propagation of malicious information, and so on. The written report should provide a comprehensive and coherence story about this topic.

10. Define the type of graph known as a mesh of trees. Explain how this graph is used in applications to very large system integration and parallel computing. Come up with your own real-world problem formulation and discuss how the problem can be solved using a mesh of trees. Your score will depend on whether your problem is interesting and innovative and the depth of your problem formulation and solution.

2 Written Report

When you write your report, please regard it as writing an academic paper. That is, it should be a complete and coherence story, and the discussions should be formal and rigorous.

Here provides a suggestion on the report organization. However, since the aforementioned projects are quite diverse, the following suggested organization may not be applicable to some of the topics. You may modify it based on the topic you choose.

- Motivation and Introduction:
  - What is the problem you are going to solve or discuss?
  - Why this problem is important or exciting?
  - What is your idea for addressing this problem? Why is it a good idea?
- Review on existing works and approaches
  - Have other people considered the same problem? How did they address it?
- Problem Formulation:
  - Formulate or explain your problem using mathematical notations and statements
- Solution or Algorithm Design:
  - Describe your solution in details. The solution could be done using mathematical techniques or programming.

  - Explain how and why the solution can solve the problem.

- Result and Discussion:
  - Analyze the performance of your solution theoretically or empirically.
  - Discuss the insights obtained from the results.

- References: cite the papers you referred to

3 Important Notes

- You are assumed to work individually. If you refer to materials (e.g., papers, online resources), please indicate clearly the references in your report.

- **Deadline**: The project report is due on Jun. 21th, 2024 (Firm deadline, NO Extension).

- **How to submit**: Submit your project on Blackboard, including
  - Submit a written report: in PDF file; in English; using IEEE conference format[1]; double-column, no longer than 6 pages.
  - Supplementary materials (if necessary): demo, codes, etc.

- **Marking**: The project is optional and counts 5% additional overall marks. In particular, if you submit a report, you will get an additional score of

$$\text{Initial Score} \times \text{Difficulty Coefficient} \times 5\%$$

  The initial score is 100 points in total. The tentative marking scheme is as follows. However, since the project covers various topics, this is only a rough scheme.
  - Motivation and research question (exiting and creative topic, reasonably and clearly motivated): 20 points
  - Review on existing works and approaches (rigorous and clear math description, review of a family of existing approaches if necessary): 20 points
  - Problem formulation (rigorous and clear math presentation, characterize important factors of the research question you are going to solve): 20 points
  - Solution (rigorous and clear math/programming presentation, whether the problem has been properly and completely solved, supplementary materials if necessary): 15 points
  - Discussion and conclusion (complete and interesting results, critical thinking): 15 points
  - IEEE conference format (format, whether the format looks good or not): 10 points

  The difficulty coefficient:
  - Trivial (a homework question that can be solved within several hours): **-20%!!!** If you do not spend time on this project, you will definitely get a negative score. Thus, if you do not want to spend time, a better strategy is to simply give up this project.

[1] Visit `https://template-selector.ieee.org/secure/templateSelector/publicationType`, select *Conference*, then select *Original Research*. You can then choose either *Word* or *Latex* template.

- Easy (you collected and learned many materials and organized the materials without your own understanding): **0%!!!**
- Good (you provide a reasonable and complete analysis and discussion on the topic you choose; from the report, I can see your own understanding and innovative ideas): 50%
- Hard (you provide a comprehensive discussion on the project and raise an interesting and novel question, which is relatively challenging to solve, and propose an innovative solution, or you bring out creative and exciting discussions): 80%
- Expert (I am totally amazed by the result, and the report can be extended to an academic paper): 100%