Midterm Guide

CSC 463

February 14, 2020

1 Midterm Information

The CSC 463 midterm exam will be on February 26 from 2-3pm in the **Exam Centre Room 300**, not the usual classroom. Please bring your TCard with you to the exam. Usual academic integrity rules apply: no notes, textbooks, or electronic devices are allowed on your person or desk while writing the exam.

2 Exam Topics

The exam will cover computability theory, which was covered in Chapter 3-6 of Sipser's textbook and in class. There will be 2-3 problems on material covered in Chapter 3-5 and one shorter problem on Chapter 6 material. More specifically, you should know the following concepts, definitions, and theorems covered so far.

- Understand the definition of a Turing machine and why it may be a useful as a formal definition of an algorithm according to the Church-Turing thesis.
- Know how different definitions of a Turing machine (nondeterministic, multi-tape etc.) can be proved equivalent to each other and be aware that non-Turing machine computational models can also be proved equivalent to the Turing machine model.
- Know what it it means for a language L (or equivalently a decision problem) to be decidable, semi-decidable, or co-semidecidable by a Turing machine.
- Prove that languages are decidable, semi-decidable, or co-semidecidable.
- Prove that languages are not decidable, semi-decidable, or co-semidecidable using various techniques, including Cantor's diagonalization proof, and mapping reductions. Mapping reductions can lead to general criterion for showing undecidability such as Rice's Theorem.
- Give examples of problems studied and classify their decidability properties. In class, we have discussed:
  - $A_{TM} = \{\langle M, w\rangle : \text{Turing machine } M \text{ accepts } w\}$ is complete for semi-decidable problems but not decidable. The halting problem has the same property.
  - The set of Turing machines with an empty language $E_{TM} = \{\langle M\rangle : L(M) = \emptyset\}$ is co-semidecidable but not decidable.
  - The set of equal Turing machines $EQ_{TM} = \{\langle M_1, M_2\rangle : L(M_1) = L(M_2)\}$ is neither semidecidable or co-semidecidable.
  - Post Correspondence Problem and problems involving context-free grammars are examples of "natural" undecidable problems (problems not involving the description of a Turing machine in its definition).
  - Kolmogorov complexity is not a computable function and deciding if a string is Kolmogorov-incompressible is undecidable.

3 Exam Preparation

To prepare for the exam, there are several things you can do.

- Review your lecture notes, assignment and tutorial questions, and textbook. Try to reproduce the proofs of various things we covered in class without looking at the notes and textbook. You are not expected to reproduce or remember the details of more complicated proofs such as proof of undecidability of Post Correspondence Problem in an exam.
- Practice from questions given on the 2017 and 2018 midterm exams from CSC 463, available online.
- Practice from the questions given at the end of each chapter in Sipser. Some suggested problems in the 3rd edition include the shorter exercises in Chapter 3 and 5, as well as longer problems 3.14, 3.18, 4.12, 5.12, 5.22, 5.30, 6.18.