CS 422 - Automata Theory

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1 General Information

(a) Instructor: K. Subramani

(b) Meeting Times: Tu-Th, 11:00 am - 12:15 pm
Location: ESB 251.

(c) Contact Information: 347 AERB.

(d) Office Hours: Tu-Th, 09:00 am - 10:00 am

(e) Textbook - [Lin16] is the primary text, although [HMU01] and [Sip06] are excellent supplementary texts.

(f) Assessment:

(a) Homework Assignments (2) - You will be handed a homework assignment on September 12, due on September 19 and a second homework on October 24, due on October 31. Each homework is worth 15% (for a total of 30%), of your grade.

(b) Quizzes (2) - The first quiz will be held on September 26, and the second quiz will be held on November 21. Quizzes are closed-book, open-notes. Each quiz is worth 15% (for a total of 30%), of your grade.

(c) Midterm - The midterm will be held on October 15 (in-class, closed-book and open-notes) and is worth 20% of your grade.

(d) Final - The final exam will be held on December 19 from 8 to 10 am. The examination will be closed-book, open-notes.

(e) 5 points will be awarded for classroom conduct, including attendance on certain days and adhering to class policies and procedures.

(g) Grade Boundaries

(a) **A**: 80 and up

(b) **B**: $65 - 79$

(c) **C**: $50 - 64$

(d) **D**: $45 - 49$

(e) **F**: $0 - 44$

(h) Attendance is **mandatory** on the following days: September 24, October 1, October 17, November 5 and December 3. Failure to attend classes on these days will result in the loss of conduct points.

(i) Grading policy - If you have any questions about the grading, you must contact the instructor within two days of your paper being returned.

(j) Makeup Policy - If for some reason, you are unable to attend a test or an exam, please meet me at the earliest and I will set an alternate date.

(k) **Course Objectives** - The objectives of this course are as follows:

(a) Presenting the theory of finite automata, as the first step towards learning advanced topics, such as compiler design.

(b) Applying the concepts learned in fundamental courses such as Discrete Mathematics, in a theoretical setting; in particular, the application of proof techniques.

(c) Discussing the applications of finite automata towards text processing.

(d) Developing an understanding of computation through Turing Machines.

(l) **Expected Learning Outcomes** - Upon successful completion of this course, students will be able to:

(i) Apply a number of proof techniques to theorems in language design.

(ii) Develop a clear understanding of undecidability.

(iii) Understand the equivalence between Nondeterministic Finite State Automata and Deterministic Finite State Automata.

(iv) Understand the equivalence between Context-Free Grammars and Nondeterministic Pushdown Automata.

(v) Appreciate the power of the Turing Machine, as an abstract automaton, that describes computation, effectively and efficiently.

2 Syllabus Sketch and Weekly Schedule

2.1 Introduction to the Theory of Computation

Sets, Functions, Relations, Graphs and Trees, Proof Techniques, Languages, Grammars, Automata. These topics will be covered from Chapter 1 of [Lin16].

2.2 Finite Automata

Deterministic Accepters and Transition Graphs, Languages and DFAs, Regular Languages, Nondeterministic Finite Accepters, Equivalence of Deterministic and Nondeterministic Finite State Automata, State Minimization. These topics will be covered from Chapter 2 of [Lin16].

2.3 Regular Languages and Regular Grammars

Regular Expressions, Connection between Regular Expressions and Regular Languages, Regular Grammars. These topics will be covered from Chapter 3 of [Lin16].

2.4 Properties of Regular Languages

Closure Properties of Regular Languages, Elementary Questions about Regular Languages, Identifying Non-regular Languages. These topics will be covered from Chapter 4 of [Lin16].

2.5 Context-Free Languages

Context-Free Grammars (CFGs), Parsers, Parsing and Ambiguity in Grammars and Languages, CFGs and Programming Languages. These topics will be covered from Chapter 5 of [Lin16].

2.6 Simplification of CFGs and Normal Forms

Methods for Transforming Grammars, Chomsky Normal Form, Greibach Normal Form, A Membership Algorithm for CFGs. These topics will be covered from Chapter 6 of [Lin16].

2.7 Pushdown Automata

Nondeterministic Pushdown Automata, Pushdown Automata and Context-Free Languages, Deterministic Pushdown Automata and Deterministic Context-Free Languages, Grammars for Deterministic Context-Free Languages. These topics will be covered from Chapter 7 of [Lin16].

2.8 Review

Review of all topics (1 Lecture).

2.9 Turing Machines

Definition of a Turing Machine, Turing Machines as Language Accepters, Turing Machines as Transducers, Combining Turing Machines for Complicated Tasks, Turing Machines with a Stay Option, Multitape Turing Machines, Multidimensional Turing Machines, Non-deterministic Turing Machines. These topics will be covered from Chapter 9 and Chapter 10 of [Lin16].

2.10 A Hierarchy of Formal Languages and Automata

Universal Turing Machines, Linear-Bounded Automata, Countability, Recursive and Recursively Enumerable Languages, The Chomsky Hierarchy. These topics will be covered from Chapter 10 and Chapter 11 of [Lin16].

2.11 Limits of Algorithmic Computation

Computability and Decidability, The Turing Machine Halting Problem, Reducing one undecidable problem to another, undecidable problems for recursively enumerable languages. These topics will be covered from Chapter 12 of [Lin16].

I would like to reiterate that this is a sketch of the topics that we will be covering. For various reasons, I may choose to drop a mentioned topic or cover a new topic. In such cases, advance notice will be given. I have also reserved some lectures for discussions on Homework Assignments, Quizzes and Exams.

3 Inclusivity Statement

West Virginia University community is committed to creating and fostering a positive learning and working environment based on open communication, mutual respect, and inclusion. If you are a person with a disability and anticipate needing any type of accommodation in order to participate in this class, please advise me and make appropriate arrangements with Accessibility Services (293-6700). For more information on West Virginia University's Diversity, Equity, and Inclusion initiatives, please see http://diversity.wvu.edu.

4 Civility Statement

In this course, you are expected to act in a manner consistent with the behavior expected in the professional workplace. Respect each other, come to class prepared, be supportive of others, be attentive, contribute when appropriate, and be engaged in your learning. Civility is expected and assumed.

In order for everyone to have the opportunity to maximize learning, inappropriate or disruptive behavior is prohibited and may result in a request to leave the classroom at a minimum.

Examples include, but are not limited to, using cell phones in class, texting in class, excessive tardiness or late arrivals, demanding special treatment, challenges to the instructor's authority, leaving class early, shuffling backpacks and book bags, using offensive language or remarks, chewing gum, wearing caps, prolonged side discussions, playing games in class, sleeping, overt inattentiveness, and using a laptop during class unless instructed to do so.

5 Policies and Procedures

1. Grades assigned during the semester on exams, quizzes, reports, or homework assignments are considered final and are not subject to negotiation for any reason other than an indisputable mistake in grading.

2. Use of cell phones, smart wearable devices, or possession of other external communication devices, including laptops is **strictly prohibited** during lectures.

3. Common standards of academic integrity prohibit not only cheating or plagiarizing, but also the unethical conduct of trying to obtain grades that the student has not earned. Violations of academic integrity are described in the WVU Catalog: http://bit.ly/2hDAeUa.

4. Students have the right to appeal final grades that do not involve charges of academic dishonesty. Students may appeal charges of academic dishonesty. The appeal process is outlined in the WVU Catalog: http://bit.ly/2uiMM9E.

5. Incidents of student misconduct or academic dishonesty will be handled promptly and appropriately in accordance with the WVU Student Conduct Code and Discipline Procedure. The case will be referred to the Office of Student Conduct. Detailed academic policies on syllabus and class conduct can be found at: https://tlcommons.wvu.edu/syllabus-policies-and-statements.

6. Violations of the policies and procedures (including the Civility Statement) will lead to the loss of conduct points and possible dismissal from the course.

7. Student evaluation of instruction will be conducted, **in class**, on a suitable date after October 20.

References

[HMU01] J. E. Hopcroft, R. Motwani, and J. D. Ullman. *"Introduction to Automata Theory, Language, and Computation"*. Addison–Wesley, 2nd edition edition, 2001.

[Lin16] Peter Linz. *An Introductionto Formal Languages and Automata*. Jones and Bartlett, 6^{th} edition, 2016.

[Sip06] Michael Sipser. *Introduction to the Theory of Computation*. Thompson Course Technology, second edition, 2006.