COMS W3261
Computer Science Theory
Lecture 1

Alexander Roth

2014 – 09 – 03

1 Schedule

- Lectures: Mondays and Wednesdays, 1:10 – 2:25pm, 833 Mudd.
- Office Hours: Mondays and Wednesdays, after class.

2 Course Objectives

- Learning computational thinking
- Understanding the fundamental models of computation that underlie modern computer hardware, software, and programming languages.
- Discovering that there are problems no computer can solve.
- Discovering that there are limits on how fast a computer can solve a problem.
- Mastering the foundations of automata theory, computability theory, and complexity theory.
- Learning about applications of computer science theory to algorithms, programming languages, compilers, natural language translation, operating systems, and software verification.

3 Course Syllabus

- Languages and decision problems
- Finite automata
- Regular expressions

- Properties of regular languages
- Context-free grammars
- Pushdown automata
- Algorithms and Turing machines
- Lambda calculus
  - The computational model for functional languages. Java 8 now has lambdas.
- Undecidability
- Complexity theory

4 Course Requirements

- Homeworks (best four out of five homeworks will constitute 20% of final grade)
- Midterm (40% of final grade)
- Final (40% of final grade)

5 Languages

- An *alphabet* Σ is a finite, nonempty set of symbols.
- A *function* maps an element to a range.

Example: $\{0, 1\}$, ASCII, Unicode.

- A *string* is a finite sequence of symbols chosen from some alphabet.

Example: ε, the empty string, 0, 01, 011

  - Don't forget about the empty string, it's important!

5.1 Terms associated with strings

Definition 1. *Prefix: Any sequence of characters at the beginning of a string.*

Example 1. *"dog" has 4 prefixes: ε, d, do, dog.*

All strings have $n + 1$ prefixes.

Definition 2. *Suffixes: Any sequence of characters at the end of a string.*

Example 2. *"dog" has 4 suffixes. ε, g, go, god.*

All strings have $n + 1$ suffixes

Definition 3. *Substrings: Obtained by maintaining the sequence of characters while reducing the size of the strings.*

Example 3. *"dog":*
Shortest String: ε
String of length 1: d, o, g
String of length 2: do, og, dg
String of length 3: dog

All substrings are of length $n! + 1$

Definition 4. *Subsequences: Obtained by deleting zero or more characters in a string*

Example 4. *"dog":* ε*, d, o, g, do, dg, og, dog*

2^n subsequences in any given string x.
A string is ordered, strings are sequences and sequences have orders.

Operations on Strings Common operations:

- Concatenation
- Reversal

Terms associated with Strings

- Prefix
- Suffix
- Substring
- Subsequence

A *language* over Σ is a set of strings whose symbols are chosen from Σ

Example 5.
- *The empty set,* $\varnothing$
- $\{0, 1\}$, $\{0\}$, $\{1\}$, $\{01\}$
- $P = \{10, 11, 101, 111, 1011, 1101, \ldots\}$ *(the binary representation of the prime numbers)*

Distinction between finite and infinite languages:

- Distinction between finite and infinite languages:
  - There are a finite number of objects in the set.
  - Two types of infinite:
    - **Countably:** 1 to 1 mapping between the numbers in the set against the natural integers. A set of all syntactically valid java programs is countably infinite.
    - **Uncountably:** Do not have 1 to 1 mapping between the natural integers and the given set.

5.2 Kleene Closure

$$L \cup M$$

$$L \cap M$$

$$LM = \{\, xy \,|x \in$$