Aalto University, School of Science
Department of Computer Science
Stavros Tripakis (0504301862)

CS-C2150 Theoretical Computer Science — Spring 2017

Exam December 13th, 2017, 9:00–12:00

Note: Use of calculators is not allowed in the exam. Use of textbooks, lecture notes, or personal notes is not allowed either.

Note: If you have not completed your computerized home assignments, your exam will not be graded.

1. (16 points)

   (a) Design a deterministic finite state machine (i.e., finite automaton) that recognizes the language

   $$\{w \in \{a,b\}^* \mid w \text{ starts with the substring } bab\}.$$

   (b) Design a deterministic finite state machine that recognizes the language

   $$\{w \in \{a,b\}^* \mid w \text{ ends with the substring } bab\}.$$

   (c) Design a deterministic finite state machine that recognizes the language

   $$\{w \in \{a,b\}^* \mid w \text{ does not contain the substring } bab\}.$$

   (d) Design a non-deterministic finite state machine that recognizes the language

   $$\{w \in \{0,1\}^* \mid w \text{ contains the substring } 111 \text{ or } 011 \text{ (or both)}\}.$$

   Give a deterministic version of your machine recognizing the same language.

2. (10 points)

   (a) Give a regular expression that describes the language

   $$L = \{w \in \{a,b\}^* \mid w \text{ begins and ends with different symbols}\}$$

   (b) Consider the regular expression $(0 \cup 1)^* 1 (0 \cup 1)$ over the alphabet $\{0,1\}$. Give the deterministic finite state machine with *minimal number of states* that recognizes the language described by the regular expression.

3. (12 points)

   (a) Give an example of a language that is not regular, but which is context-free.

   (b) Prove that the language that you defined above is not regular.

   (c) Design a contex-free grammar that describes the language that you defined above.

4. (12 points)

   (a) Desribe in your own words (with at most 5 sentences), what the “Church–Turing thesis” is.

   (b) Define the “Halting Problem” for Turing Machines. You don’t need to, and shouldn’t define what a Turing Machine is, how it operates, etc.

   (c) Formulate as a Theorem the undecidability of the Halting Problem.

   (d) Prove the above theorem, i.e., the undecidability of the Halting Problem.

   (Again, you don’t need to define what a Turing Machine is nor how it operates, for any of the questions above.)

5. (1 point)
   At what time did you finish answering the exam questions?