BMI 861 Brain Automata

A Distance Learning Course

June 22 - July 10, 2015

http://www.brain-mind-institute.org/

Brain-Mind Institute (BMI) 3 credits Available via Internet

This course is intended for those majoring in biology, neuroscience, psychology, electrical engineering, and all others who have not learned the theory of Turing Machines. Students will learn the symbolic brain theory related to how the brain works, leaving the emergent brain theory to BMI 871. Agents. Continuous time and discrete time. Mathematical induction. Finite Automata. Concepts as actions. Spatial abstraction. Temporal abstraction. Turing Machines. Universal Turing Machines. Von Neumann computers. Rules vs. data. Formal languages. The controller of a Turing machine is a Finite Automaton. Brains as ground and emergent Turing Machines.

Lectures: Each lecture in video is available online hopefully by 9:00am Beijing Time, Monday to Friday, via Internet. Due to the material of this course, the instructor has decided to use chalk board for lectures, instead of PowerPoint slides. You are encouraged to take the class notes if you like but this is not required. Unfortunately, Google is currently not available from China. Lecture video files will be available at Baidu Cloud `pan.baidu.com`. You will receive email for sharing the files, but the files are for your eyes only as they are copyright protected. Some lectures will mention the models taught at BMI 871, but treat them as a preview only if you have not taken BMI 871.

Instructor: Juyang (John) Weng

Course web: `http://www.brain-mind-institute.org/bmi-861.html`

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Prerequisites: An admission to a bachelor degree in any discipline is generally sufficient. Physical science and social science applicants are all encouraged. This course is self-contained for the course homework assignments and exams.

Required text: John Martin, Introduction to Languages and the Theory of Computation, 4th edition, ISBN: 978-0073191461, McGraw-Hill, New York, 2011. This text does not mention brains at all. Additional material related to brains will be added.

Homework: There will be online homework assignments, administered through LON-CAPA, an integrated system for online learning and assessment, at http://s10.lite.msu.edu. All homework assignments will be due before the exam of the week, but a same-day completion is highly encouraged to catch up the following lecture. No late work will be accepted. Some homework problems will be graded, but not all.

Exams: Three exams, to be done by each Sunday, of 1.5 hours each. Exams are closed book and must be done within the specific time length. Homework will be collected and some will be graded. Reading textbook and doing homework are also important for doing well in the exams.

Exam proctor: You need to identify a keep-an-eye-on-you exam proctor who is a licensed librarian, one of your parents, or a licensed teacher. Send the proctor's name, address, email address, and proof of qualification required above to the instructor via email. Grading results of the exams are private and confidential, not known to the proctor. Ask the proctor to send a statement via email, at least 24 hours before the first exam, with email subject "BMI 861 Proctor Statement for First-Name Last-Name" to the instructor: "I guarantee to observe the responsibilities of the proctor, including the closed-book, no-access-to-electronics, and the exam time length requirements." The proctor is responsible for printing the exam and the answer sheet before the exam and, within 1.5 hours after giving you the exam, taking a picture of your answer sheet and sending it back via email.

Grading: Three exams equally weighted, each counted as 100%/3. Homework is not counted for the total score. Pass: the total score is 60% or above. Those who successfully pass will receive a BMI 861 Certificate.

Time Schedule

The added contents are marked by asterisk $*$. The section numbers refer to the textbook.

- Week 1, Day 1, Monday: $*$ Agents and Brains. $*$ Symbols and Patterns.
- Week 1, Day 2, Tuesday: 1.1 Logic and Proofs. 1.2 Sets.
- Week 1, Day 3, Wednesday: 1.3 Functions and Equivalence Relations. 1.4 Computer Languages. $*$ Natural Languages.
- Week 1, Day 4, Thursday: 1.5 Recursive Definitions. 1.6 Structural Induction.
- Week 1, Day 5, Friday: 2.1 Finite Automata: Examples and Definitions. $*$ Brain Controls as Emergent Finite Automata.
- Week 2, Day 6, Monday: 2.2 Accepting the Union, Intersection, or Difference of Two Languages. 2.3 The Pumping Lemma.
- Week 2, Day 7, Tuesday: 2.5 How to Build a Simple Computer Using Equivalent Classes. 2.6 Minimizing the Number of States in a Finite Automaton
- Week 2, Day 8, Wednesday: $*$ Concepts and abstraction. $*$ Attention in Space and Time.
- Week 2, Day 9, Thursday: $*$ Attentive Finite Automata. $*$ Specificity and Invariances.
- Week 2, Day 10, Friday: 3.1 Regular Languages and Regular Expressions. 3.4-3.5 Kleenes Theorem.
- Week 3, Day 11, Monday: $*$ Grammars and Semantics. 4.2 Context-Free Languages and Context-Sensitive Languages.
- Week 3, Day 12, Tuesday: 7.2-7.3 Turing Machines. 7.8 Universal Turing Machines.
- Week 3, Day 13, Wednesday: $*$ The Control of any Turing Machine is a Finite Automaton. $*$ Brains as Emergent Turing Machines.

- Week 3, Day 14, Thursday: $*$ Prediction in Emergent Finite Automata. $*$ Prediction in Emergent Turing Machines.
- Week 3, Day 15, Friday: 11.1 Computational Complexity. $*$ Complexity of Brains.