Department of Mathematics

Math 6720 (CRN 35436): Topics in Logic

Algorithmic Learning Theory

Spring 2018

MW 3:45–5:00pm

1957 E Street, Room 310

- **Professor**

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Office Hours: M 2:00–3:30pm

W 5:15–6:45pm

At other times by appointment.

- **Mathematics department**

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- **Description**

Algorithmic learning theory is a mathematically precise, general framework for studying the existence of strategies for converging to truth when identifying formal languages or computably enumerable sets of natural numbers that represent them. A computably enumerable language is also called a Chomsky language. By exploiting the concepts and methods of computability theory, we will present a learning paradigm independently invented by E. Mark Gold and Hilary Putnam. It is known as identification in the limit and is intended as a model of language acquisition by children. We will consider different types of identification, locking sequences, and learning strategies.

Computably enumerable sets are enumerated by Turing machines and can be identified with their Gödel codes. Although each Turing machine has a unique Gödel code, different Turing machines can enumerate the same set. Thus, knowing a computably enumerable set means knowing one of its infinitely many Gödel codes. An inductive inference learner for a computably enumerable set A is a system or a device, usually algorithmic, which when successively fed data for A outputs a sequence of Gödel codes that at certain point stabilize at codes correct for A. The convergence is called semantic or behaviorally correct, unless the same code for A is eventually output, in which case it is also called syntactic or explanatory. There are classes of sets that are semantically inferable, but not syntactically inferable.

We will study learning from all data, that is, learning from an informant, and learning from positive data only, that is, learning from text, as well as some intermediate concepts of learning that involve switching type of information. We will show how different convergence criteria interact with different ways of supplying data to the learner. Finally, we will apply learning theory to computable algebra by using tools of algorithmic learning theory to describe important classes of computably enumerable structures. For sets, inference from switching is more restrictive than inference from an informant, but more powerful than inference from text. This is not always the case with structures where various elements may be interrelated.

- **Textbook**

  Systems That Learn, 2nd edition, S. Jain, D. Osherson, J.S. Royer, and A. Sharma, MIT Press, 1999.

  "Inductive inference systems for learning classes of algorithmically generated sets and structures," V. Harizanov, in: *Induction, Algorithmic Learning Theory, and Philosophy*, pp. 27–54, Springer, 2007.

- **Required background**

  Math 2971 or an equivalent, and familiarity with the notion of an algorithm.

  Math 6720 can be taken for credit repeatedly.

Advanced **undergraduate** students may also take this course for credit.

- **Learning Outcomes**

  As a result of completing this course students should be able to:

  1. Analyze distinguishing charateristics of language identification in the limit;

  2. Classify computably enumerable languages as learnable from a general learner and from an algorithmic learner;

  3. Identify languages inferable from text, from an informant, and from switching type of information;

  4. Compare and contrast different convergence criteria such as explanatory learning and behaviorally correct learning;

  5. Apply identification in the limit to classes of effective algebraic structures.

- **Grading**

  Based on class participation (10%); take-home assignments (50%), midterm project (20%), take-home final exam (20%), and their in-class presentations.

- **Academic integrity code**

  Academic dishonesty is defined as cheating of any kind, including misrepresenting one's own work, taking credit for the work of others without crediting them and without appropriate authorization, and the fabrication of information. For the remainder of the code,
  see: https://studentconduct.gwu.edu/code-academic-integrity

- **Support for students outside the classroom**

  Academic support services: https://advising.columbian.gwu.edu/academic-support

  Mental health services: 202–994–5300

The University's Mental Health Services offers 24/7 assistance and referral to address students' personal, social, career, and study skills problems. Services for students include: crisis and emergency mental health consultations confidential assessment, counseling services (individual and small group), and referrals. https://healthcenter.gwu.edu/mental-health

- **Emergency preparadeness**: www.gwu.edu/~gwalert