CS598  MP
Software Verification, Program Synthesis, and Interpretable AI

Fall 2021
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Lectures: Mon, Wed: 9:30am-10:15am (Online/Zoom)
Zoom: https://illinois.zoom.us/j/87442632749?pwd=Y0liRGRteDlFMVlRaTVmY3hzOHVPdz09

Website: http://courses.engr.illinois.edu/cs598mp/
Piazza: http://piazza.com/illinois/fall2021/cs598mp
Aims of this course

Broadly:

- Challenges of reasoning with software today lie in **synthesis**

- **Synthesis** is called for because we need to divine ways to reach goals
  People do this currently well; machines don’t.

  **Examples:**
  For proving theorems: induction hypotheses, quantifier instantiation, and lemma application
  For mining specifications from code (preconditions/abduction; contracts)
  For automated programming - find programs that satisfy (nebulous) specifications/input-output examples
  Synthesis is hard: no clear method to look for expressions; no clear goals even

- Connections to interpretable machine-learning
  - Logic expressions are interpretable classifiers
  - Synergy of ML methods and program synthesis techniques for interpretable AI
Aims of this course

• Primary topics:
  – Understand state-of-the-art logic-based automatic software verification
    • Logic
    • Decidable logics and SMT solvers
    • The challenging problems in reasoning with programs:
      – Specifications, inductive invariants, induction hypothesis, quantifier instantiation, ...
      – Calls for expression synthesis
  – Program Synthesis; Learning Logics
    • Program/logic synthesis from specifications
    • Program/logic learning from examples
    • Program/logic learning from noisy data
    • Use of neural networks and other ML algorithms to learn programs/logic
  – Applications
    • Applications of program synthesis
    • Applications of logic learning from examples to specification mining
    • Applications of logic learning from examples to interpretable AI
Logic and AI

- AI in the past (till about 2000) was obsessed with logic, but was too early.
- We need to first be able to detect cats in a picture, before understanding more complex thinking!
- Daniel Kahneman’s “Thinking, Fast and Slow”
- Advent of Machine Learning --- captures “quick”/intuitive/unexplainable thinking
- But humans think symbolically too!

- How does symbolic thinking happen?

- Interface between symbolic and “neural” thinking is still a mystery.
Administrivia

• Homework
  – Two sets of homework early in the semester

• Presentation of papers
  – Mid-semester
  – Perhaps aligned with your project interest

• Project discussions in groups (informal)
• Project presentations
Projects

Starts mid-semester (when paper presentations start)

• A project that works on a research-ish problem and tries to build a solution
  (work in groups of at most two, work in something that’s close to your research, I can work with you, you can even send it for publication if you get good results.)
Other tools

• We will use Gradescope for homework

• And Piazza for discussions.

• Sign up for Piazza!

• Look out for emails on these topics.
Survey

Email me:

1) What do you expect to learn in this course?

2) What are your general interests?