Machine Learning for Programming (ML4P)

Prof. Dr. Michael Pradel

Winter 2018/19 – Software Lab – TU Darmstadt

Course site:

http://software-lab.org/teaching/winter2018/ml4p

Piazza site:

http://piazza.com/tu-darmstadt.de/winter2019/ml4p

About Me

- **Michael Pradel**
- **At TU Darmstadt since 2014**
- **Before joining TUDA**
  - Master-level studies in Dresden and Paris
  - Master thesis at EPFL, Switzerland
  - PhD at ETH Zurich, Switzerland
  - Postdoctoral researcher at UC Berkeley, USA

About the Software Lab





- **My research group since 2014**
- **Focus: Tools and techniques for building reliable, efficient, and secure software**
  - Program analysis
  - Test generation
- **Thesis and job opportunities**

Plan for Today

1. Organization

2. Topic of this seminar

3. Recent research from the Software Lab

Why Have a Seminar?

- **Learn fundamentals of doing research**
  - Read and digest papers
  - Present complex ideas to others
  - Scientific writing
  - Reviewing
- **Learn about machine learning and program analysis**
  - Maybe your future thesis topic
  - Opportunities for HiWis

Organization

- **Today: Kick-off meeting**
- **January 14–18: One full-day meeting (or two half-day meetings)**
  - Talks by students
- **Your tasks:**
  - Term paper
  - Reviews
  - Talk
  - Active participation

Organization

- **Today: Kick-off meeting**
- **January 14–18: One full-day meeting (or two half-day meetings)**
  - Talks by students

- **Your tasks:** **Grading:**
  - Term paper ← 30%
  - Reviews ← 10%
  - Talk ← 40%
  - Active participation ← 20%

Talk

- **15 minutes + questions**
- **English**
- **Present a recent research paper**

- **Your mentor will help you prepare the presentation**
  - Send slides one week before the talk
  - Incorporate feedback given by the mentor

Talk: Some Advice

Content:

- **No need to explain all technical details**
- **But: Must contain some ”meat”**

Presentation:

- **Examples are your secret weapon**
- **Stick to the time limit**
- **Practice, practice, practice**

Pro tip: View video *How to give a good research talk* by Simon Peyton Jones

Talk: Rules

- **Prepare your own slides**
  - No copy & paste from existing slides, even if available
- **You may use examples from the paper**

Term Paper

- 6 pages
- English
- LaTeX template on course web site
- Summarize the paper in your own words
- Must be self-containing

Term Paper: Some Advice

- **Don’t waste space on basics**
- **Examples are your secret weapon (yes, again)**
- **Bad English distracts from good content**
- **Revise, revise, revise**

Term Paper: Rules

- **No verbatim copying of text**
  - Exception: Clearly marked, short quotes
- **You may copy figures (e.g., result graphs)**
- **You must use your own example(s)**

Reviews

- **Imitates peer reviewing process**
- **Each student reviews three term papers**
- **Revise your term paper after getting reviews**
  - Grade will be for final term paper

- **Plain text format**
- **About 1 page, English**

Reviews: Some Advice

- **Be constructive**
- **Be polite**
- **Your reviews contribute to your grade, not to the reviewee's grade**

Dates

- **Deadlines:**
  - Oct 21, 2018: Pick preferred topics
  - Nov 23: Term paper
  - Dec 7: Reviews
  - Dec 21: Revised term paper
  - 7 days before final meeting: Send slides to mentor
- **Optional (and recommended):**
  - Before Nov 23: Meet mentor to clarify questions about your topic

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Topic of This Seminar

Machine Learning for Programming

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Machine Learning for Programming

- Tools for improving software reliability and security
- E.g., program analyses to detect bugs, to complete partial code, or to de-obfuscate code

Topic of This Seminar

Machine Learning for Programming

- Source code as data
- Large code corpora to learn from
- Train models that predict program properties

What is Program Analysis?

- **Automated analysis of program behavior, e.g., to**
  - find programming errors
  - optimize performance
  - find security vulnerabilities

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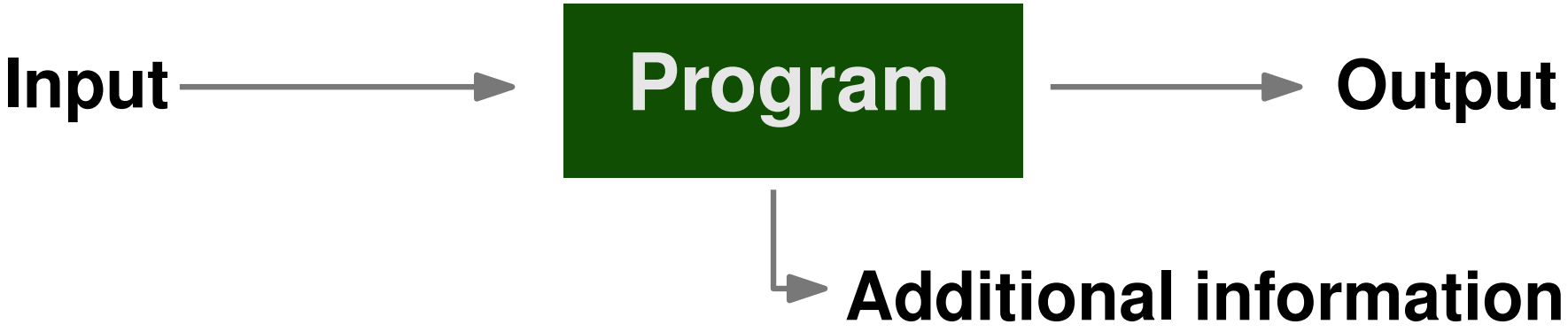

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Why Do We Need It?

Basis for various tools that make developers productive

- Compilers
- Bug finding tools
- Performance profilers
- Code completion
- Automated testing
- Code summarization/documentation

Traditional Approaches

- **Analysis has built-in knowledge about the problem to solve**
- **Significant human effort to create a program analysis**
  - Conceptual challenges
  - Implementation effort
- **Analyze a single program at a time**

Learning from Existing Data

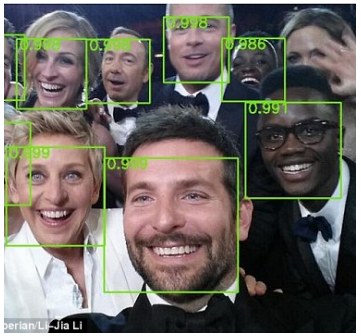
- **Huge amount of existing code ("big code")**
- **Programs are regular and repetitive**
- **Machine learning: Extract knowledge and apply in new contexts**
- **Learn how to ..**
  - .. complete partial code
  - .. use an API
  - .. fix programming errors
  - .. create inputs for testing

Deep Learning

Class of machine learning algorithms

- Neural network architectures
- ”Deep” = multiple layers
- Features and representation of inputs are extracted automatically

Revolutionizes entire areas



AlphaGo

Topics To Choose From

- **19 recently published research papers**
- **Submit your preferences by end of week**
  - You pick three topics, we assign one

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