Chair of Aerodynamics and Fluid Mechanics
Department of Mechanical Engineering
Technical University of Munich

Probabilistic Programming for Scientific Discovery

Lecture 1

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Lviv Data Science Summer School

July 29, 2020

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Course Outline

Example Applications of Probabilistic Programming

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- 4 Lectures
  1. Foundational Knowledge
  2. Inference Engines & Introduction to Turing.jl
  3. Hierarchical Bayesian Approaches & Bayesian Deep Learning
  4. The Connection to Scientific Problems
- 3 Tutorials for Self-Paced Consumption
  1. In-Depth Introduction to Probabilistic Programming Systems with Turing.jl
  2. Bayesian Approaches in Probabilistic Programming
     - Bayesian Deep Learning
     - Hierarchical Bayesian Modelling
  3. Machine-Learning Based Design with Probabilistic Programming

Lecture 1

- Example Applications of Probabilistic Programming
  1. *ETALUMIS: Bringing Probabilistic Programming to Scientific Simulators at Scale*
  2. *DreamCoder: Growing Generalizable, Interpretable Knowledge with Wake-Sleep Bayesian Program Learning*
- Why do we even need Probabilistic Programming?
- Underlying Theoretical Ideas
- Different Types of Probabilistic Programming Systems

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Lecture 2

- Approaches to Inference - the Inference Engine
- Practical Introduction to a Probabilistic Programming Framework
- Extending our learned ideas to a more complex example

Lecture 3

- Bayesian Hierarchical Approaches
- Bayesian Deep Learning, including but not limited to
  - Inference Networks
  - Uncertainty Quantification
- Marrying Deep Learning Frameworks with Probabilistic Programming for Type 2 Machine Learning

Lecture 4

- Interaction with Scientific Simulators
  - What types of simulators would I want to link to?
  - What are the hidden pitfalls?
- Areas of application
  - Robotics
  - Physics
  - Engineering
  - Machine-Learning Based Design
- Extensive Machine-Learning Based Design Example

Outline

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Example Applications of Probabilistic Programming

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