Nordic probabilistic AI school

Introduction to probabilistic programming languages (PPLs)

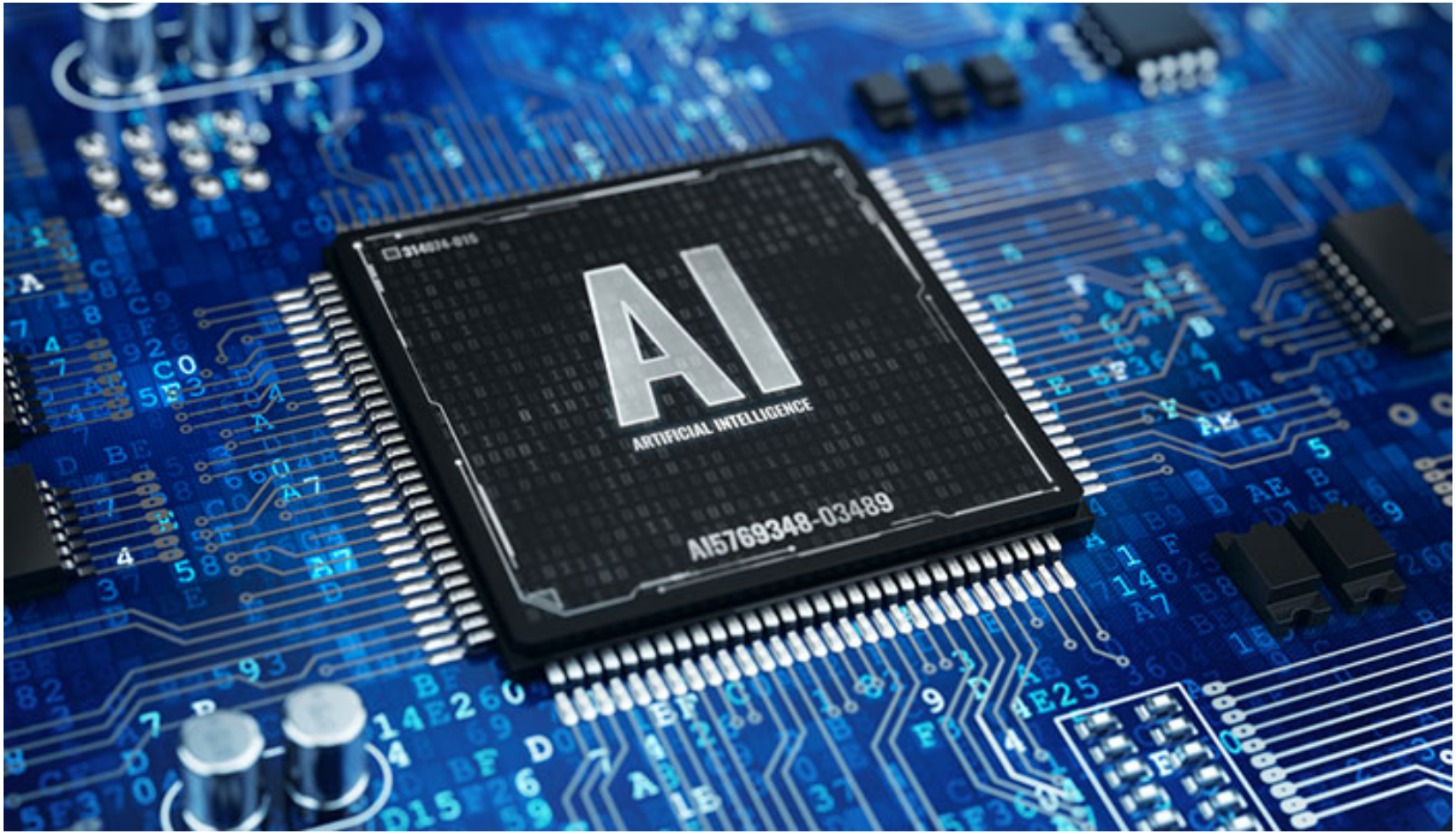
Andrés Masegosa, and Thomas Dyhre Nielsen

June 13, 2022

Plan

- **Day 1: Probabilistic programming**
  - Introduction to probabilistic programming
  - Probabilistic programming in Pyro
- **Day 2 (Before Lunch): Classical Variational Inference**
  - Introduction to Variational Inference
  - Mean-Field Approximation
  - Coordinate-ascent variational inference
- **Day 2 (After Lunch): Modern Variational Inference**
  - Black box variational inference
  - Variational inference in Pyro
- **Day 2 (Evening): Modern Variational Inference**
  - Variational AutoEncoders
  - Amortized Inference

Machine Learning Systems



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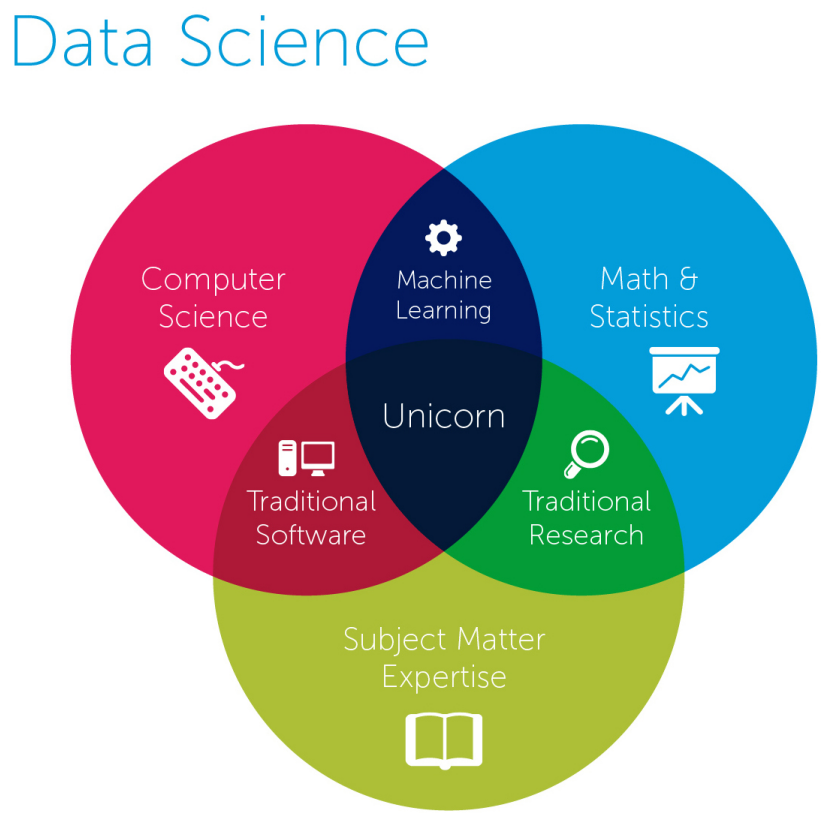

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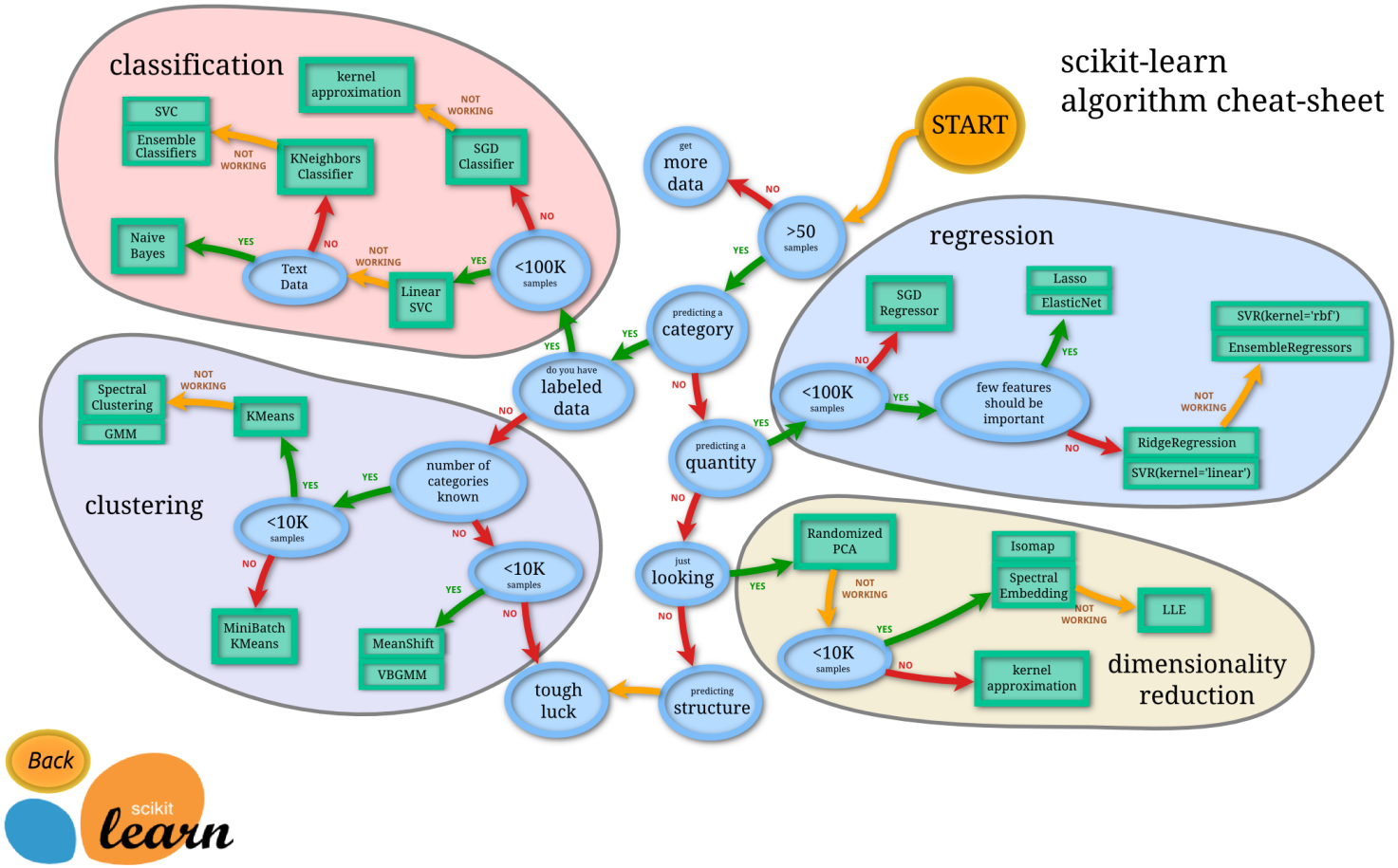
- **It requires of highly qualified experts.**



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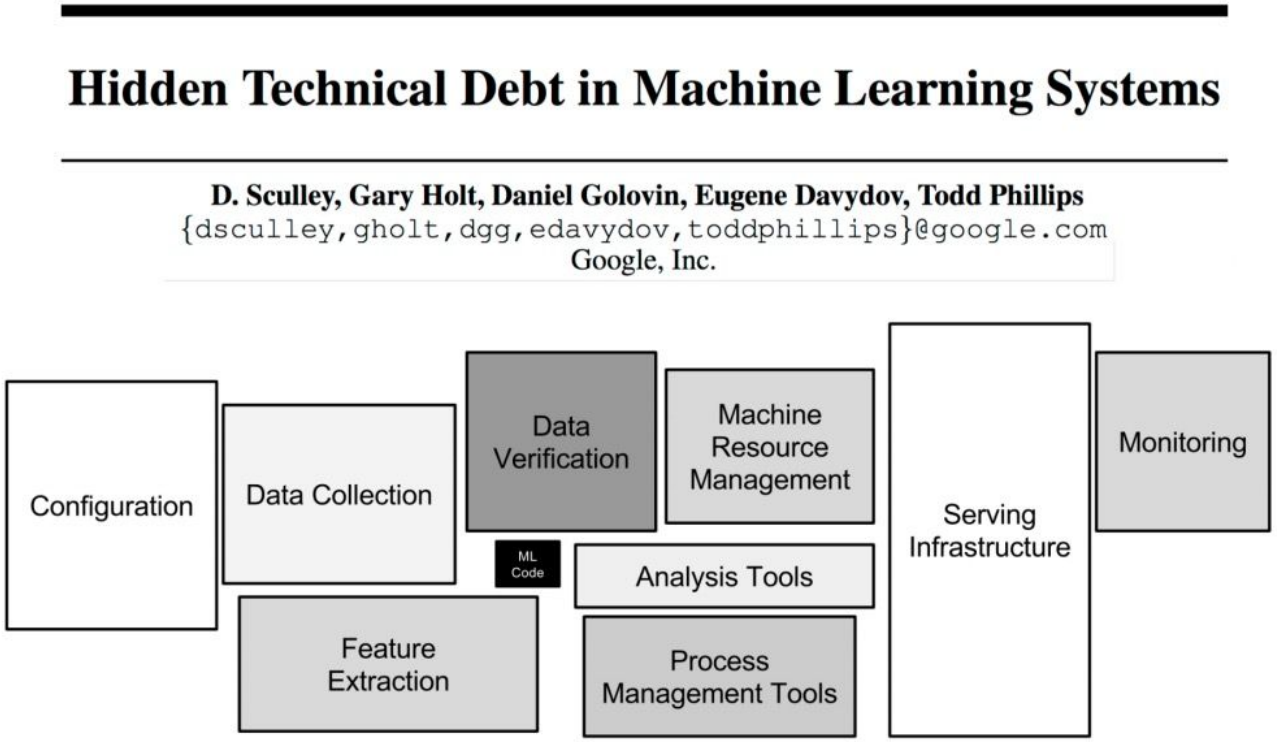
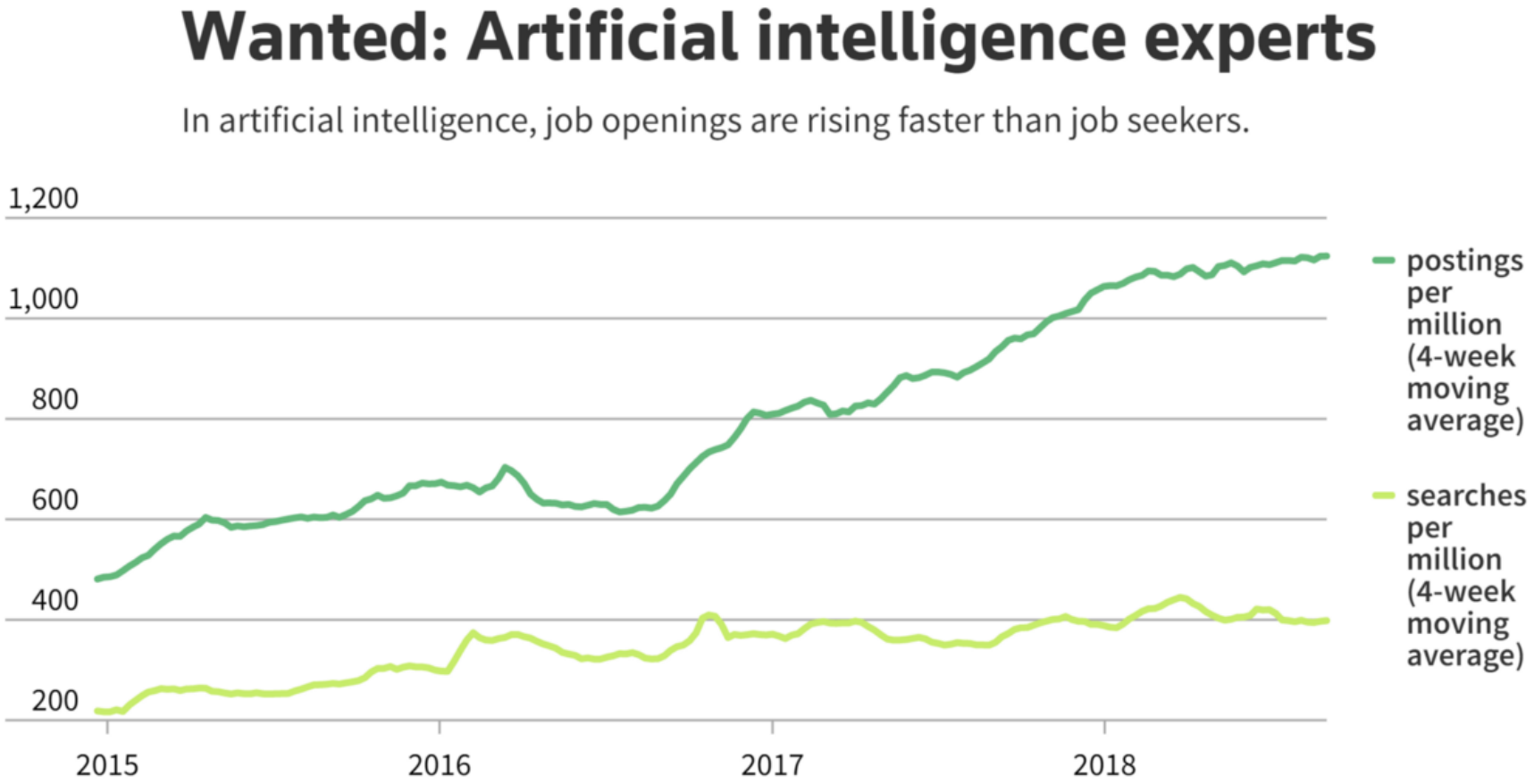
- It is necessary to have highly qualified experts.
- **It is difficult to find the ML model most suitable for an application.**



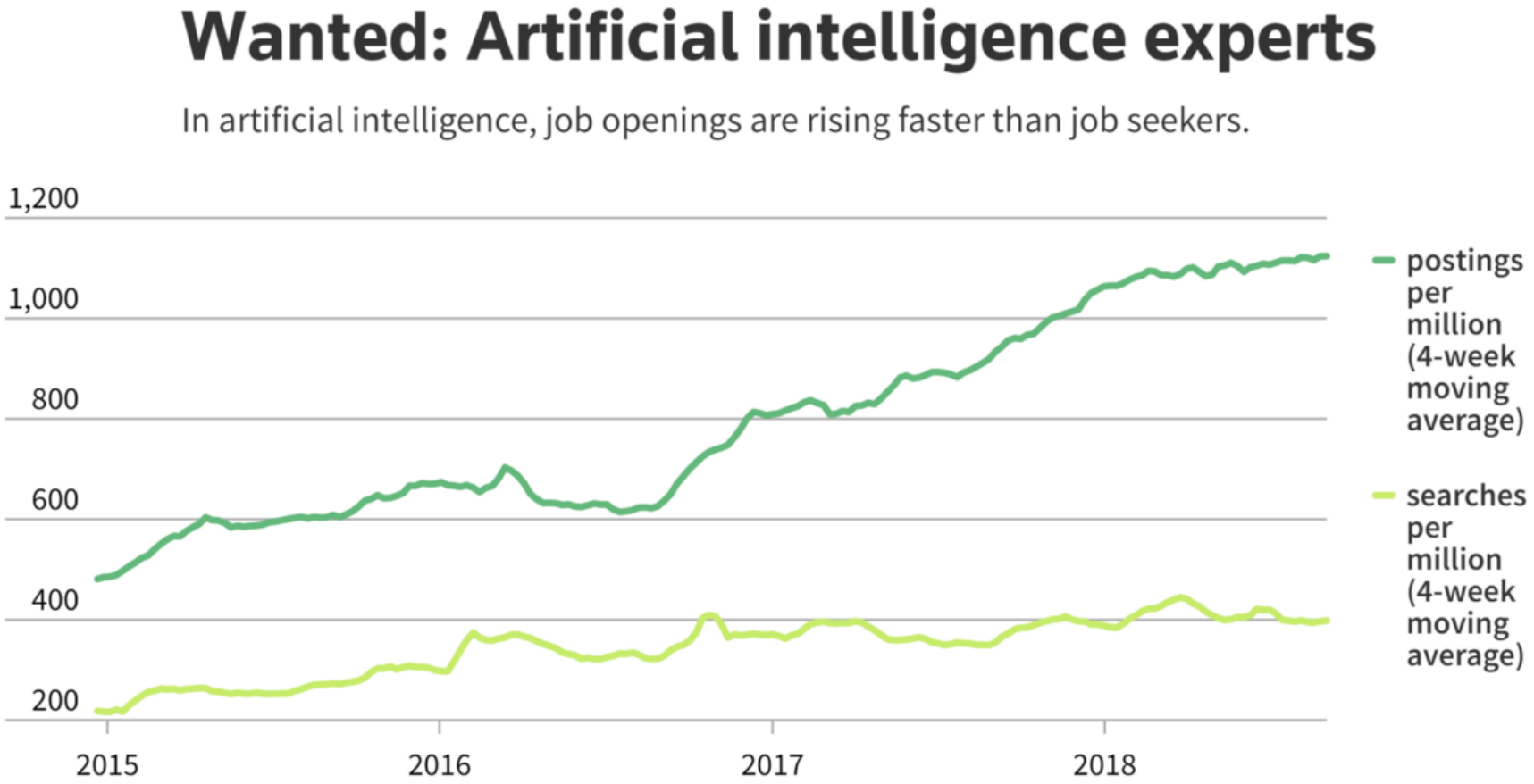
The development of machine learning applications requires enormous effort.

- It is necessary to have highly qualified experts.
- It is difficult to find the ML model most suitable for an application.
- **Programming a ML model is a complex task where many problems are intermingled**.



Consequences:

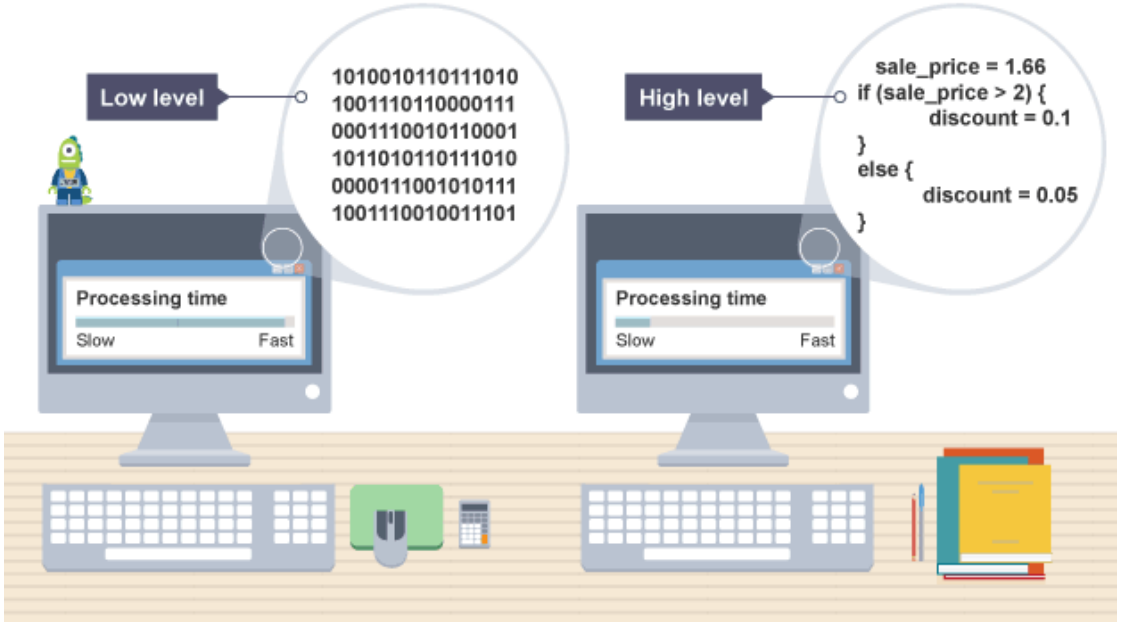
- Shortage of AI experts (and high salaries).



Consequences:

- Shortage of AI experts (and high salaries).
- Only big corporations have the resources for developing ML systems.

Programming Languages



Similar situation than 50 years ago:

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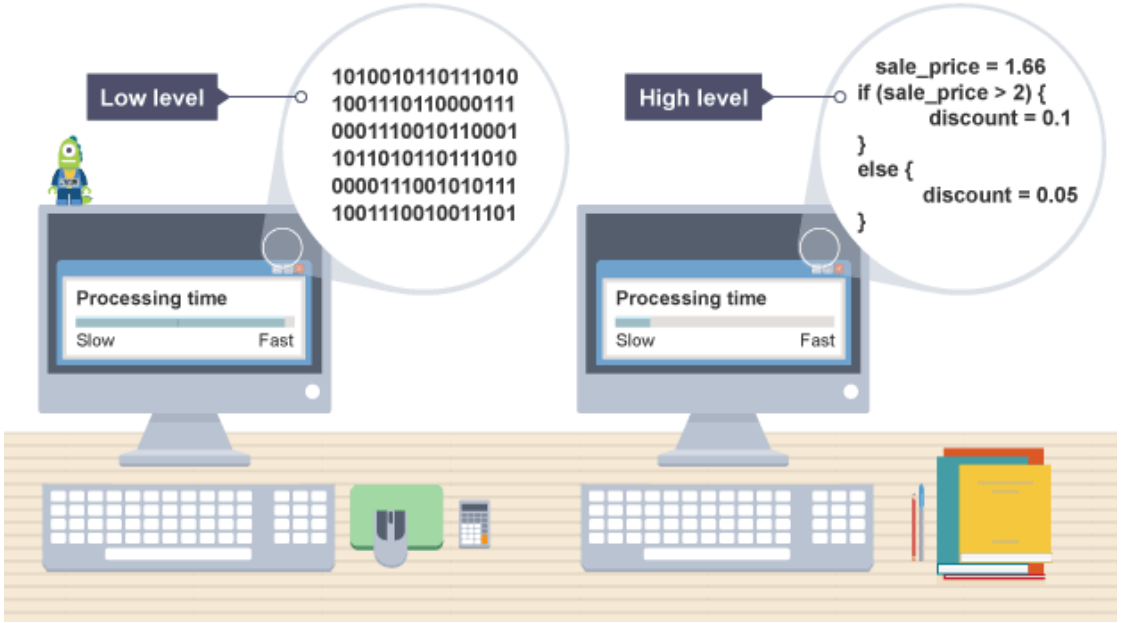

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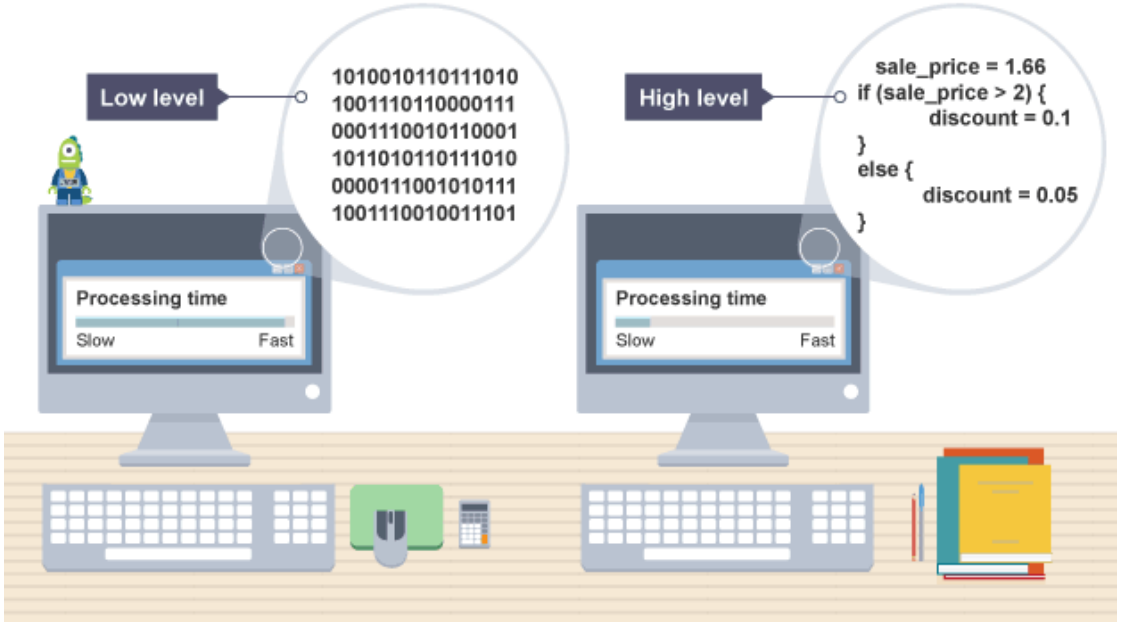

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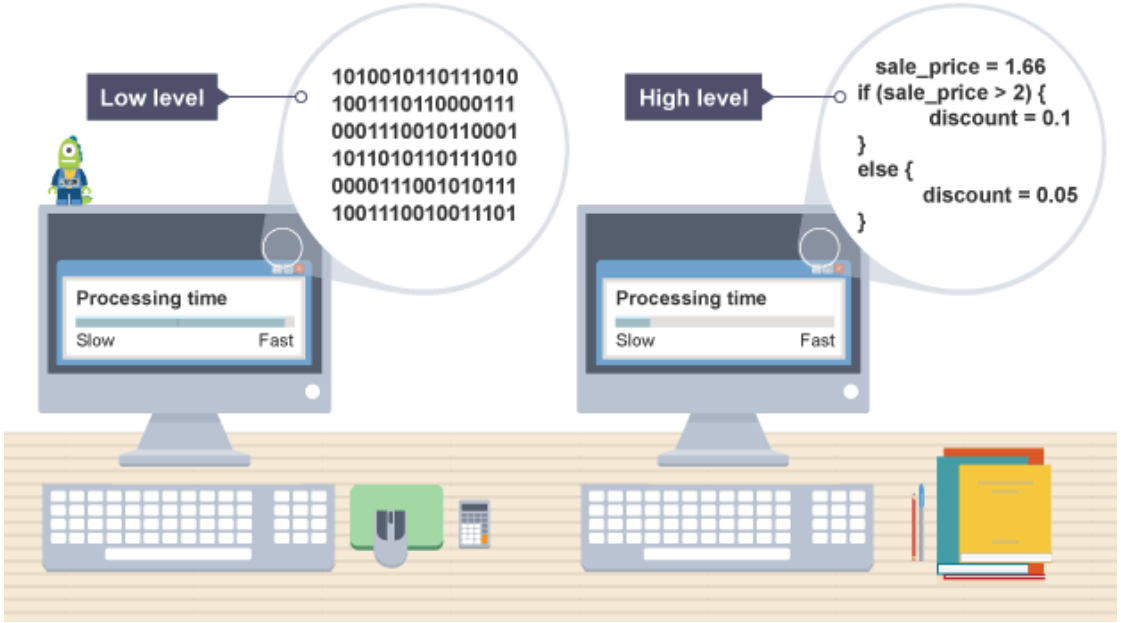

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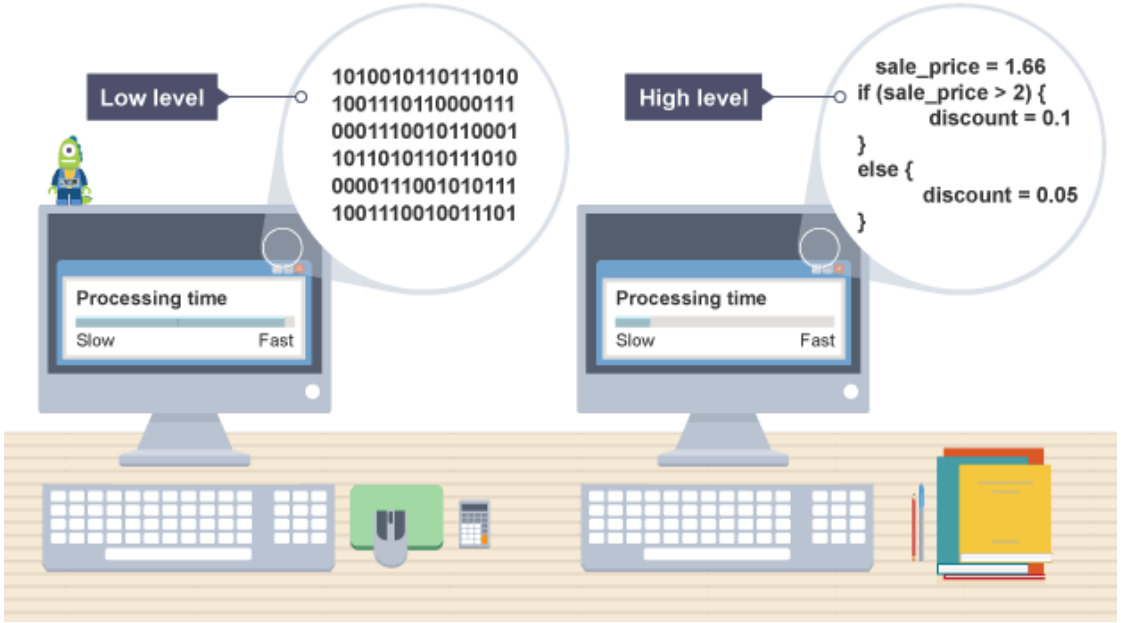
- People used to program in low-level programming languages.
- Programming was complex and demand high-expertise.
- Focus on application and low-level hardware details.

Programming Languages



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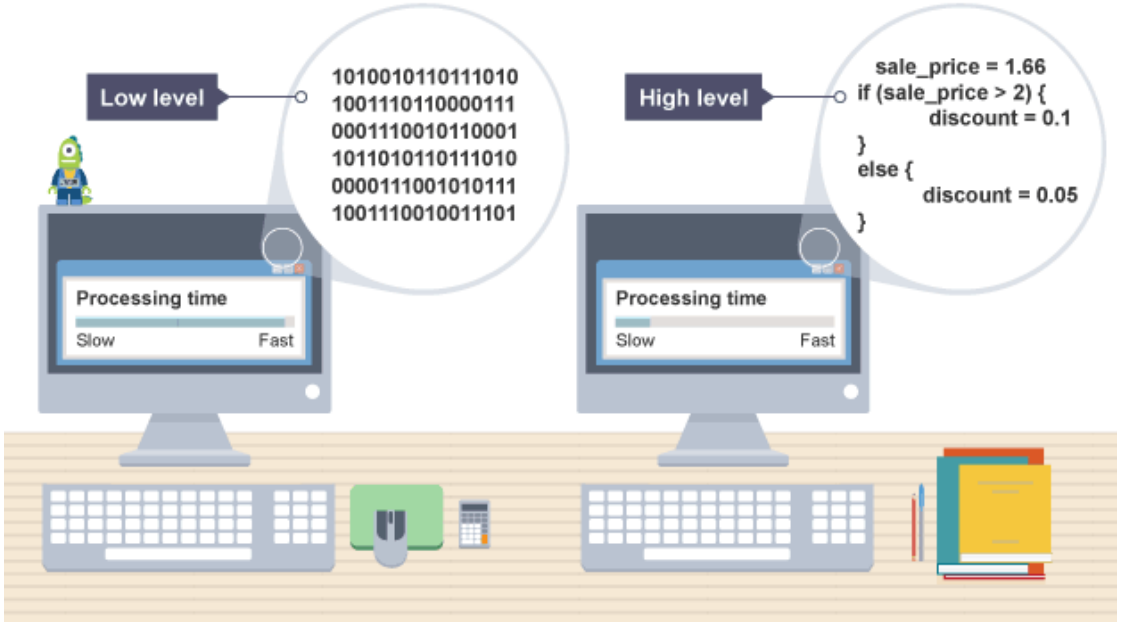

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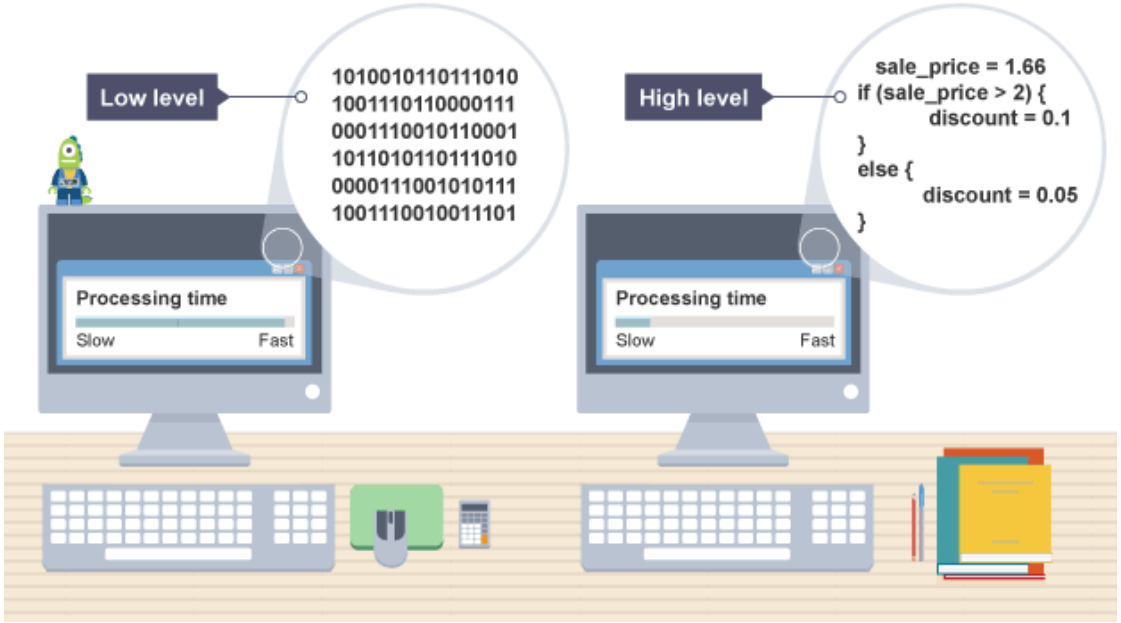

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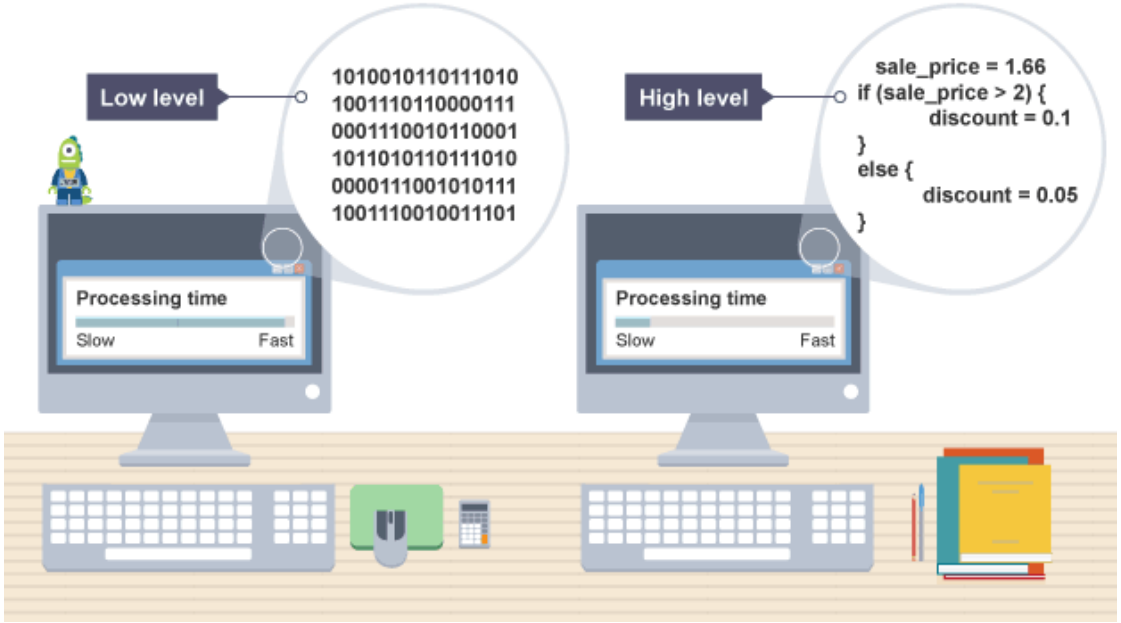

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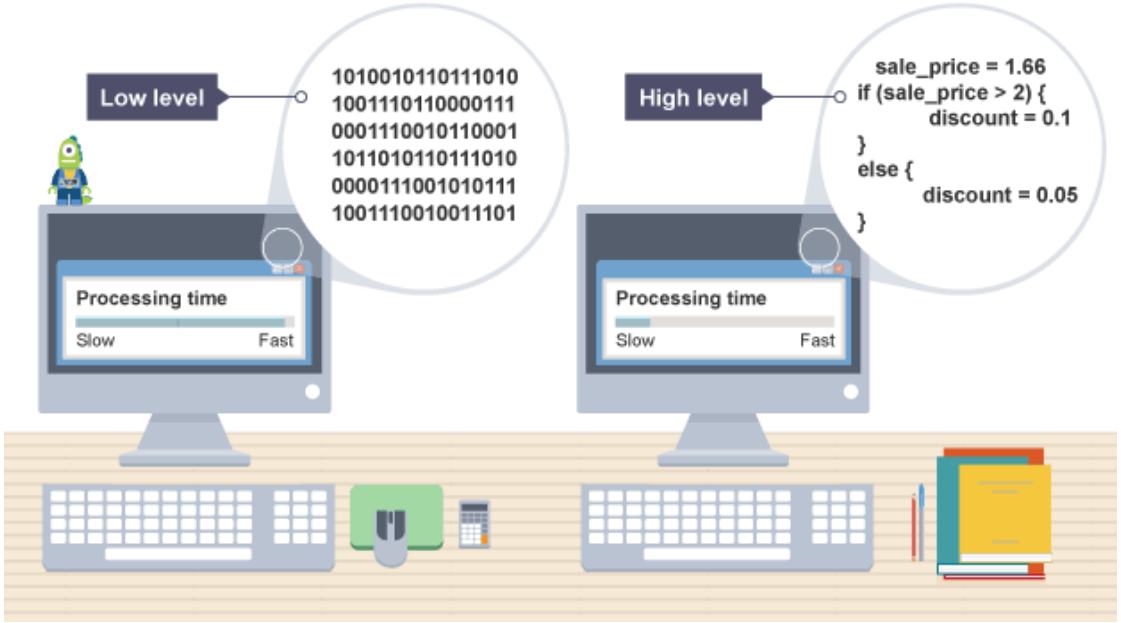

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- Programmers focused on the applications.
- Hardware Experts focused on compilers.
- High gains in productivity.
- “Democratization” of the software development.

Big Data and Machine Learning Ecosystem

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Big Data and Machine Learning Libraries:

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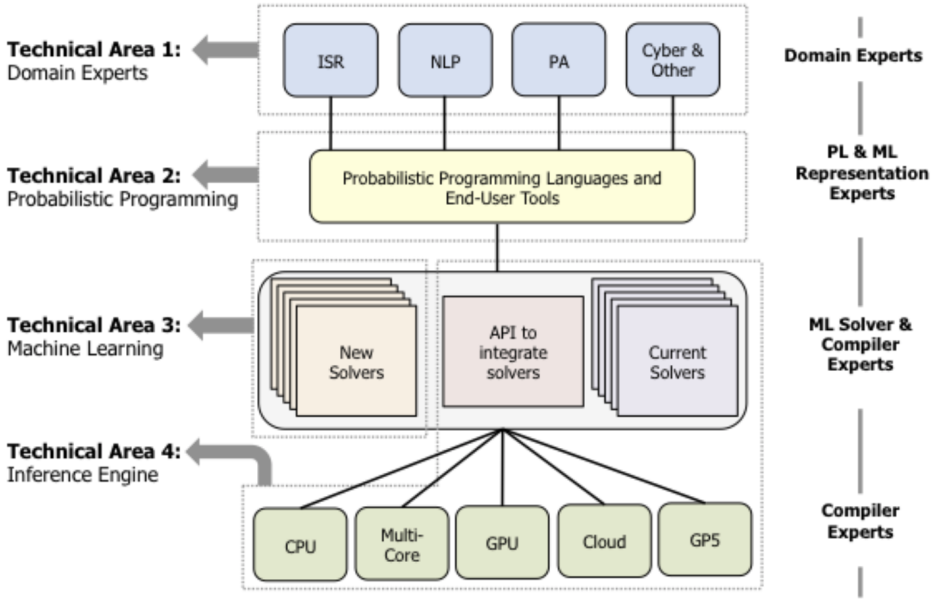
- Increase the **adoption** of these technologies.

What about in Probabilistic AI?

Which are the "high-level libraries" in Probabilistic AI?

Why PPLs?



PPLs as high-level programming languages for **probabilistic machine learning systems**:

- Stacked architecture

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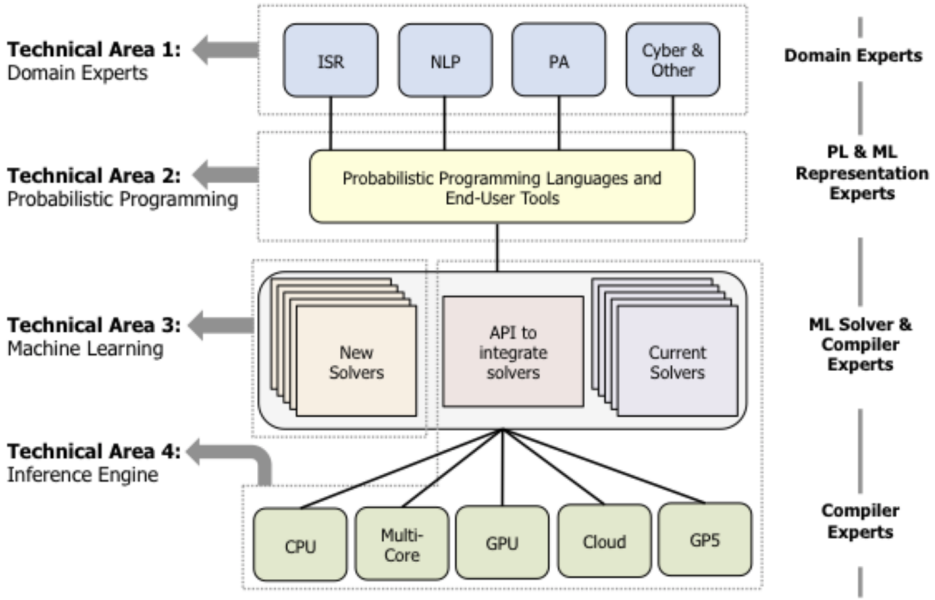

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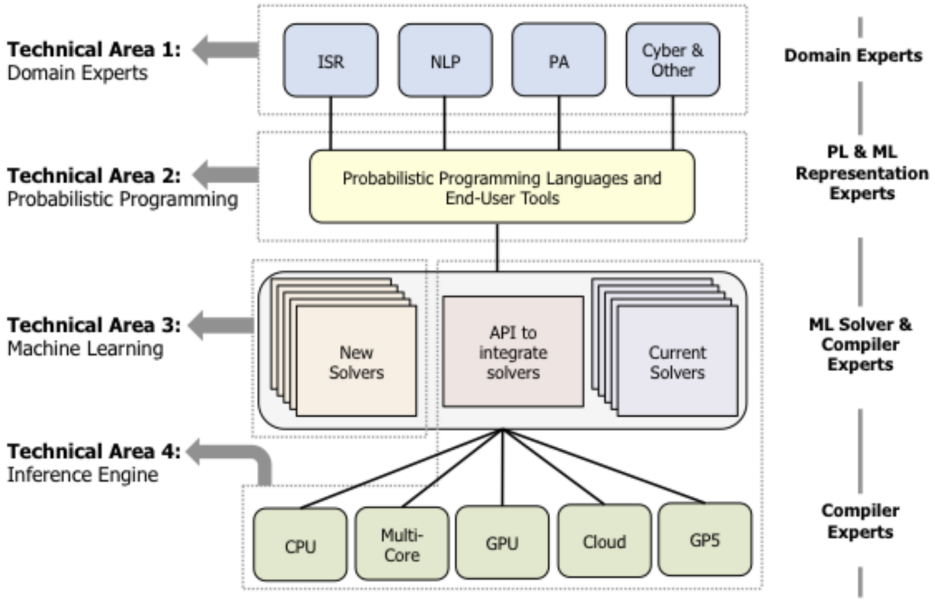

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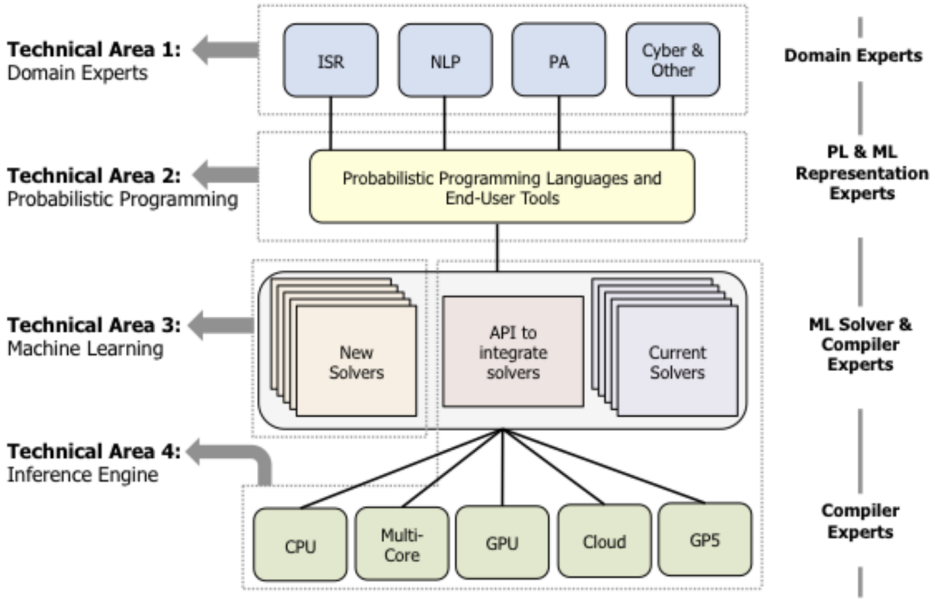

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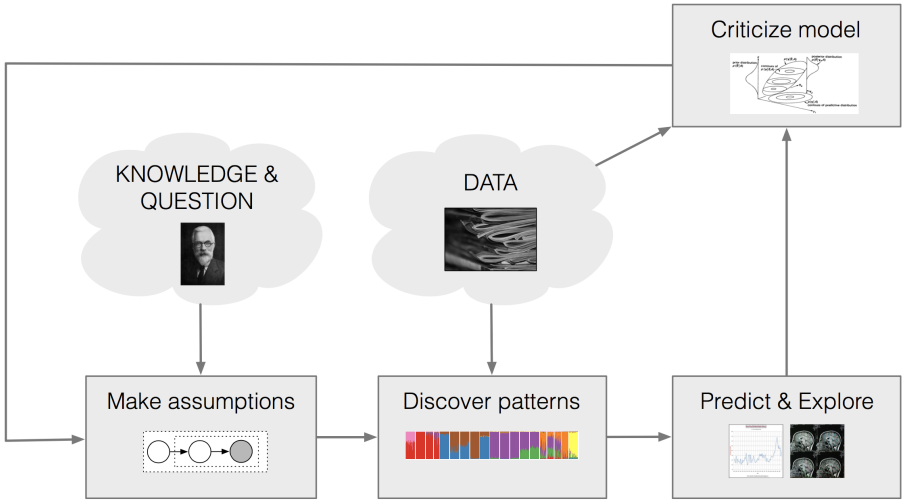
- Compile experts will focus on running these ML solvers on specialized hardware.

Box's Loop



[Box, 1980; Rubin, 1984; Gelman+ 1996; Blei, 2014]

Benefits of PPLs for developing probabilistic machine learning systems:

- Simplify probabilistic machine learning model code.

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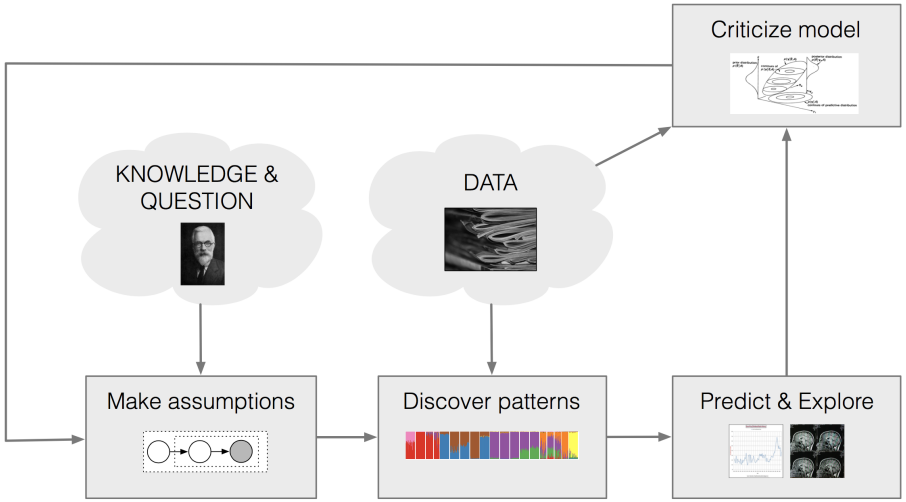

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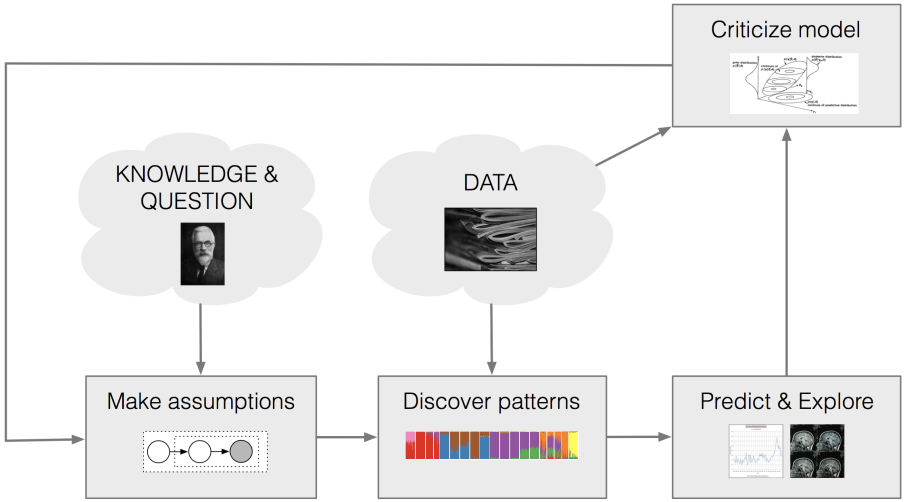

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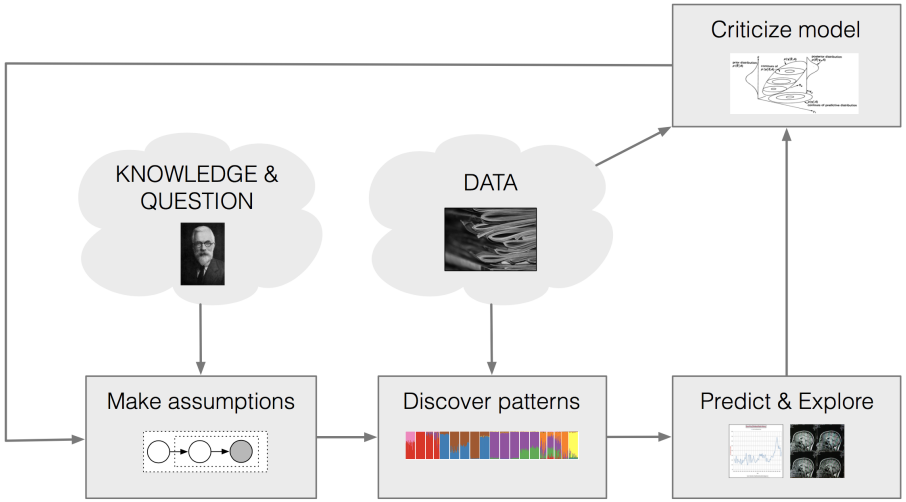

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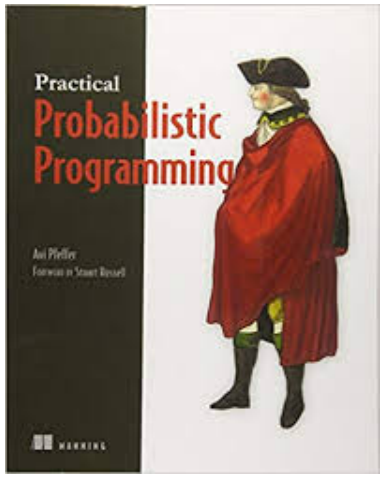
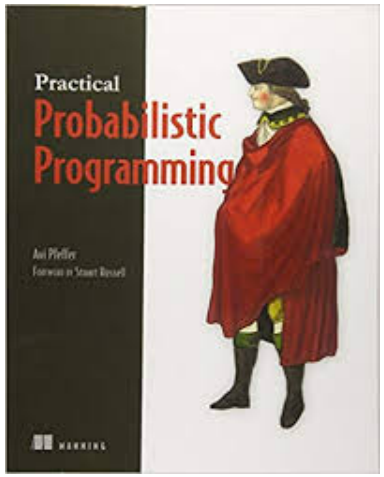


1st Generation of PPLs :

- Bugs, WinBugs, Jags, Figaro, etc.



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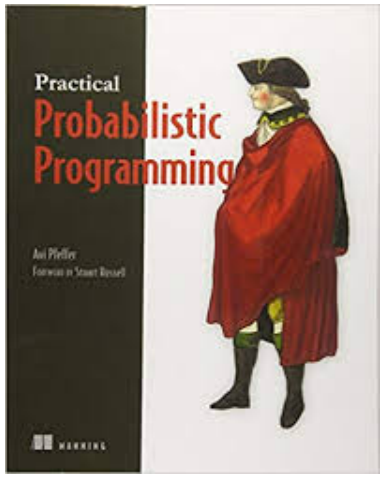

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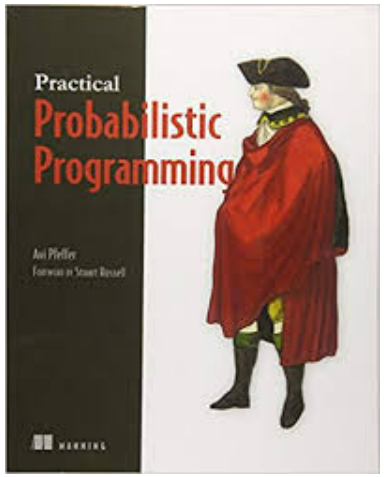

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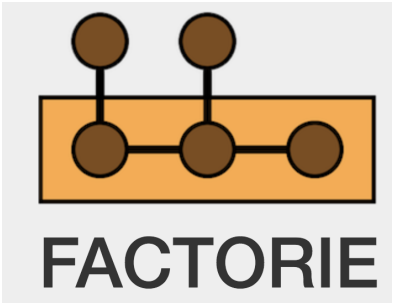

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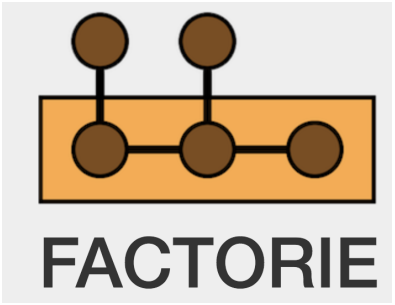

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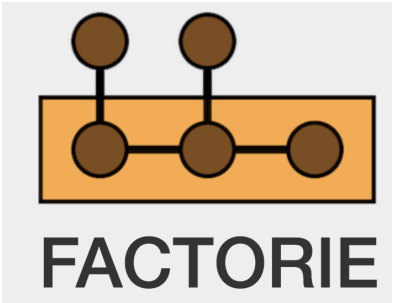

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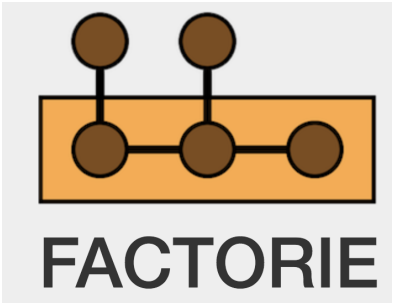

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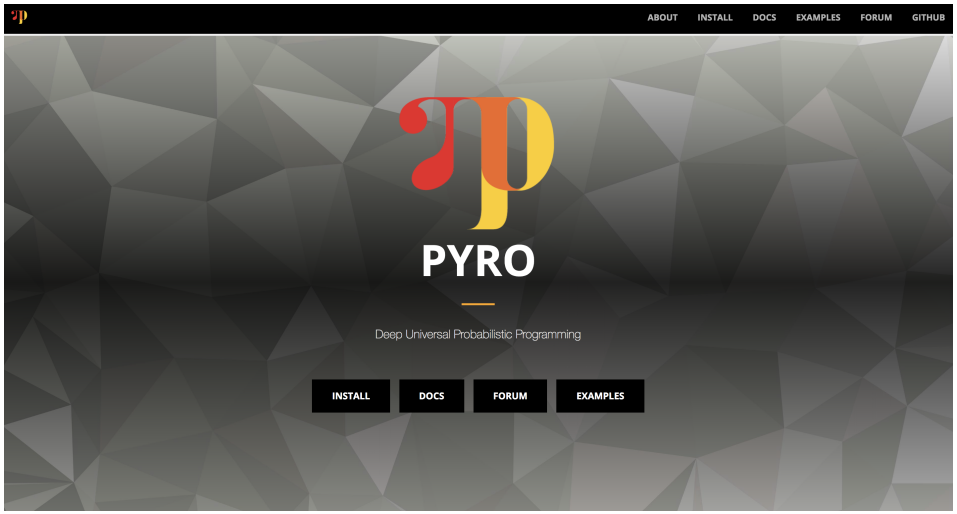
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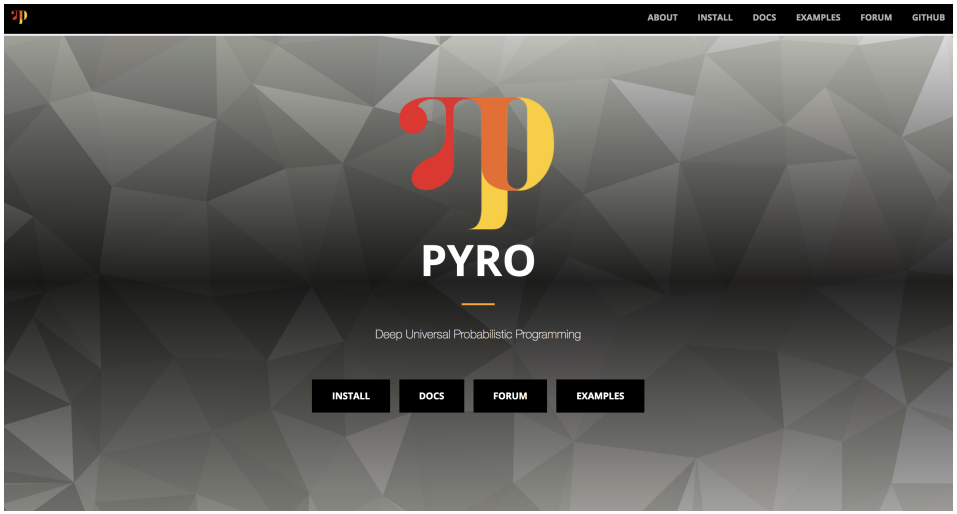

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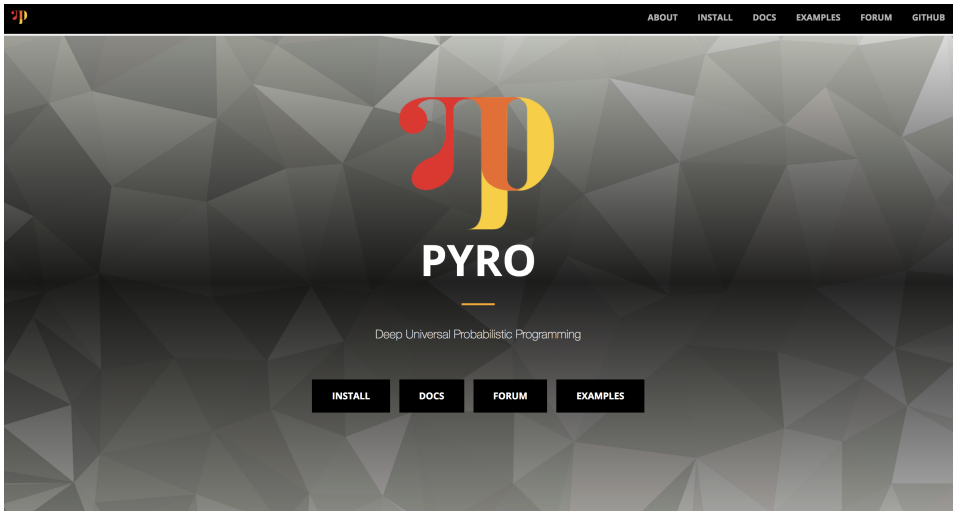

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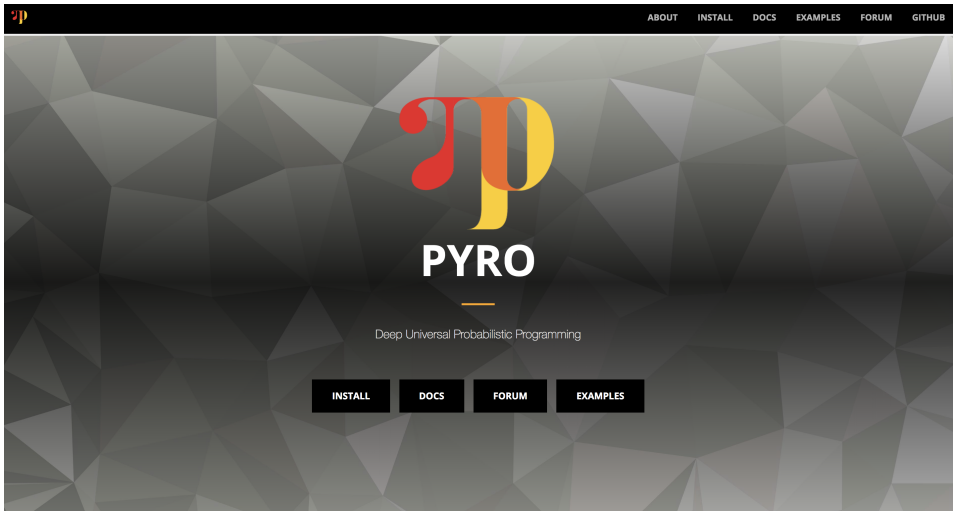

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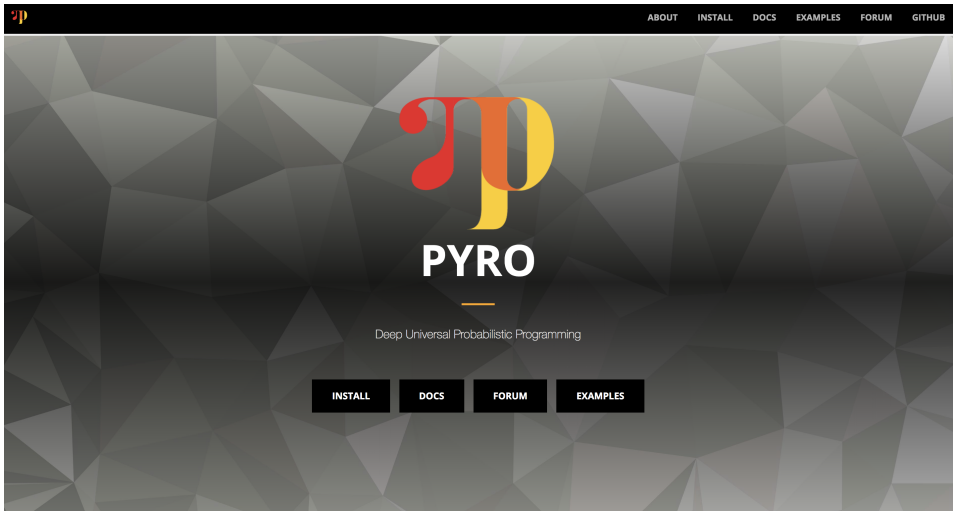

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