

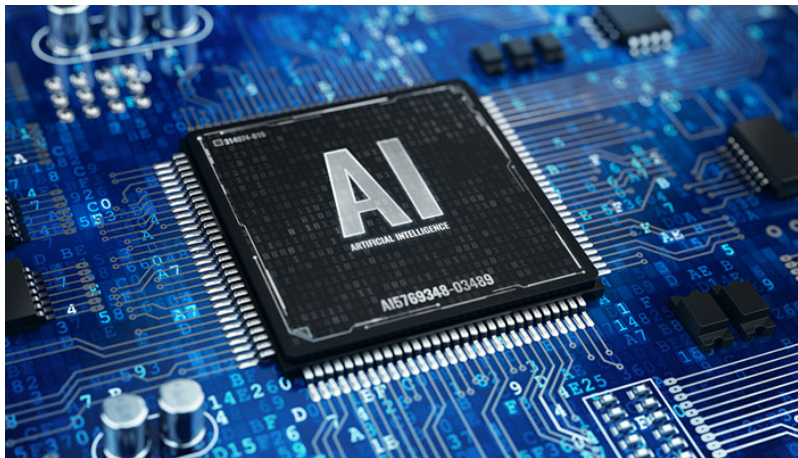
Nordic probabilistic AI school

Introduction to probabilistic programming languages (PPLs)

Andrés Masegosa, and Thomas Dyhre Nielsen

June 13, 2022

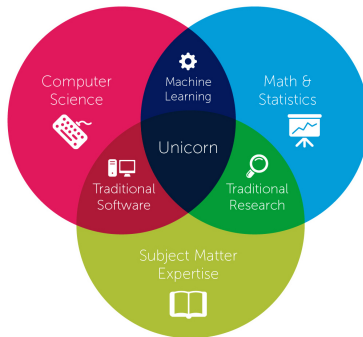
- **Day 1: Probabilistic programming**
 - Introduction to probabilistic programming
 - Probabilistic programming in Pyro
- **Day 2 (Before Lunch): Classical Variational Inference**
 - Introduction to Variational Inference
 - Mean-Field Approximation
 - Coordinate-ascent variational inference
- **Day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



The development of **machine learning systems** requires enormous efforts.



Data Science



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The development of **machine learning systems** requires enormous efforts.

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

Machine Learning Systems

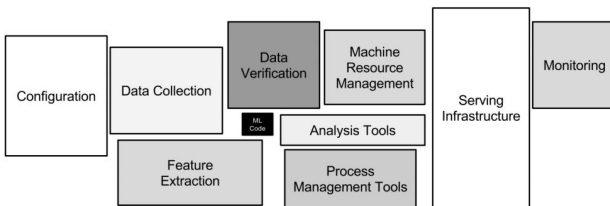


The development of machine learning systems requires enormous effort.

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

Hidden Technical Debt in Machine Learning Systems

D. Sculley, Gary Holt, Daniel Golovin, Eugene Davydov, Todd Phillips
{dsculley, gholt, dgg, edavydov, toddphillips}@google.com
Google, Inc.

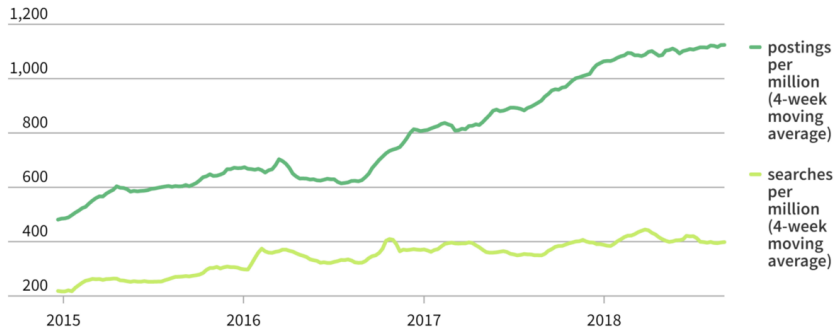


The development of machine learning applications requires enormous effort.

- 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.**

Wanted: Artificial intelligence experts

In artificial intelligence, job openings are rising faster than job seekers.

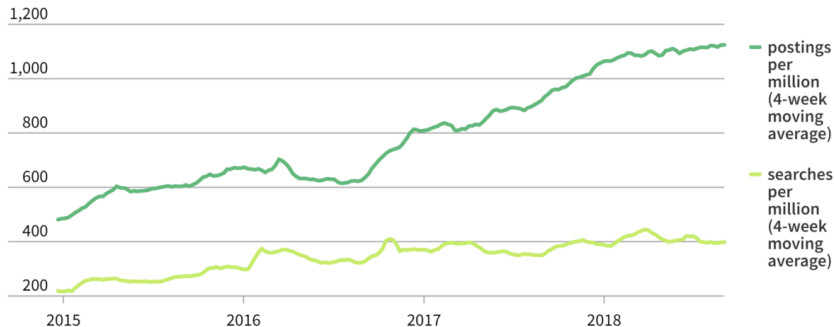


Consequences:

- Shortage of AI experts (and high salaries).

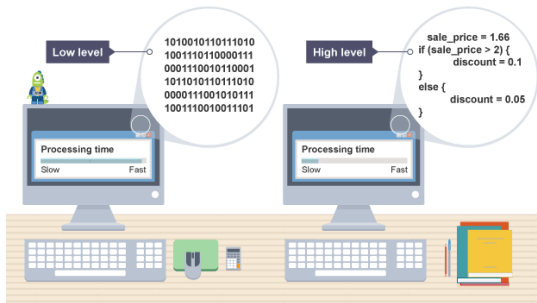
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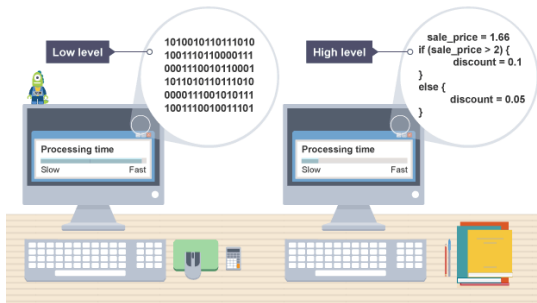


Consequences:

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

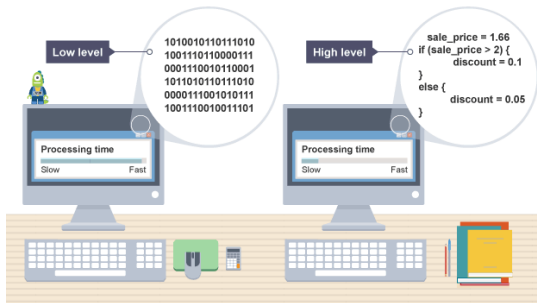


Similar situation than 50 years ago:



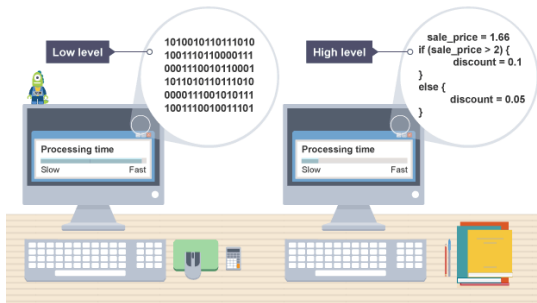
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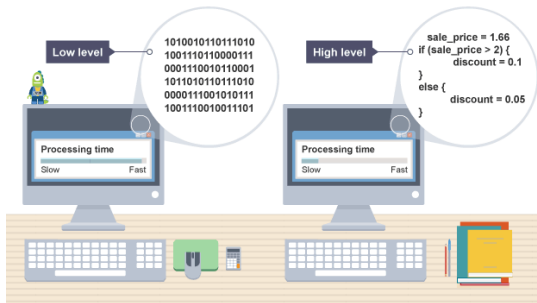
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- Programming was complex and demand high-expertise.



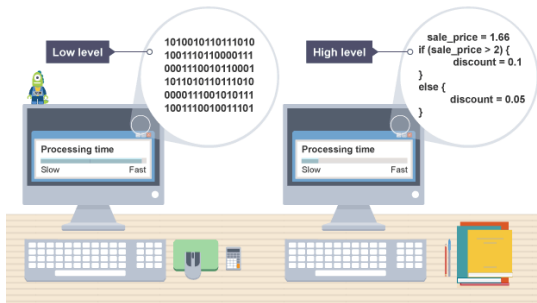
Similar situation than 50 years ago:

- 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

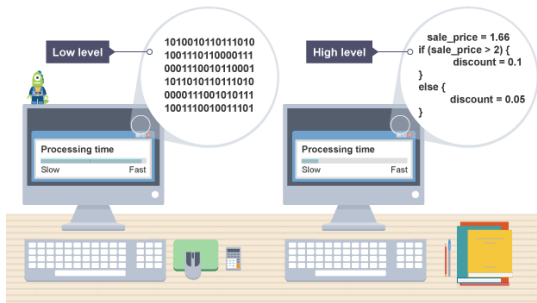


High-level programming languages brought many advantages:



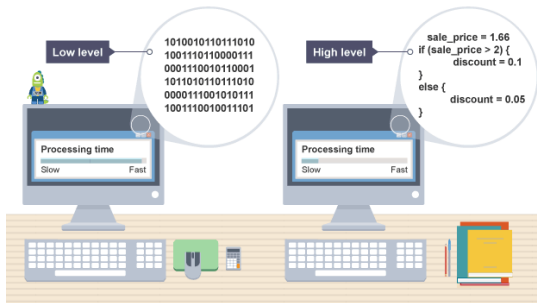
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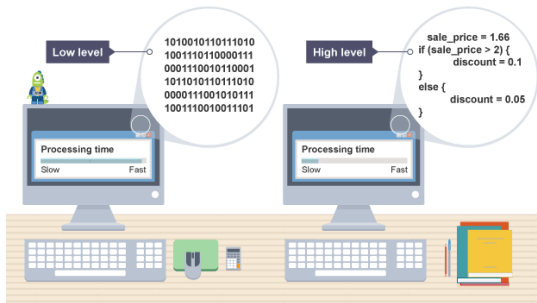
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- Programmers focused on the applications.
- Hardware Experts focused on compilers.
- High gains in productivity.
- “Democratization” of the software development.



Claire D. Costa. Best Python Libraries for Machine Learning and Deep Learning.

<https://towardsdatascience.com/best-python-libraries-for-machine-learning-and-deep-learning-b0bd40c7e8c>

Big Data and Machine Learning Libraries:

- **High-quality**, well-maintained and open-source libraries



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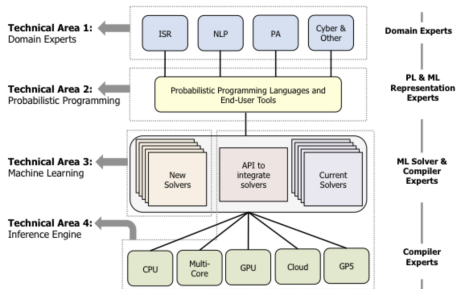
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Big Data and Machine Learning Libraries:

- **High-quality**, well-maintained and open-source libraries
- They try to provide **high-level abstractions**.
- Hiding under the hood **low level details**.
- Increase the **adoption** of these technologies.

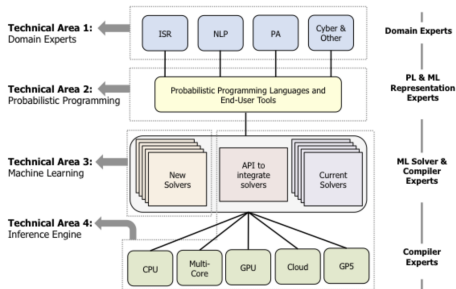
Which are the "high-level libraries" in Probabilistic AI?

Why PPLs?



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

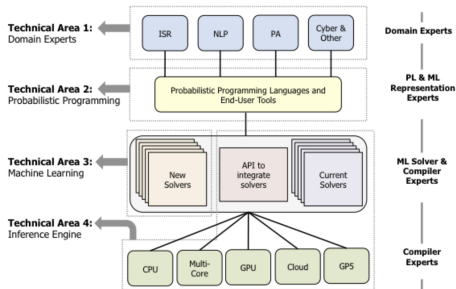
- Stacked architecture



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

- Stacked architecture
- Different Domain Experts will code their models using the same language.

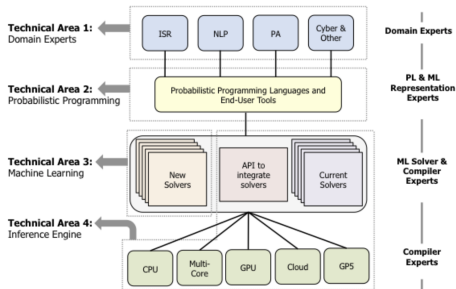
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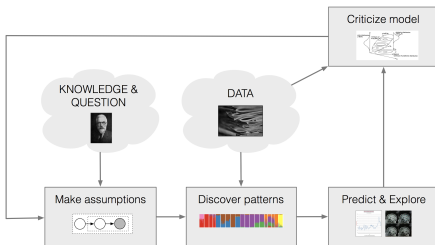
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PPLs as high-level programming languages for **probabilistic machine learning systems**:

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

Box's Loop

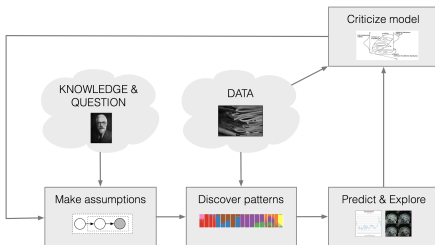


[Box, 1980; Rubin, 1984; Gelman+ 1996; Blei, 2014]

Benefits of PPLs for developing probabilistic machine learning systems:

- Simplify probabilistic machine learning model code.

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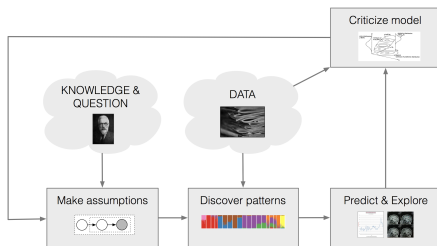


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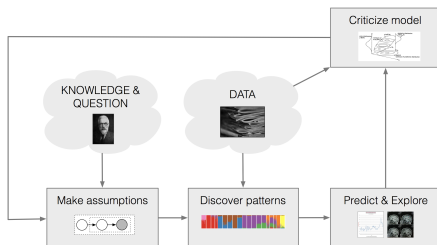


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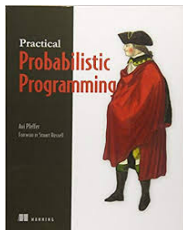
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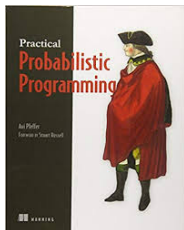
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- “Democratization” of the development of probabilistic ML systems.



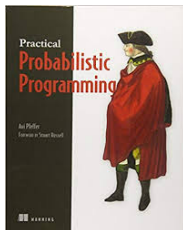
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- Bugs, WinBugs, Jags, Figaro, etc.



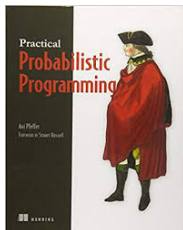
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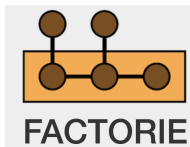
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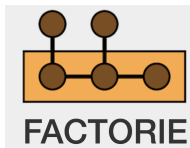
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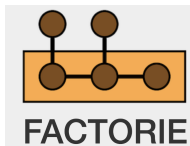
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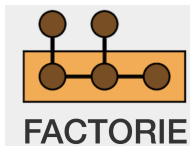
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- Restricted probabilistic model family (i.e. factor graphs, conjugate exponential family, etc.)



PYMC3



3rd Generation of PPLs :

- TensorFlow Probability, Pyro, PyMC3, InferPy, etc.



PYMC3



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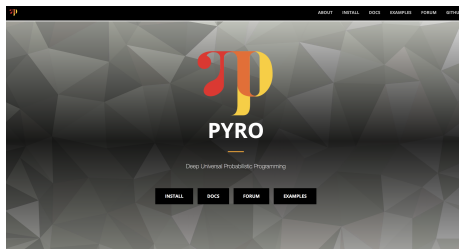


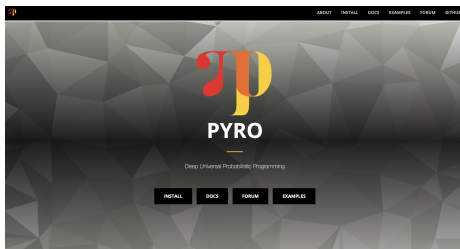
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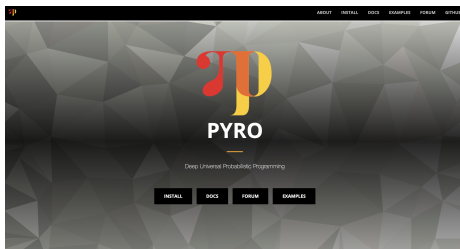
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 - Automatic differentiation methods.





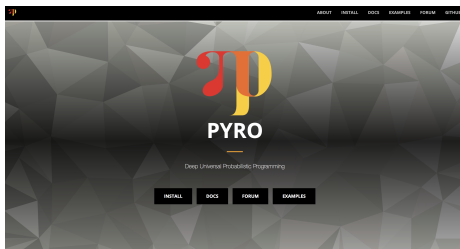
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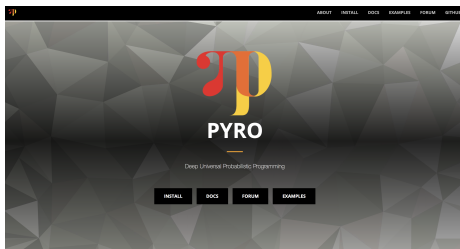
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<https://github.com/PGM-Lab/2022-ProbAI>