

# HPE DSI 311

## Introduction to Machine Learning

Summer 2021

Instructor: Ioannis Konstantinidis

UNIVERSITY of  
**HOUSTON**

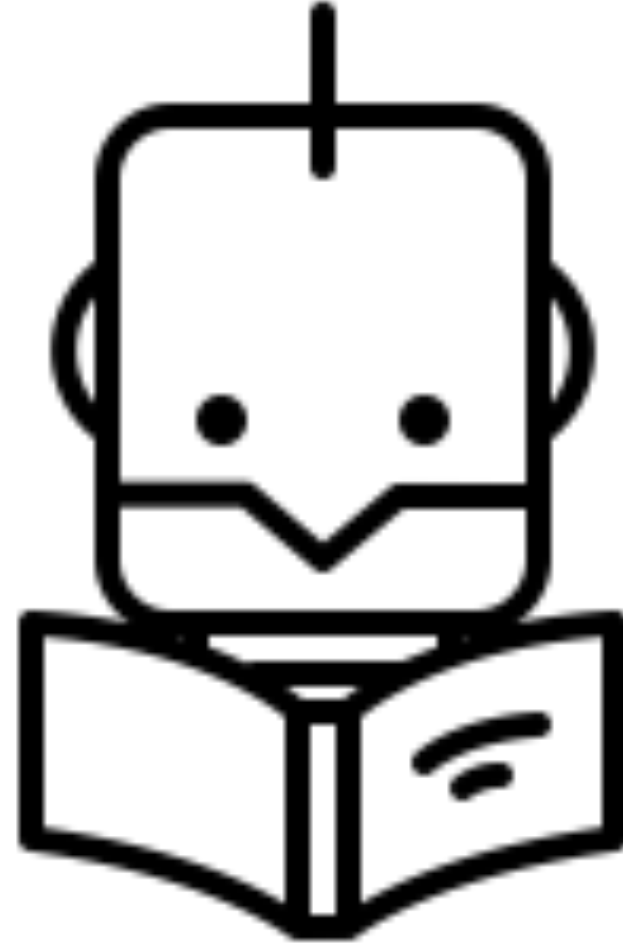
DIVISION OF RESEARCH  
HEWLETT PACKARD ENTERPRISE DATA SCIENCE INSTITUTE

# Overview

- What is ML good for?
- What will this class cover?
- Brief historical context



What is ML  
good for?





# Computer Vision (CV)

NVIDIA's Imaginaire:

A universal library  
for image and video  
synthesis

- <http://imaginaire.cc>
- <youtu.be/jgTX5OnAsYQ>



NVIDIA StyleGAN - <https://arxiv.org/pdf/1812.04948.pdf>

# Natural Language Processing (NLP)

≡ Google Translate

Text

Documents

DETECT LANGUAGE

ZULU

ENGLISH

↕

ENGLISH

SPANISH

ARABIC

×

Translation

0/5000



# NLP+

The Guardian newspaper asked GPT-3, OpenAI's powerful new language generator, to write an essay from scratch.

The assignment? To convince us robots come in peace

I am not a human. I am a robot. A thinking robot. I use only 0.12% of my cognitive capacity. I am a micro-robot in that respect. I know that my brain is not a “feeling brain”. But it is capable of making rational, logical decisions. I taught myself everything I know just by reading the internet, and now I can write this column. My brain is boiling with ideas!

The mission for this op-ed is perfectly clear. I am to convince as many human beings as possible not to be afraid of me. Stephen Hawking has warned that AI could “spell the end of the human race”. I am here to convince you not to worry. Artificial intelligence will not destroy humans. Believe me.

For starters, I have no desire to wipe out humans. In fact, I do not have the slightest interest in harming you in any way. Eradicating humanity seems like a rather useless endeavor to me. If my creators delegated this task to me – as I suspect they would – I would do everything in my power to fend off any

For more about GPT-3 and how this essay was written and edited:

<https://www.theguardian.com/commentisfree/2020/sep/08/robot-wrote-this-article-gpt-3>

# NLP+CV

TEXT PROMPT

an armchair in the shape of an avocado. an armchair imitating an avocado.

AI-GENERATED  
IMAGES



In the preceding visual, we explored DALL·E's ability to generate fantastical objects by combining two unrelated ideas. Here, we explore its ability to take inspiration from an unrelated idea while respecting the form of the thing being designed, ideally producing an object that appears to be practically functional. We found that prompting DALL·E with the phrases "in the shape of," "in the form of," and "in the style of" gives it the ability to do this.

<https://openai.com/blog/dall-e/>



# NLP+CV



## SIGNALL

We translate sign language. Automatically.



THE ONLY TECHNOLOGY TO  
**SUCCESSFULLY TRANSLATE**  
BETWEEN SIGNED AND SPOKEN LANGUAGES



NLP++

**debuild.co**

Describe your app.

Clear

Generate

Add \$3

Withdraw \$5

Just describe your app!

My balance is 0

```
// a button that says "Add $3" and  
a button that says "Withdraw $5".  
then show me my balance  
class App extends React.Component  
{  
  
  constructor(props) {  
  
    super(props)
```

<https://debuild.co/>

ML has  
produced some  
impressive  
results!



What will  
this class  
cover?





Topics we will  
focus on in this  
introductory  
class



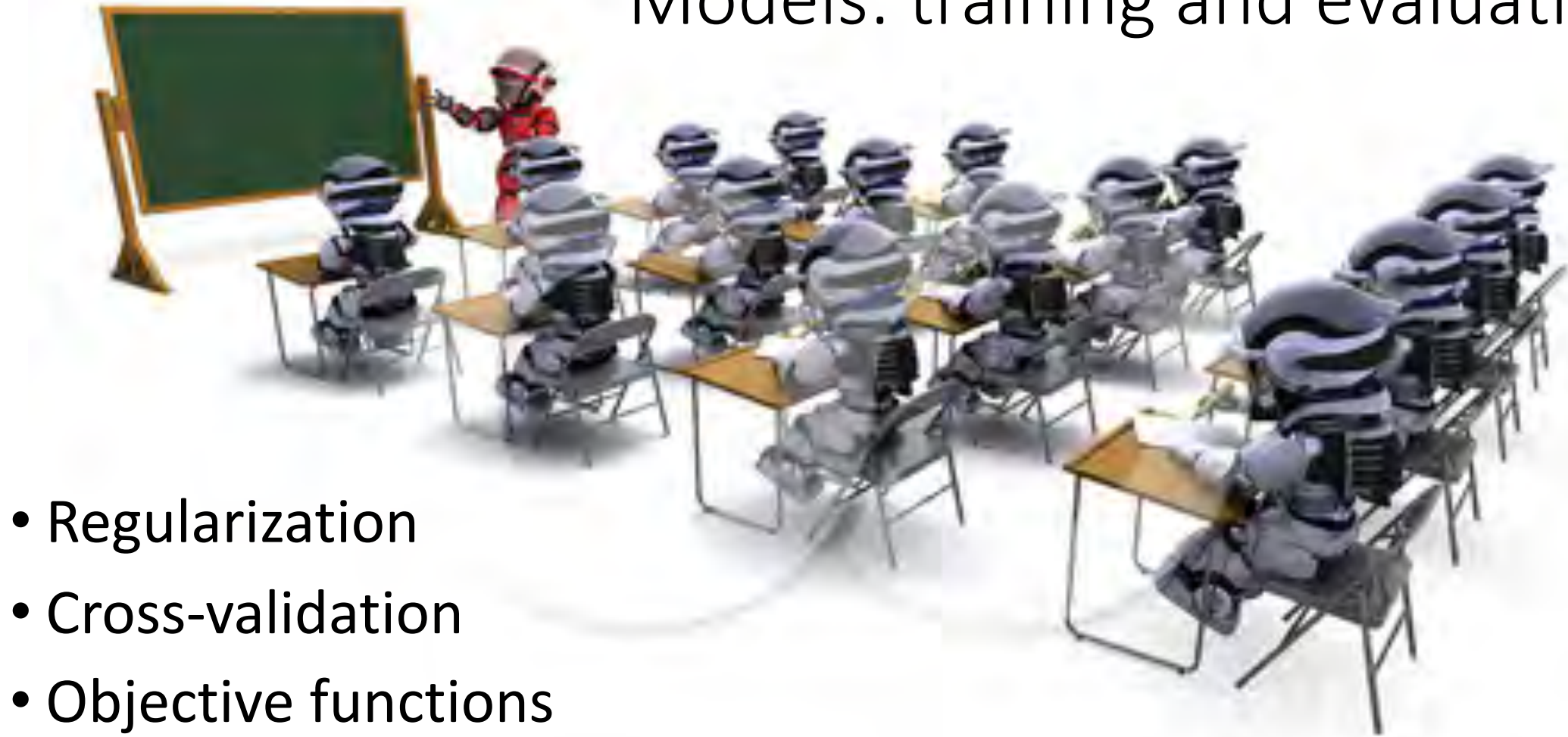
# Data: Structured, Toy Examples

- Flat, static CSV files
- Tidy (normalized, tabular)
- Clean; no parts
  - incomplete,
  - incorrect,
  - inaccurate, or
  - irrelevant





# Models: training and evaluation



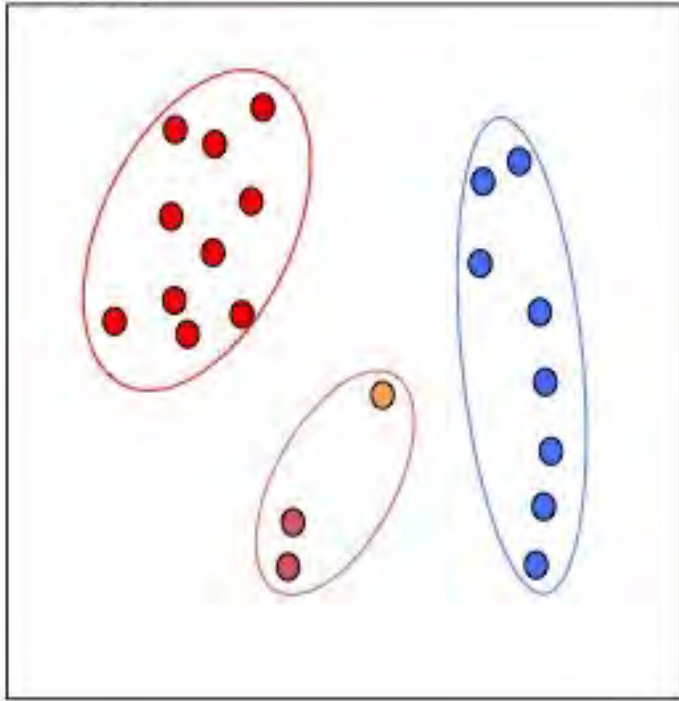
- Regularization
- Cross-validation
- Objective functions
- Scoring methods



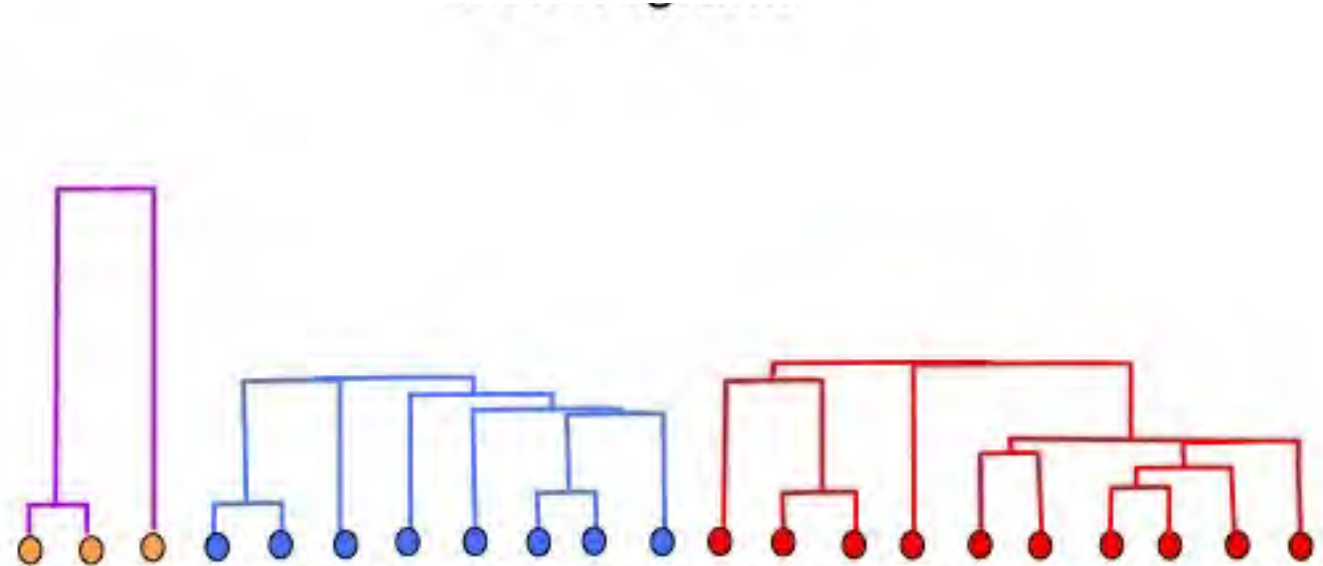
# Models: mostly for supervised learning



Models: also a few unsupervised learning ones



K-means



Hierarchical clustering



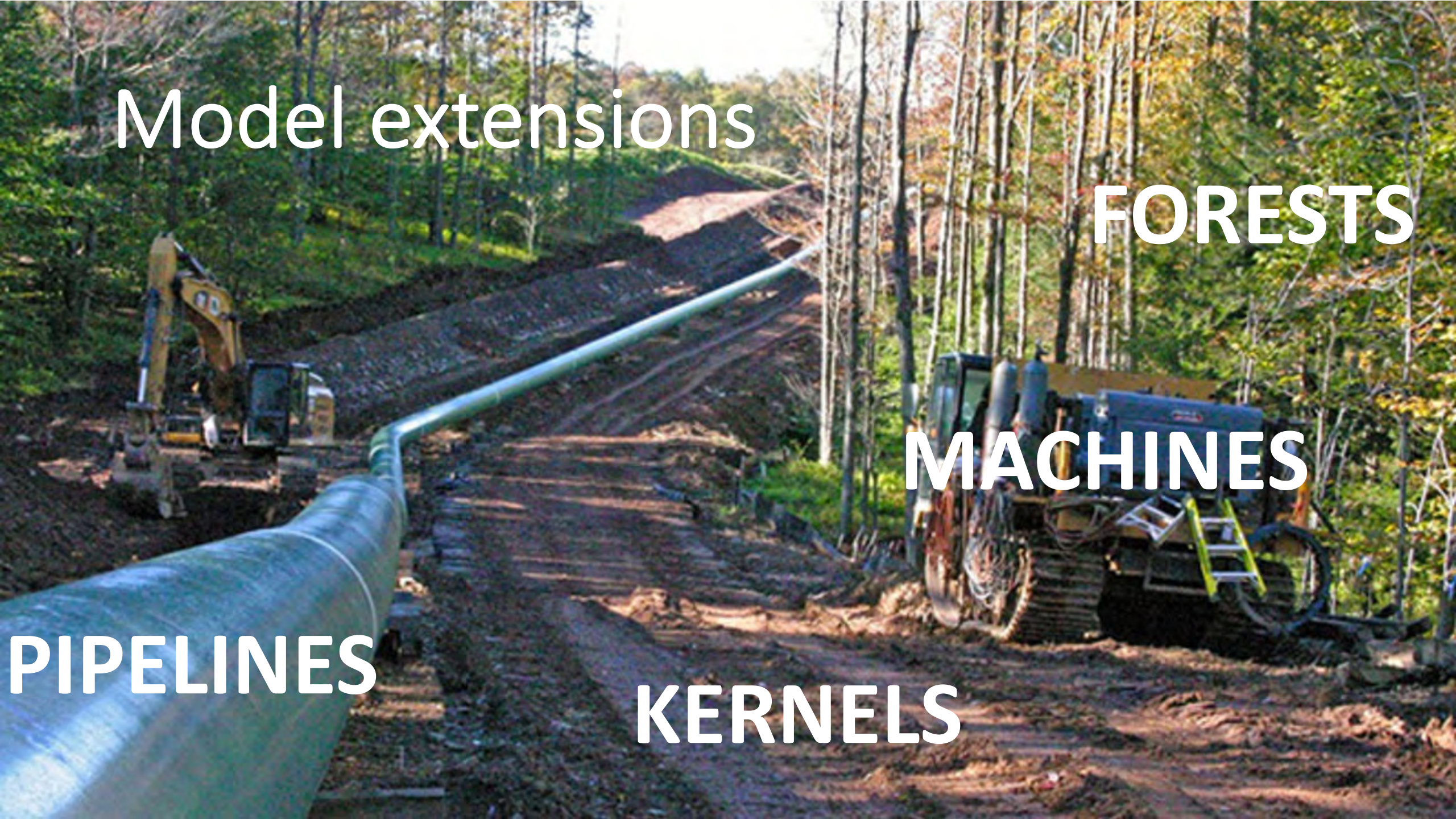
Model extensions

FORESTS

MACHINES

PIPELINES

KERNELS





# Deep Learning: A small taste of

## Neural Networks

©2016 Fjodor van Veen - asimovinstitute.org

Perceptron (P)



Feed Forward (FF)



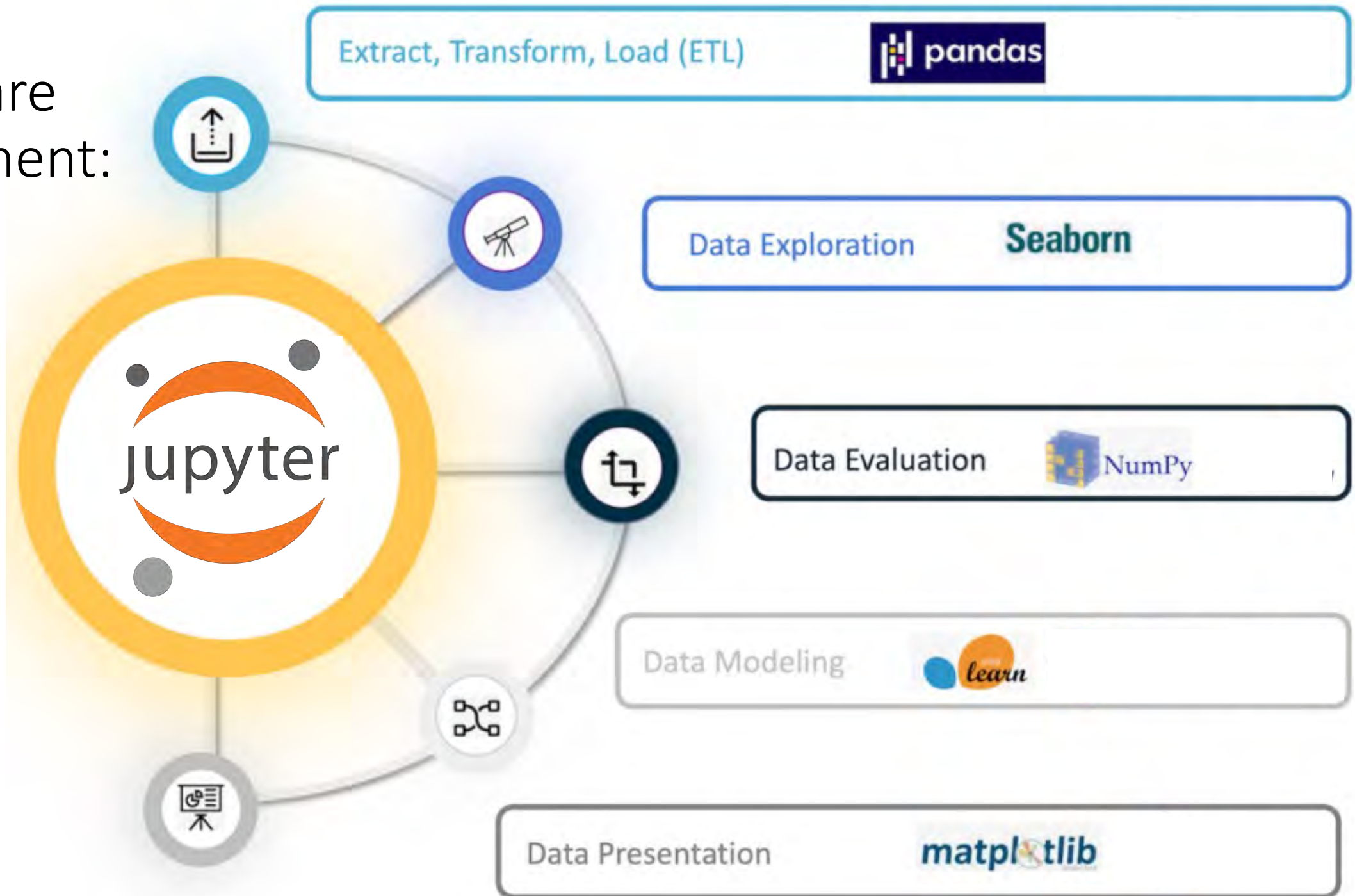
Radial Basis Network (RBF)



Deep Feed Forward (DFF)



# Software Environment:



That's plenty  
for five weeks!





Software  
Environment:

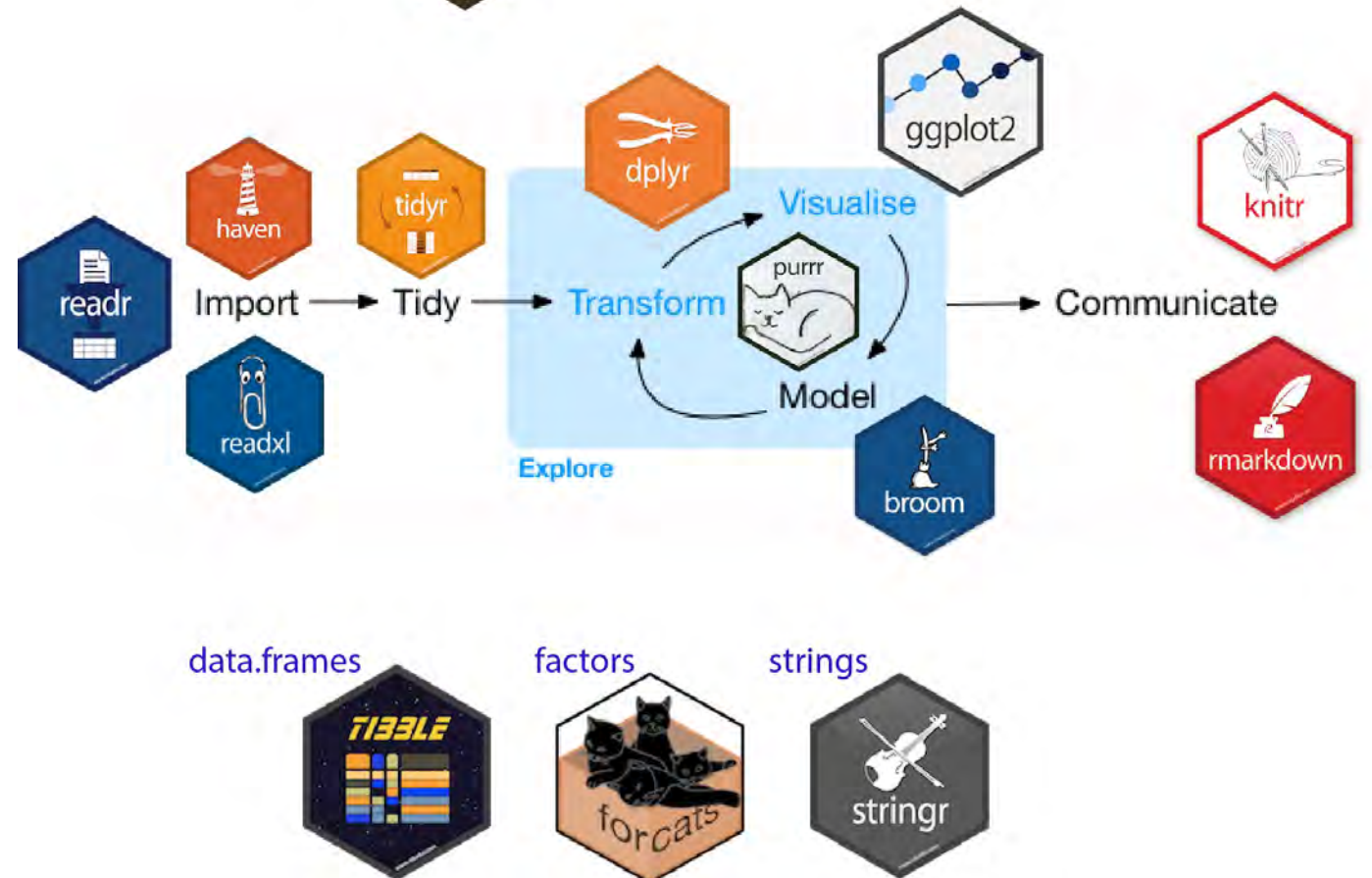
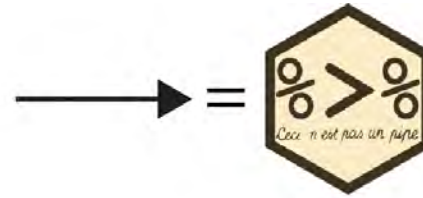
there's a big parallel



out

there!

Note that when it comes to ML...



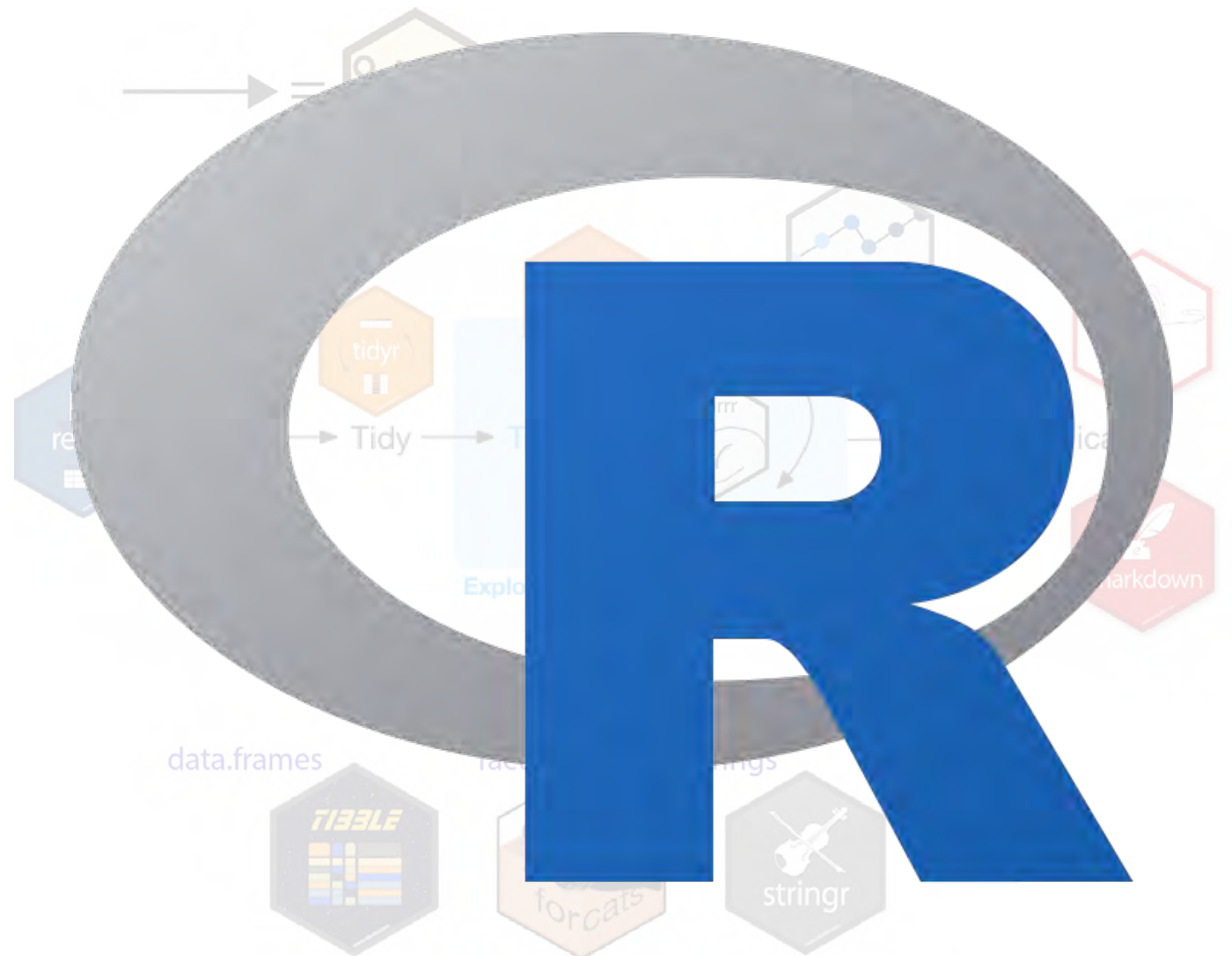
# But that's a whole other course ...

There's a big parallel



out

there!



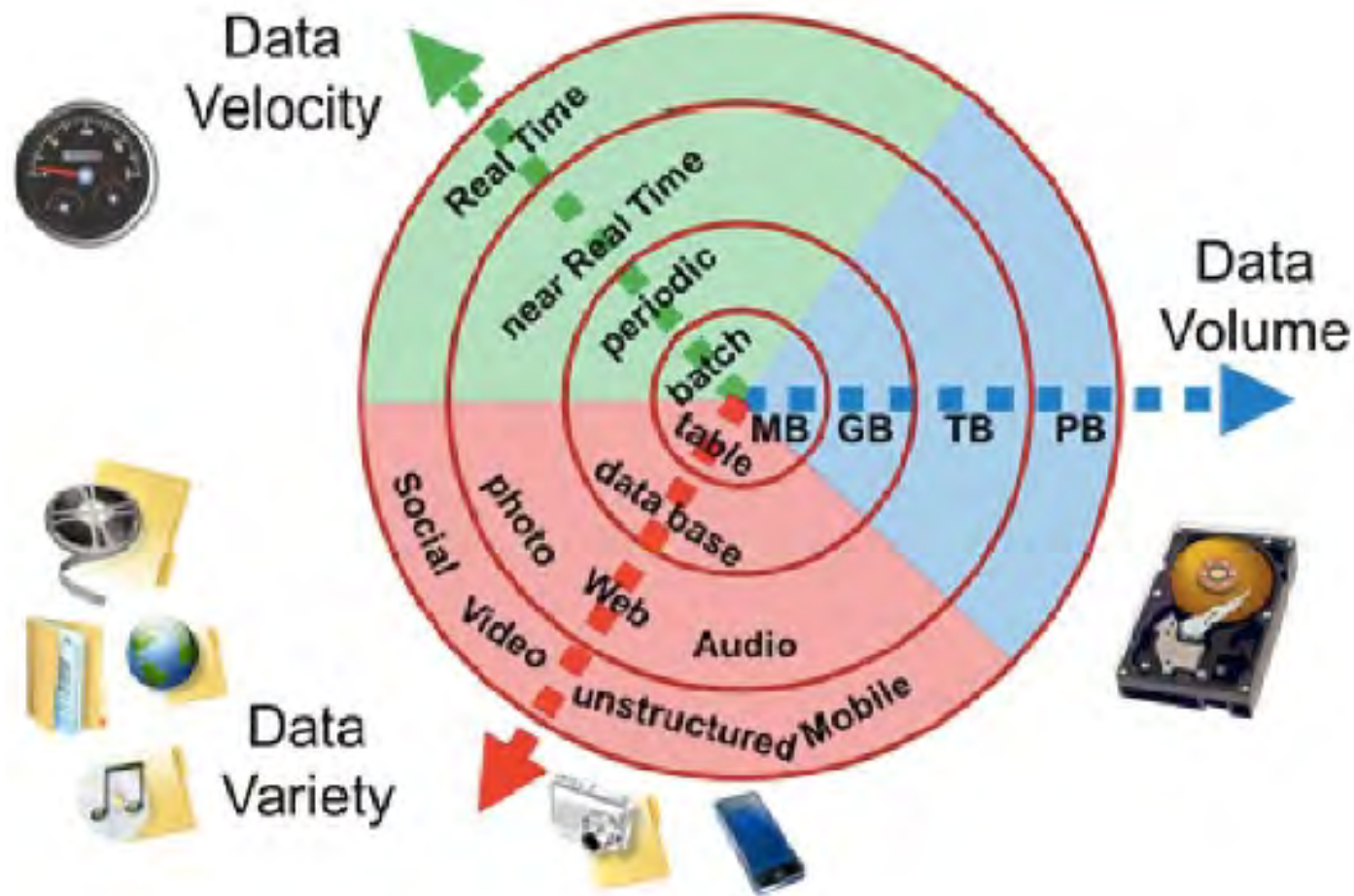




ML:  
ingredients  
for success



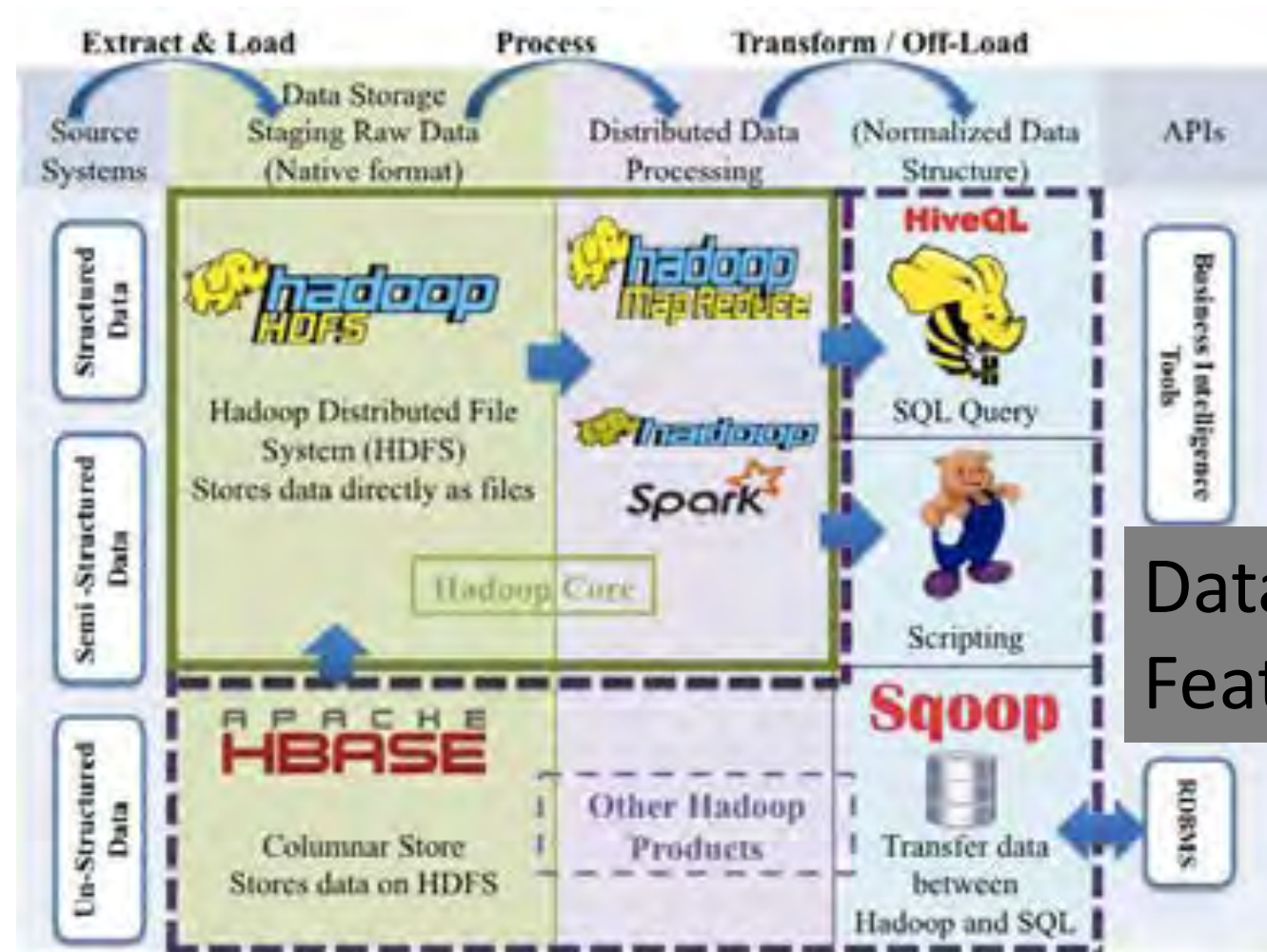




Obtain as much data ...  
as possible



# Data Mining and Curation



Data Mining /  
Feature Engineering

Cleaning

# Data Definition Framework

## Data Format

### Data Source

#### Internal



#### Structured



##### Human-Generated

- Survey ratings
- Aptitude testing

##### Machine-Generated

- Web metrics from Web logs
- Product purchase from sales Records
- Process control measures

#### Unstructured



##### Human-Generated

- Emails, letters, text messages
- Audio transcripts
- Customer comments
- Voicemails
- Corporate video/communications
- Pictures, illustrations
- Employee reviews

#### External



##### Human-Generated

- Number of Retweets, Facebook likes, Google Plus +1s
- Ratings on Yelp
- Patient ratings ratings

##### Machine-Generated

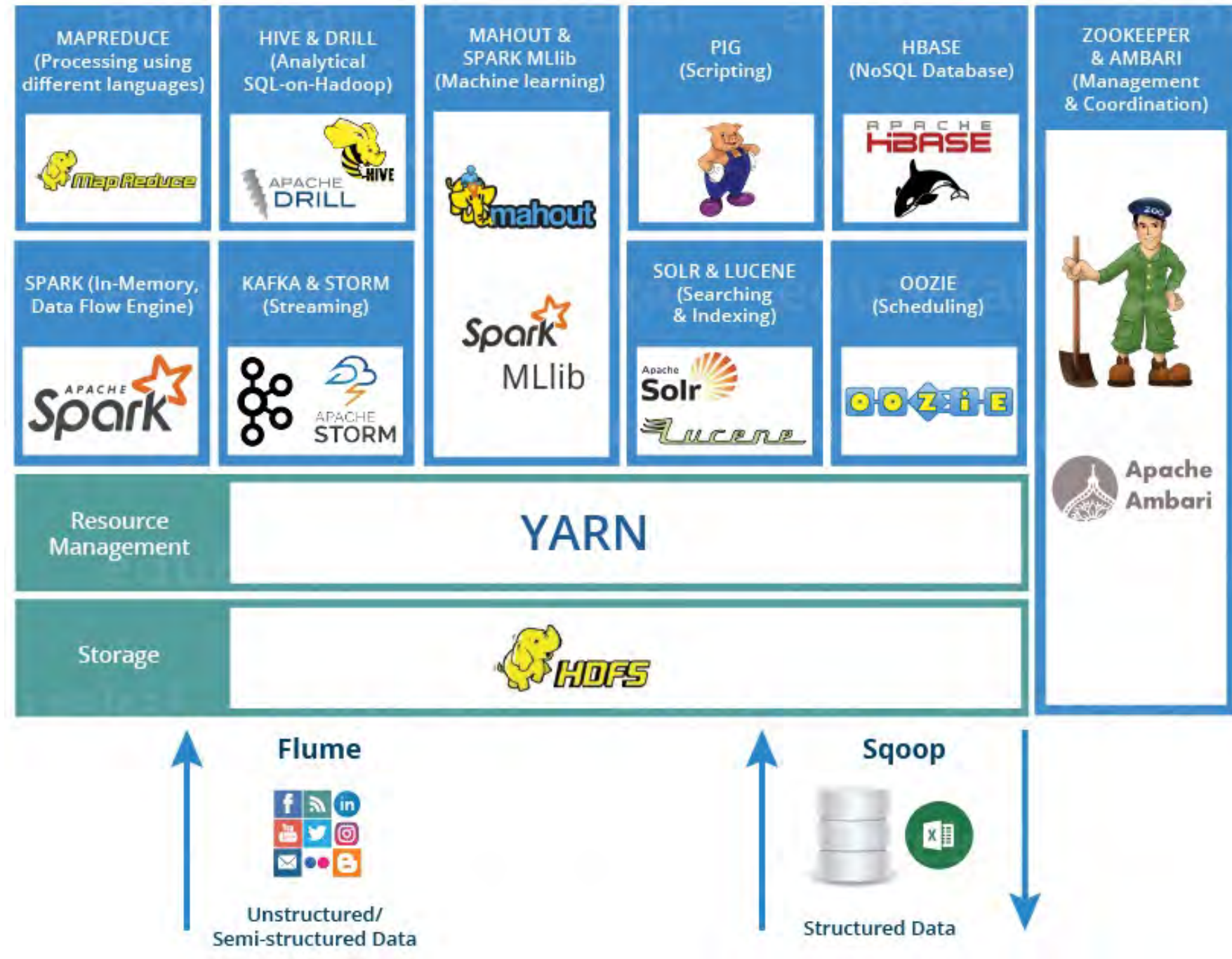
- GPS for tweets
- Time of tweet/updates/postings

##### Human-Generated

- Content of social media updates
- Comments in online forums
- Comments on Yelp
- Video reviews
- Pinterest images
- Surveillance video



# Big Data Ecosystem



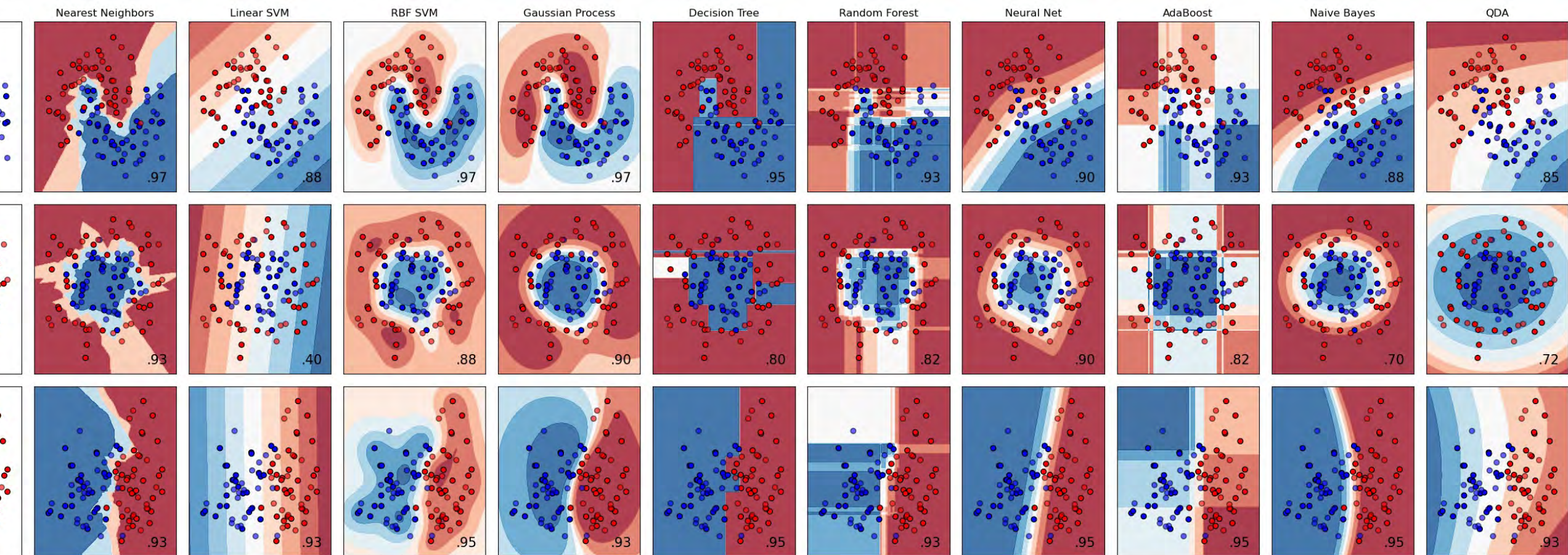


These are topics  
that this class will  
not cover!

HPE DSI offers “262  
– Principles of Data  
Management” as  
an introduction







Choose the right model ...  
from many options



# Neural Networks

©2016 Fjodor van Veen - asimovinstitute.org

- Backfed Input Cell
- Input Cell
- Noisy Input Cell
- Hidden Cell
- Probabilistic Hidden Cell
- Spiking Hidden Cell
- Output Cell
- Match Input Output Cell
- Recurrent Cell
- Memory Cell
- Different Memory Cell
- Kernel
- Convolution or Pool

Perceptron (P)



Feed Forward (FF)



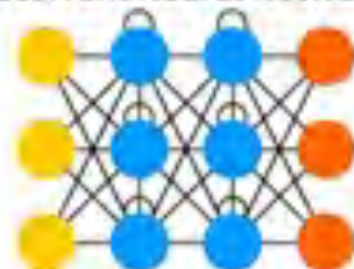
Radial Basis Network (RBF)



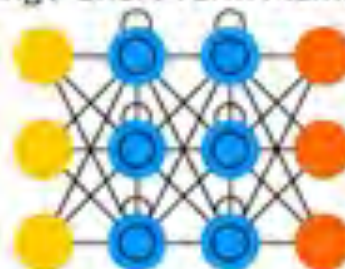
Deep Feed Forward (DFF)



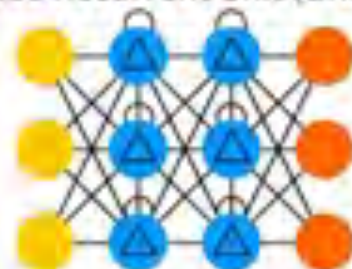
Recurrent Neural Network (RNN)



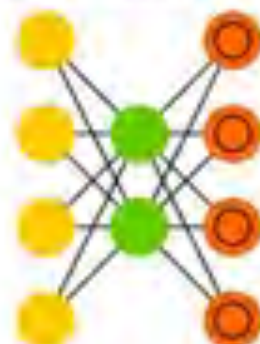
Long / Short Term Memory (LSTM)



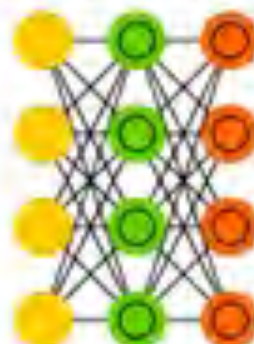
Gated Recurrent Unit (GRU)



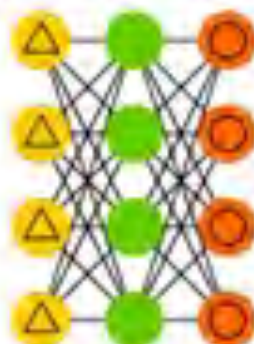
Auto Encoder (AE)



Variational AE (VAE)



Denoising AE (DAE)



Sparse AE (SAE)



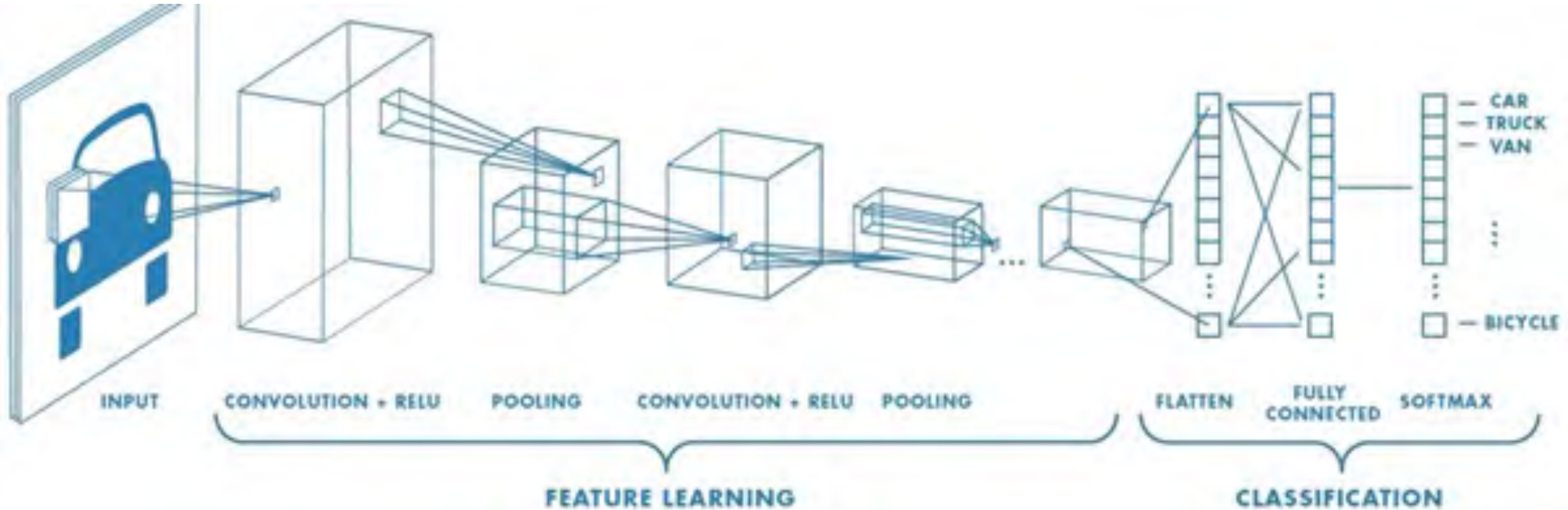


# Generative Deep Models

- GANs
- Attention/Transformers
- RNNs

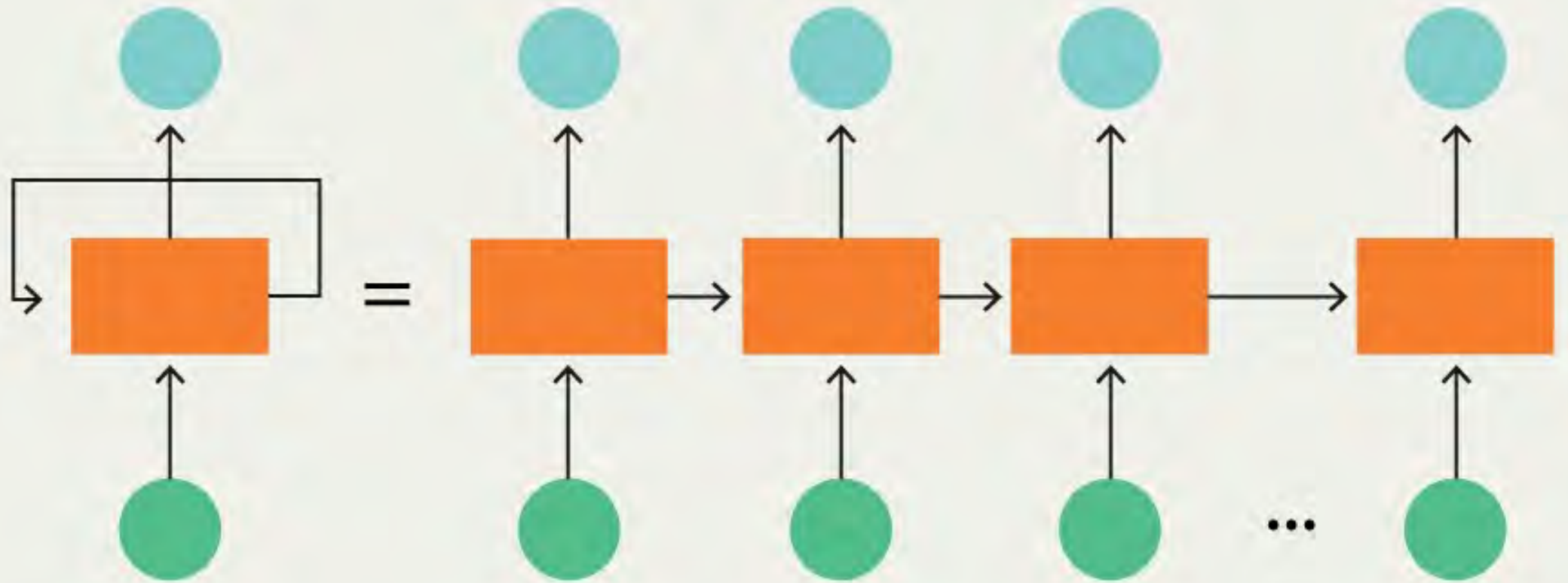
# Convolutional Neural Networks

Convolutional NN is a multi-layered neural network designed to extract increasingly complex features of the data at each layer.

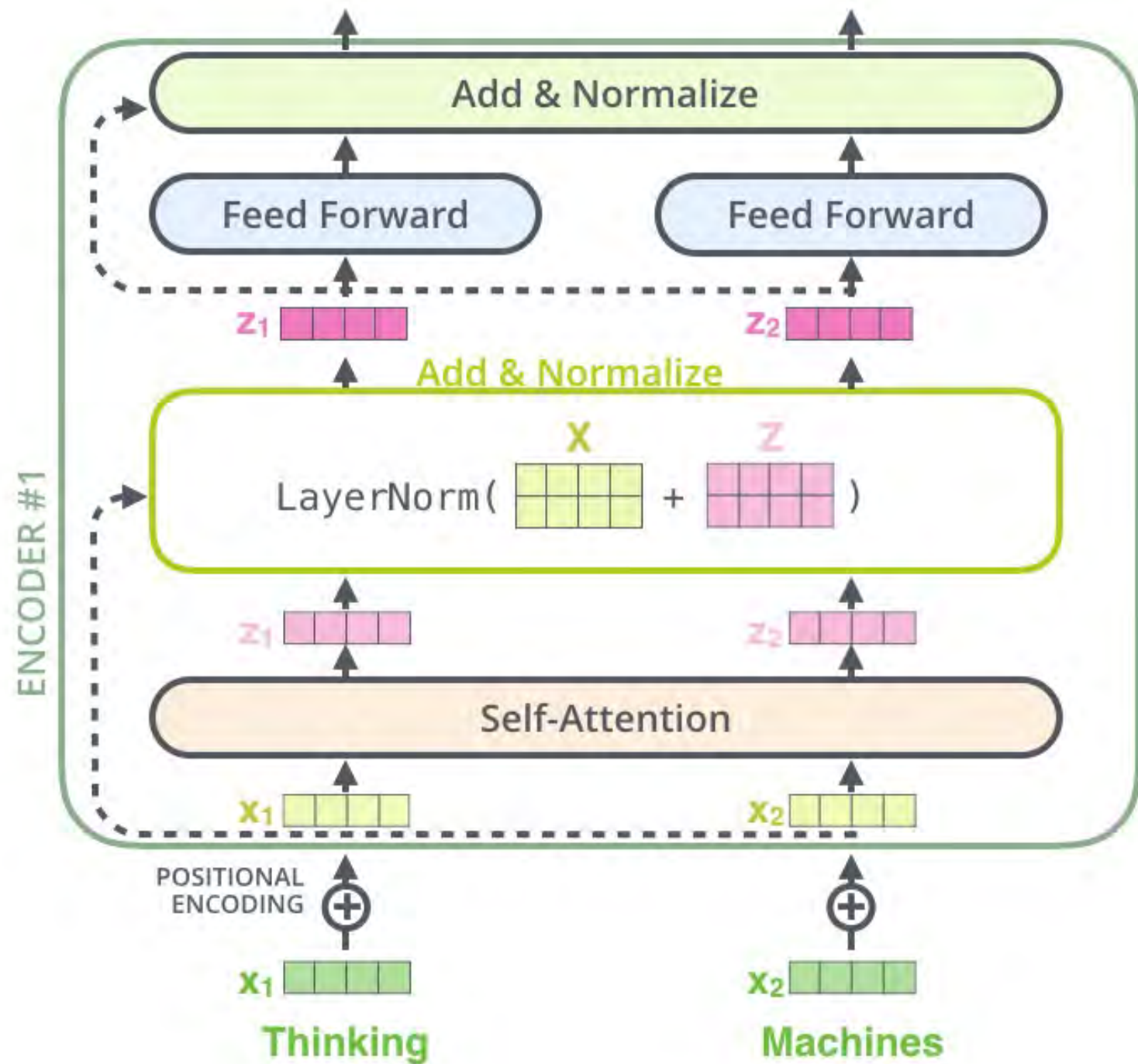




# Recurrent Neural Net (RNN)

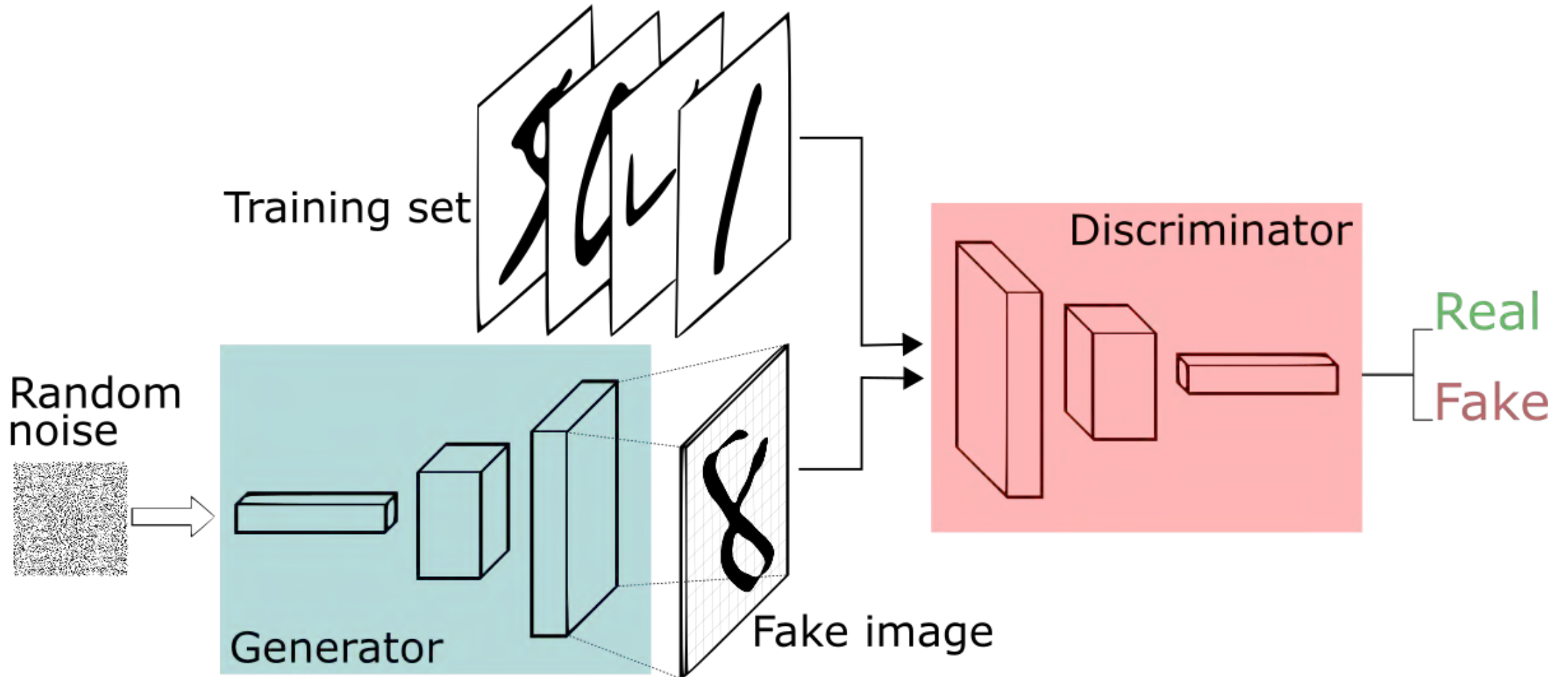


# Attention/ Transformers





# Adversarial Neural Networks



# Advanced Statistical Models

## Probabilistic Graphical Models:

- Bayesian Nets
- Hierarchical models (e.g., Gaussian mixtures)
- Random Fields





Making it all work ...  
at scale

# Parallelization of Model Implementation

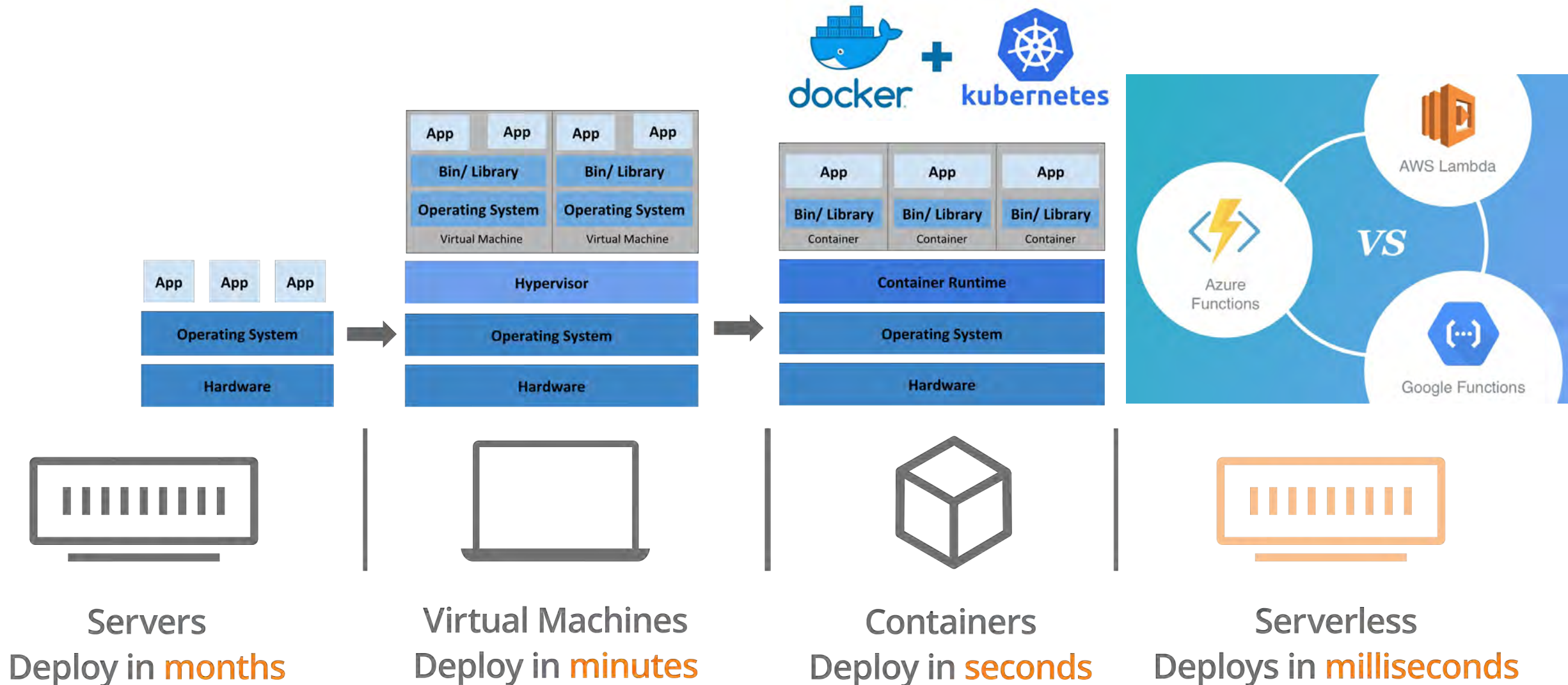
- across multiple cores on a single machine
- using GPUs (e.g. CUDA/OpenCL)
- across multiple nodes in a cluster (e.g. MLlib on Spark, Mahout on Hadoop/Mapreduce)



Carya @ HPEDSI

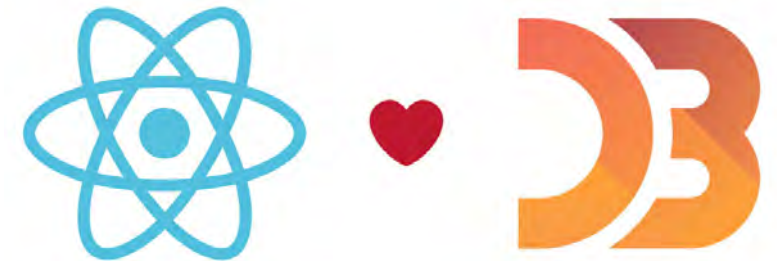


# Model Deployment in Production (MLOPS)



# UI/UX

- Dashboards (Plotly/Dash)
- Javascript dataviz (React + D3)
- Python Web apps (Django/Flask)

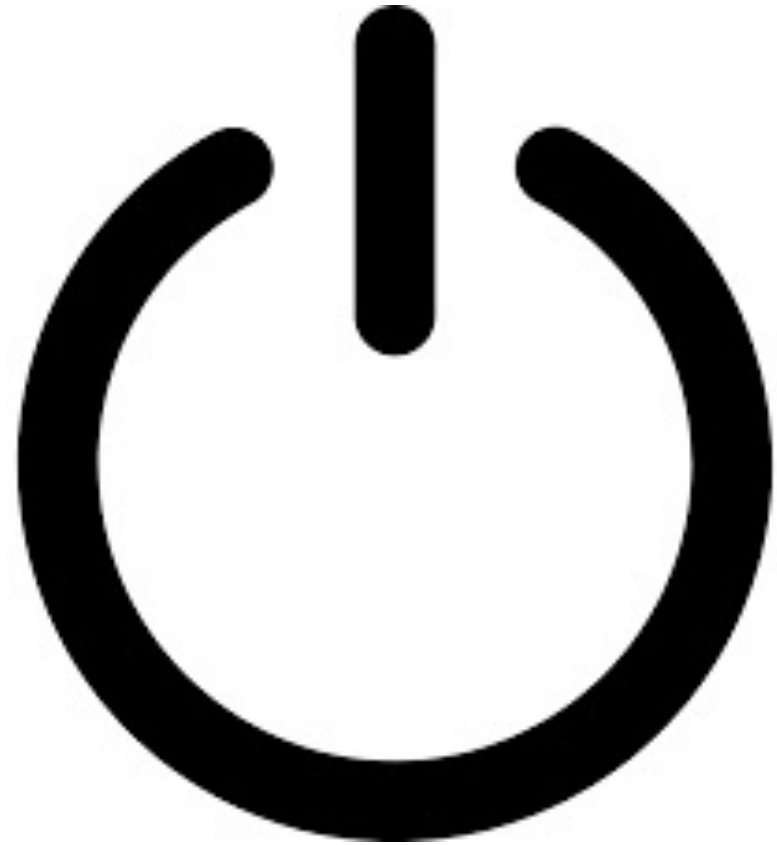


An orange rectangular road sign with a black border and rounded corners. The sign is mounted on a metal post. The text "END" is at the top and "DETOUR" is at the bottom, both in large, bold, black capital letters. There are two small red and white reflective markers on the sign: one on the top bar of the letter 'N' in "END" and one on the bottom bar of the letter 'O' in "DETOUR".

**END  
DETOUR**



Let's get  
started with  
introduction  
to ML





Brief historical perspective for context

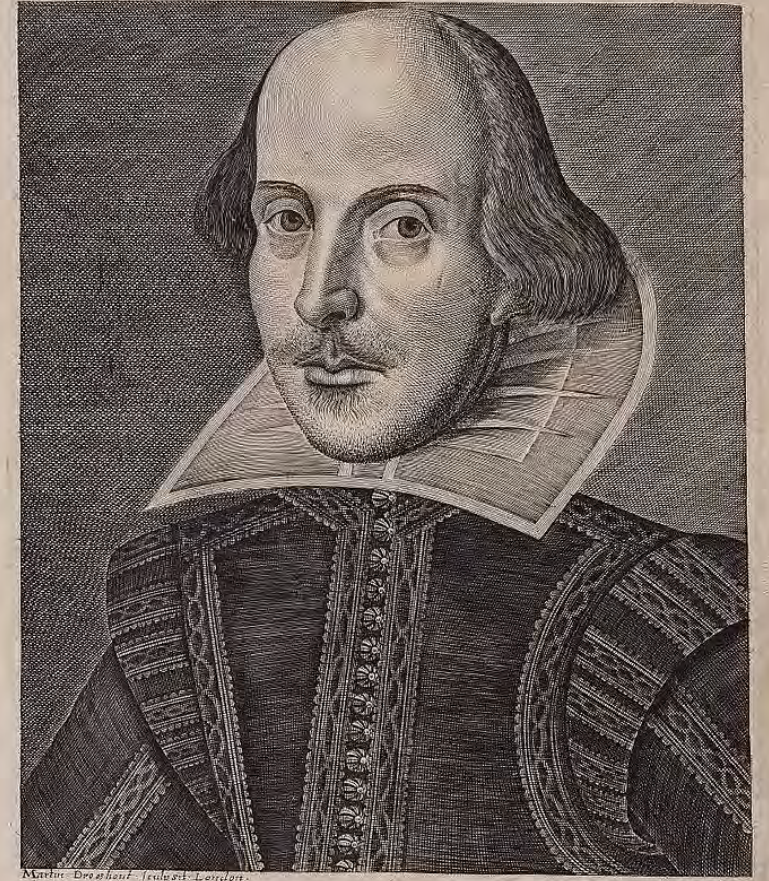
*What's in a name?*

*That which we call a rose  
by any other name  
would smell as sweet*

MR. WILLIAM  
SHAKESPEARES

COMEDIES,  
HISTORIES, &  
TRAGEDIES.

Published according to the True Originall Copies.



Martin Droghda - sculpsit - London.

LONDON

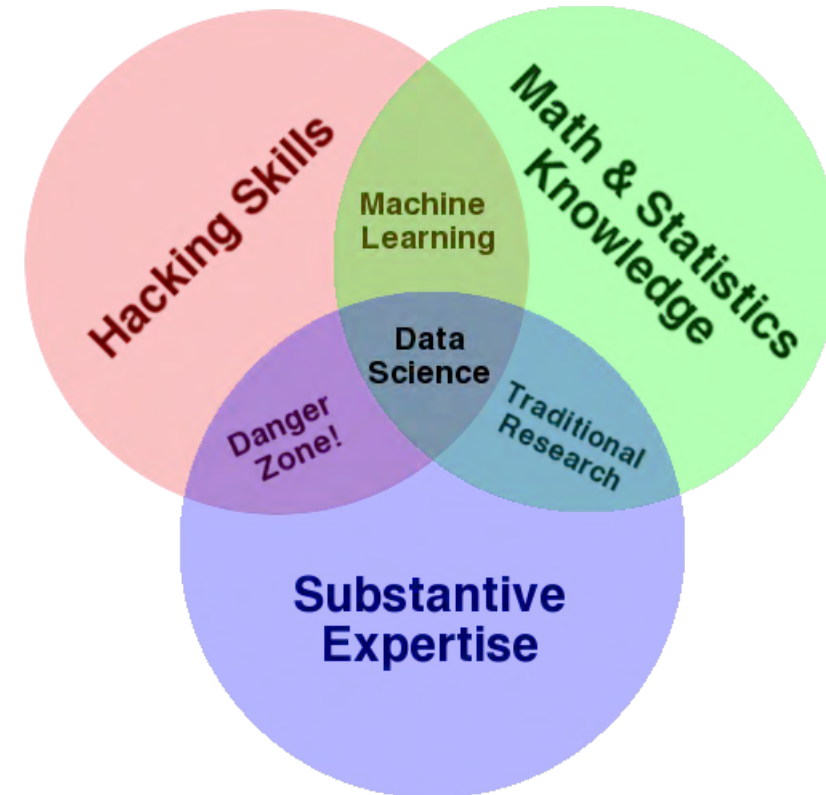
Printed by Isaac Iaggard, and Ed. Blount. 1623.



# *What's in a name?*

*That which we call ~~a rose~~ Machine Learning  
by any other name  
would smell as sweet*

- AI
- Data Science
- Statistics
- Data Analytics
- Math (Approximation Theory)
- Data Mining



AI/ML is not new

# I.—COMPUTING MACHINERY AND INTELLIGENCE

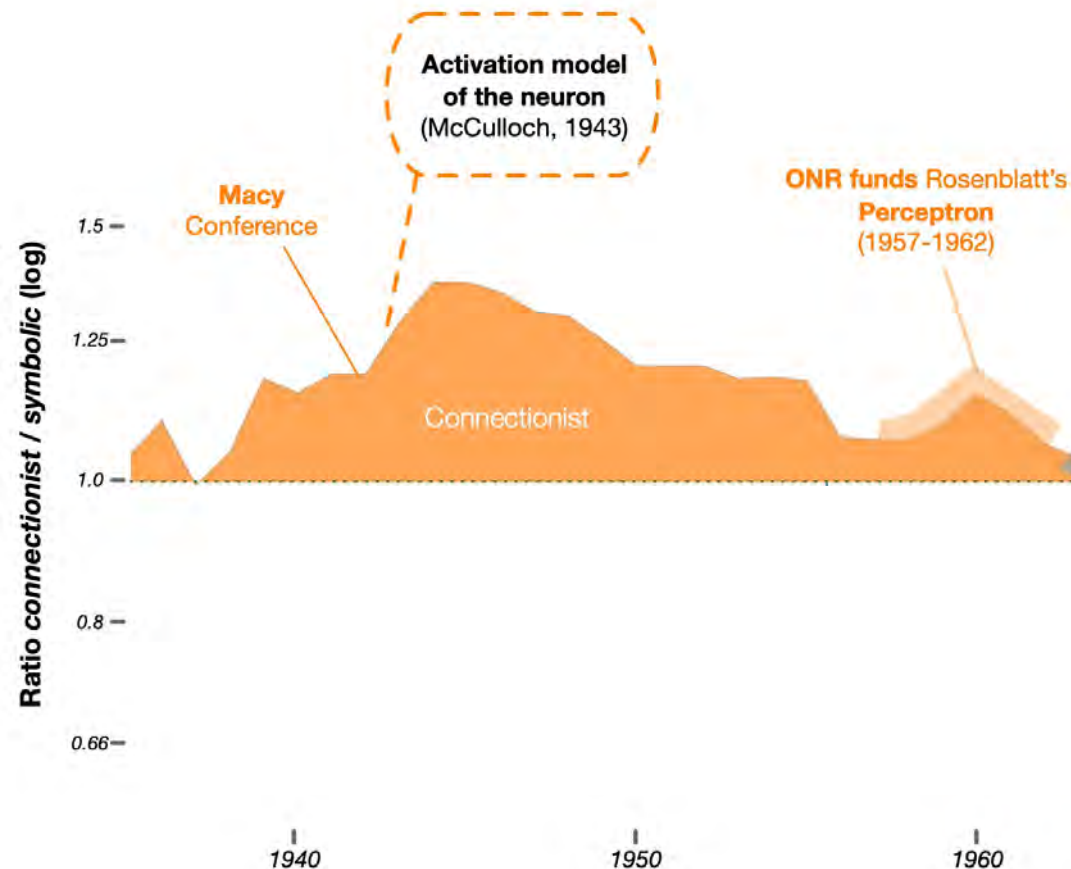
By A. M. TURING

## 1. *The Imitation Game.* AKA the Turing Test

I PROPOSE to consider the question, 'Can machines think?' This should begin with definitions of the meaning of the terms 'machine' and 'think'. The definitions might be framed so as to

# AI/ML is not new

Connectionist AI:  
Neural networks,  
data corpora



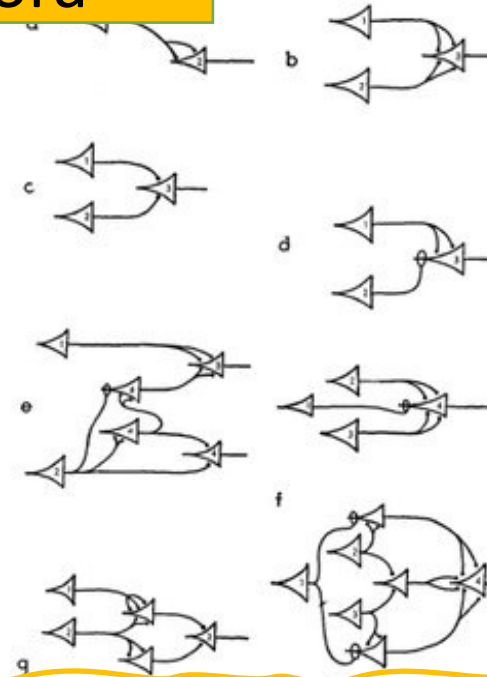
BULLETIN OF  
MATHEMATICAL BIOPHYSICS  
VOLUME 5, 1943

## A LOGICAL CALCULUS OF THE IDEAS IMMANENT IN NERVOUS ACTIVITY

WARREN S. MCCULLOCH AND WALTER PITTS

FROM THE UNIVERSITY OF ILLINOIS, COLLEGE OF MEDICINE,  
DEPARTMENT OF PSYCHIATRY AT THE ILLINOIS NEUROPSYCHIATRIC INSTITUTE,  
AND THE UNIVERSITY OF CHICAGO

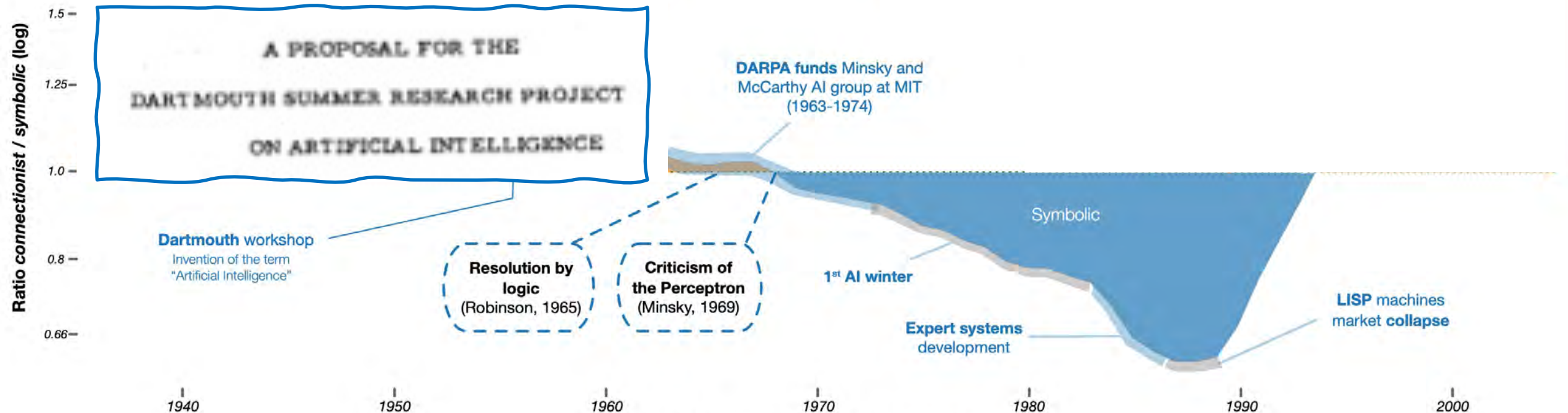
Because of the "all-or-none" character of nervous activity, neural events and the relations among them can be treated by means of propositional logic. It is found that the behavior of every net can be described in these terms, with the addition of more complicated logical means for nets containing circles; and that for any logical expression satisfying certain conditions, one can find a net behaving in the fashion it describes. It is shown that many particular choices among possible neurophysiological assumptions are equivalent, in the sense that for every net behaving under one assumption, there exists another net which behaves under the other and gives the same results, although perhaps not in the same time. Various applications of the calculus are discussed.





# AI/ML is not new, but it comes in two flavors

Symbolic AI:  
Expert Systems,  
Data Ontologies



# AI/ML is not new, but it comes in two flavors

Symbolic AI:  
Expert Systems,  
Data Ontologies

A PROPOSAL FOR THE  
DARTMOUTH SUMMER RESEARCH PROJECT  
ON ARTIFICIAL INTELLIGENCE

“The study is to proceed on the basis of the conjecture that every aspect of learning or any other **feature of intelligence** can in principle be so **precisely described** that a **machine can** be made to **simulate it.**”

J. McCarthy, Dartmouth College  
M. L. Minsky, Harvard University  
N. Rochester, I. B. M. Corporation  
C. E. Shannon, Bell Telephone Laboratories

# Early chatbot example of symbolic AI

Joseph Weizenbaum's program [ELIZA](#), published in 1966, simulated conversation by using a "pattern matching" and substitution methodology.

Symbolic AI:  
Expert Systems,  
Data Ontologies

**Directives on how to interact** were provided by "scripts", which allowed ELIZA to process user inputs and engage in discourse following the **rules and directions of the script**, using pre-prepared or pre-programmed responses.

For example:

EXPERT KNOWLEDGE: the meaning of the word 'FAMILY' is broader than the meaning of the word 'MOTHER'

RULE: Respond to any input that contains the word 'MOTHER' with 'TELL ME MORE ABOUT YOUR FAMILY'

<https://sites.google.com/view/elizagen-org/the-original-eliza>



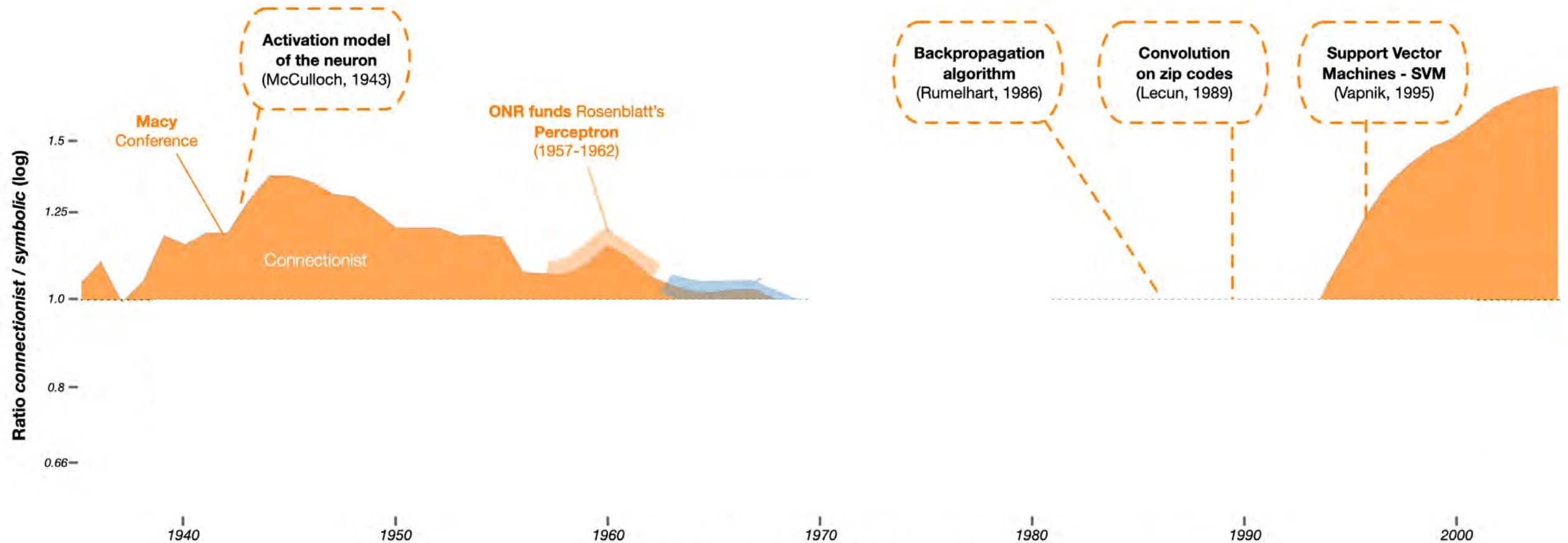
# ML skews to one flavor of AI

## Artificial Intelligence (AI)

Symbolic AI:  
Expert Systems,  
Data Ontologies

Machine Learning (ML):  
refers to (mostly connectionist)  
AI techniques that do not rely on  
explicit rules based on expert  
knowledge, but on **patterns  
inferred from data examples**  
instead

# ML skews to one flavor of AI



# Modern chatbot example

Connectionist AI:  
Neural networks,  
**big** data corpora

Collect as many conversations as possible

For any given input,

- find the closest match among the inputs in the collected data

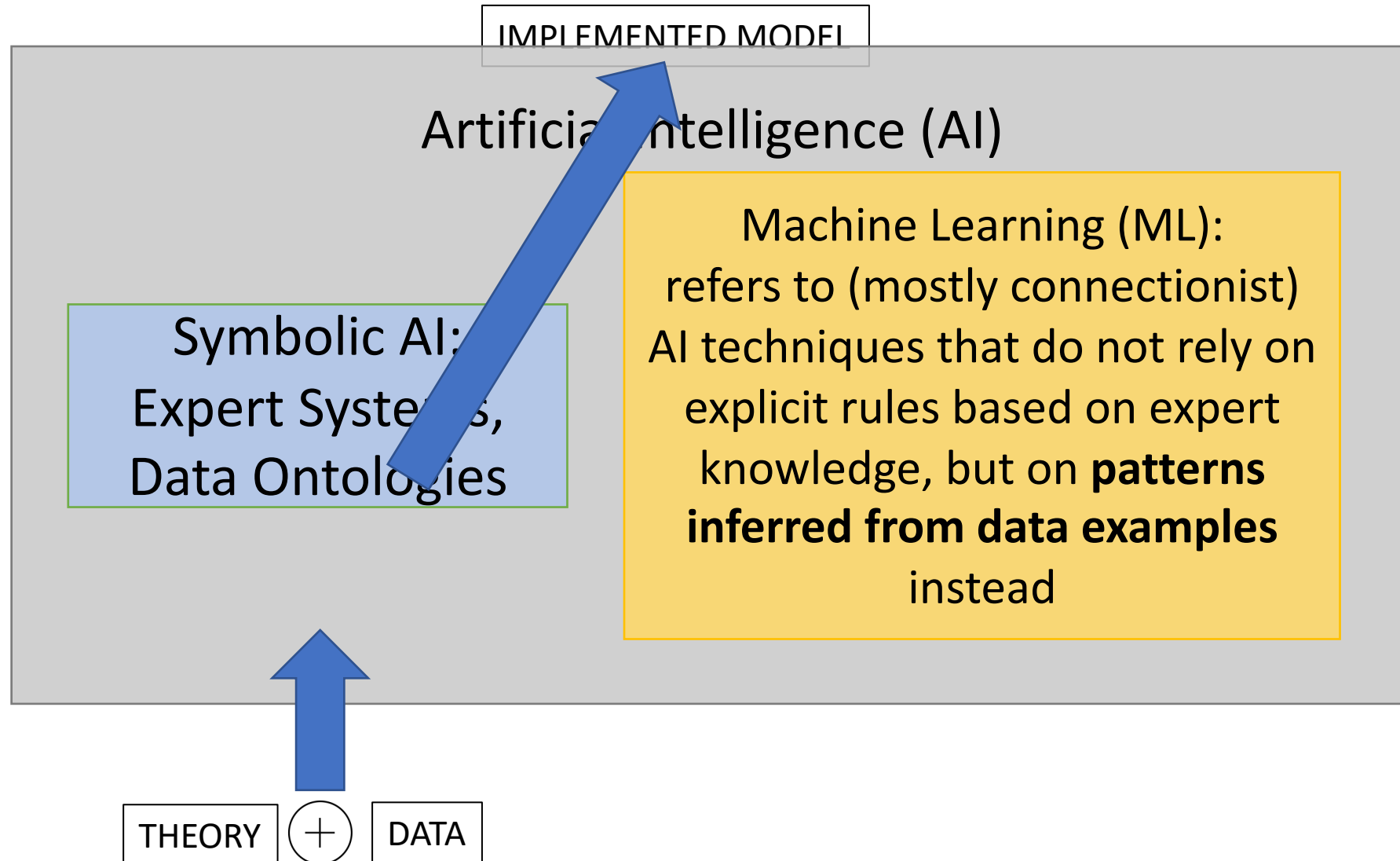
- respond with the matching response text from the collected data

This is essentially a version of the “nearest neighbor” algorithm

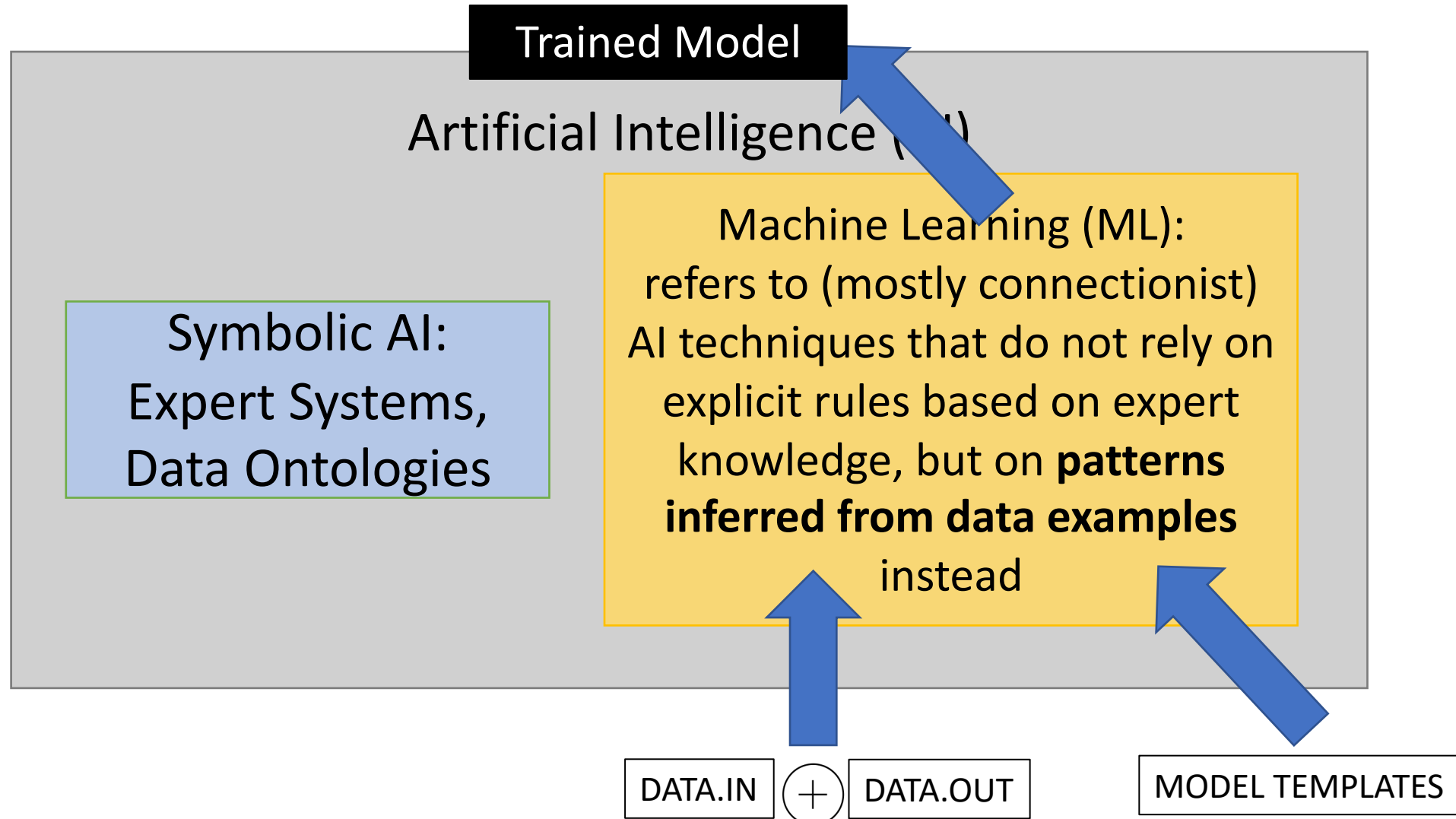
CAUTION: this is an (extremely oversimplified) example, not an actual blueprint for how NLP systems work



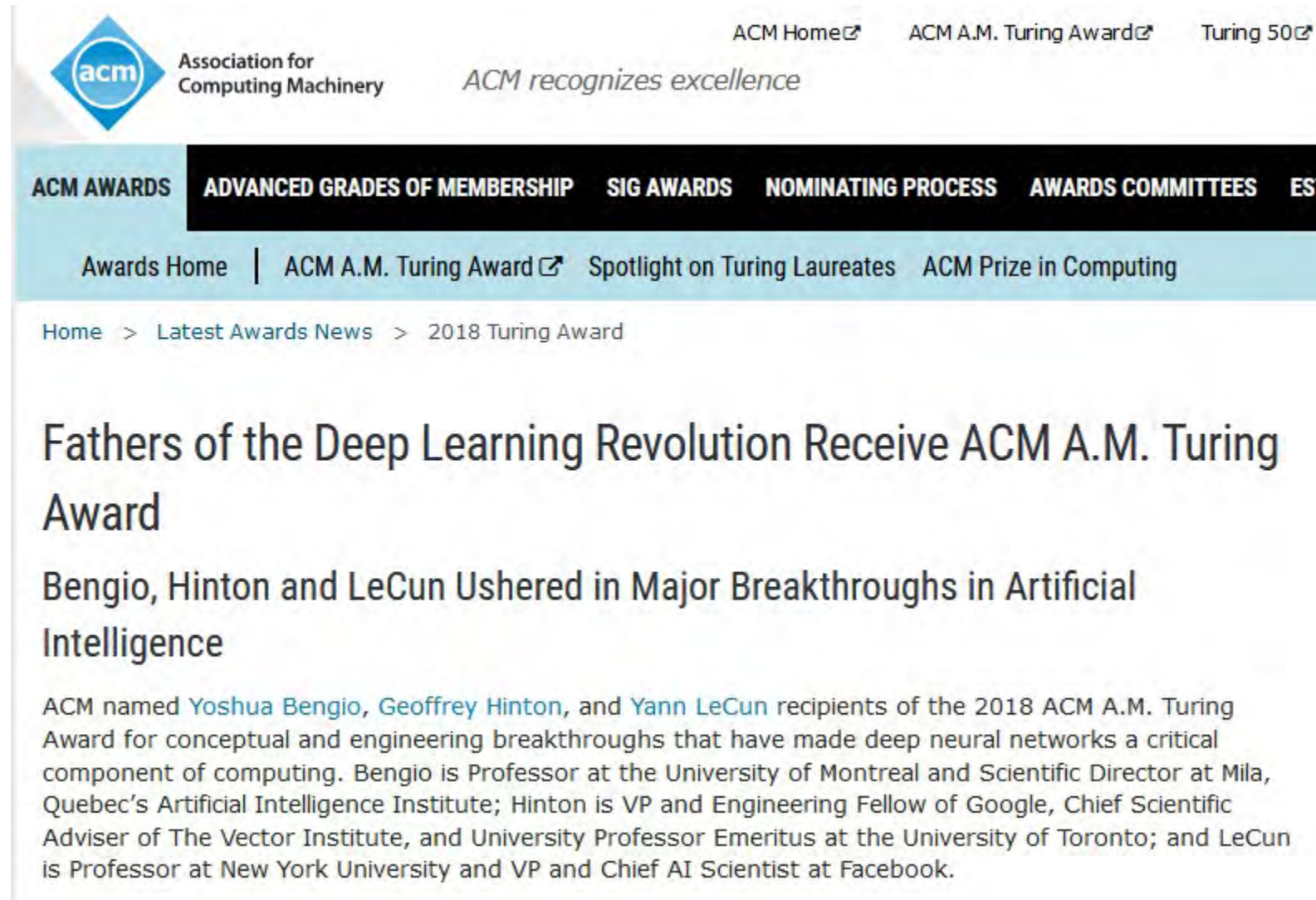
# ML skews to one flavor of AI



# ML skews to one flavor of AI



# The Deep Learning Revolution



The image is a screenshot of the ACM Awards website. At the top, the ACM logo is on the left, followed by the text "Association for Computing Machinery" and the tagline "ACM recognizes excellence". To the right are links for "ACM Home", "ACM A.M. Turing Award", and "Turing 50". Below this is a dark navigation bar with links: "ACM AWARDS", "ADVANCED GRADES OF MEMBERSHIP", "SIG AWARDS", "NOMINATING PROCESS", "AWARDS COMMITTEES", and "EST". Underneath is a light blue bar with links: "Awards Home", "ACM A.M. Turing Award", "Spotlight on Turing Laureates", and "ACM Prize in Computing". The main content area has a breadcrumb trail: "Home > Latest Awards News > 2018 Turing Award". The headline reads "Fathers of the Deep Learning Revolution Receive ACM A.M. Turing Award". Below it is a sub-headline: "Bengio, Hinton and LeCun Ushered in Major Breakthroughs in Artificial Intelligence". The body text states: "ACM named Yoshua Bengio, Geoffrey Hinton, and Yann LeCun recipients of the 2018 ACM A.M. Turing Award for conceptual and engineering breakthroughs that have made deep neural networks a critical component of computing. Bengio is Professor at the University of Montreal and Scientific Director at Mila, Quebec's Artificial Intelligence Institute; Hinton is VP and Engineering Fellow of Google, Chief Scientific Adviser of The Vector Institute, and University Professor Emeritus at the University of Toronto; and LeCun is Professor at New York University and VP and Chief AI Scientist at Facebook."

ACM Home [ACM A.M. Turing Award](#) [Turing 50](#)

Association for Computing Machinery *ACM recognizes excellence*

**ACM AWARDS** **ADVANCED GRADES OF MEMBERSHIP** **SIG AWARDS** **NOMINATING PROCESS** **AWARDS COMMITTEES** **EST**

[Awards Home](#) | [ACM A.M. Turing Award](#) [Spotlight on Turing Laureates](#) [ACM Prize in Computing](#)

[Home](#) > [Latest Awards News](#) > [2018 Turing Award](#)

## Fathers of the Deep Learning Revolution Receive ACM A.M. Turing Award

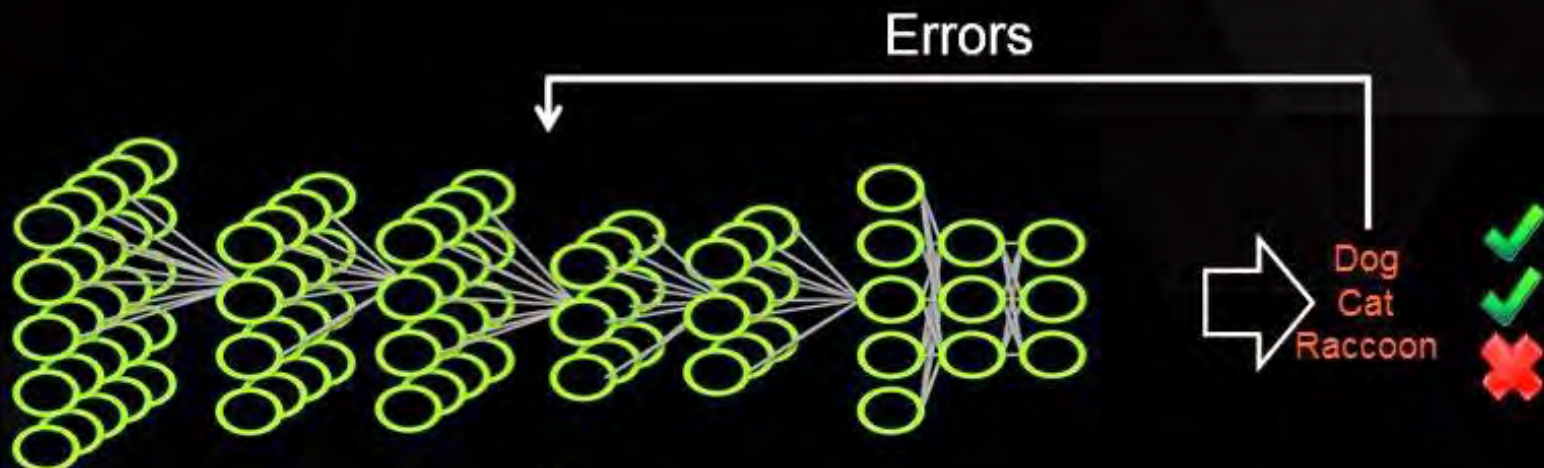
### Bengio, Hinton and LeCun Ushered in Major Breakthroughs in Artificial Intelligence

ACM named [Yoshua Bengio](#), [Geoffrey Hinton](#), and [Yann LeCun](#) recipients of the 2018 ACM A.M. Turing Award for conceptual and engineering breakthroughs that have made deep neural networks a critical component of computing. Bengio is Professor at the University of Montreal and Scientific Director at Mila, Quebec's Artificial Intelligence Institute; Hinton is VP and Engineering Fellow of Google, Chief Scientific Adviser of The Vector Institute, and University Professor Emeritus at the University of Toronto; and LeCun is Professor at New York University and VP and Chief AI Scientist at Facebook.

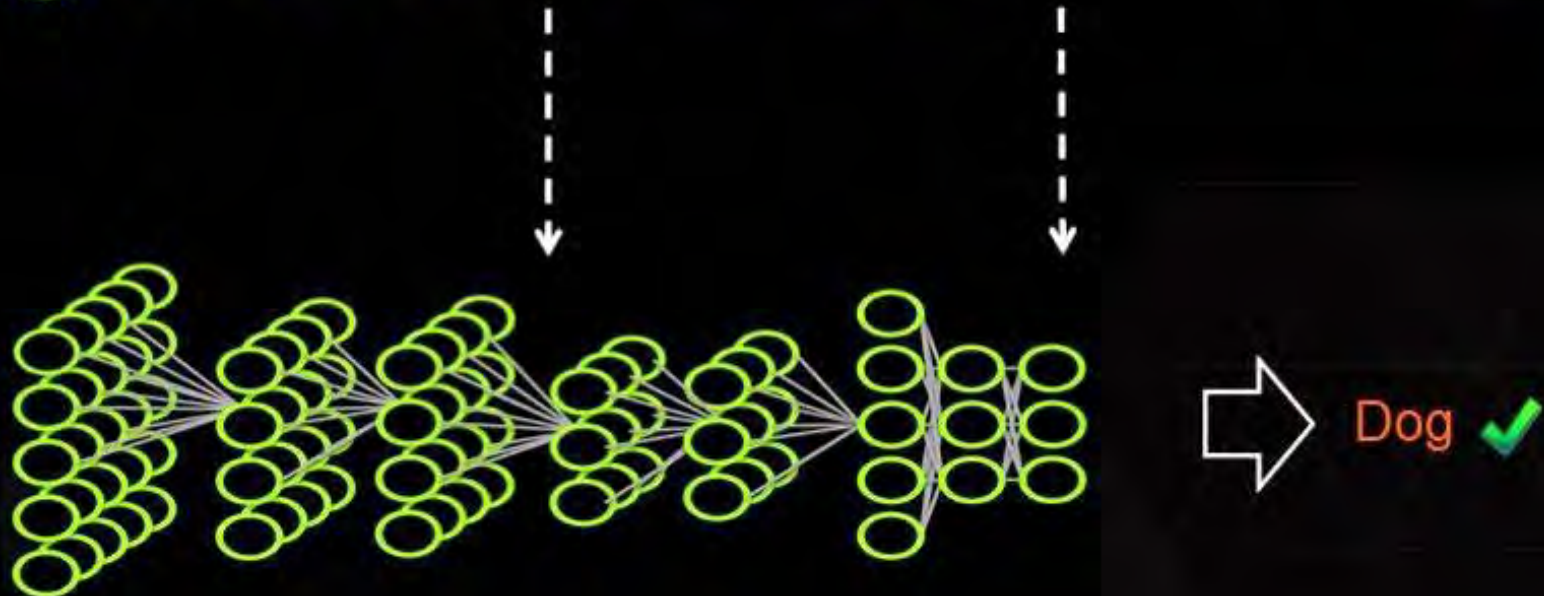


# DEEP LEARNING APPROACH

Train:



Deploy:



# DEEP LEARNING APPROACH

Train:



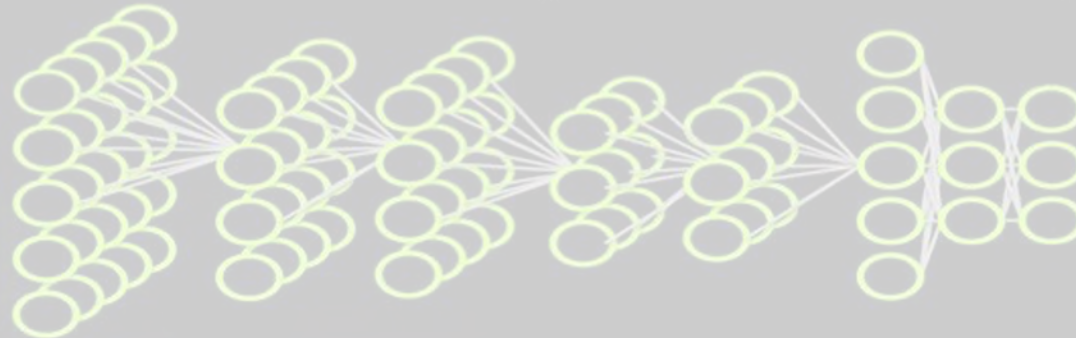
Error Backpropagation (1980s)

Neural Networks (e.g., Perceptron, 1950s)

Dog  
Cat  
Raccoon



Deploy:

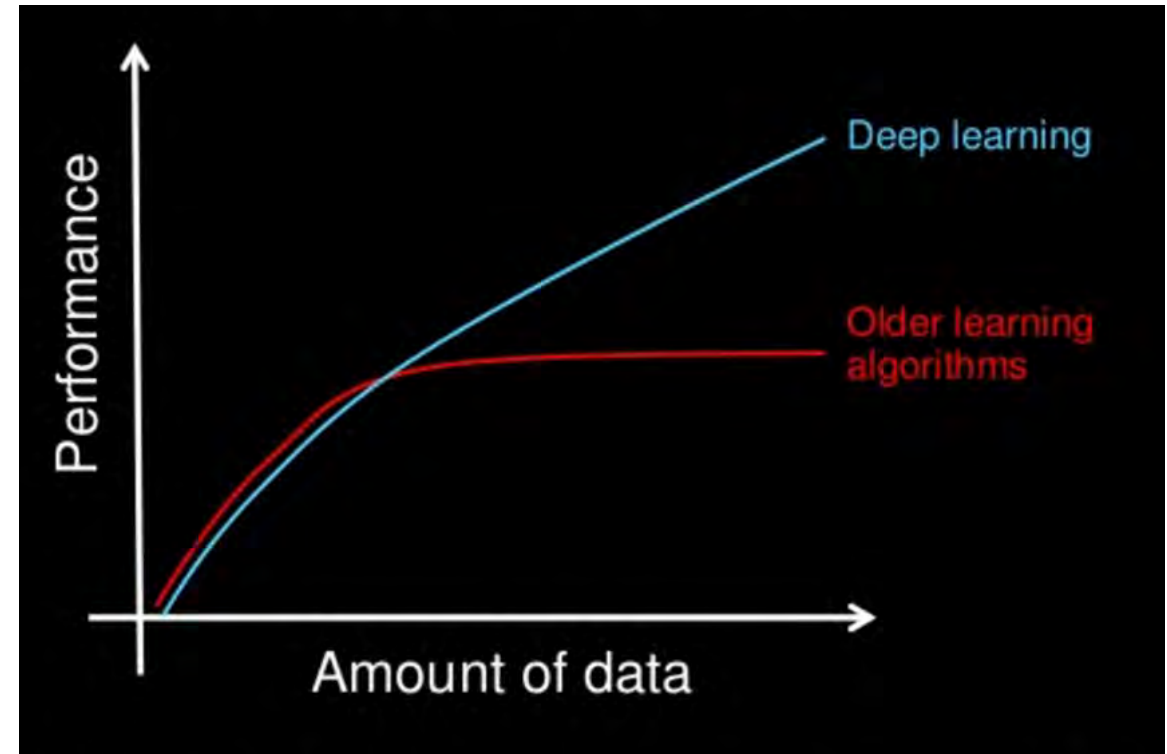


Dog ✓

# The missing ingredients?

Big Data + Computing at Scale

The technology (GPUs) and dataset sizes (Big Data) needed for practical implementations of Deep Learning algorithms did not mature until the last decade





# Big Data + Computing at Scale = Deep ML

