Machine Learning

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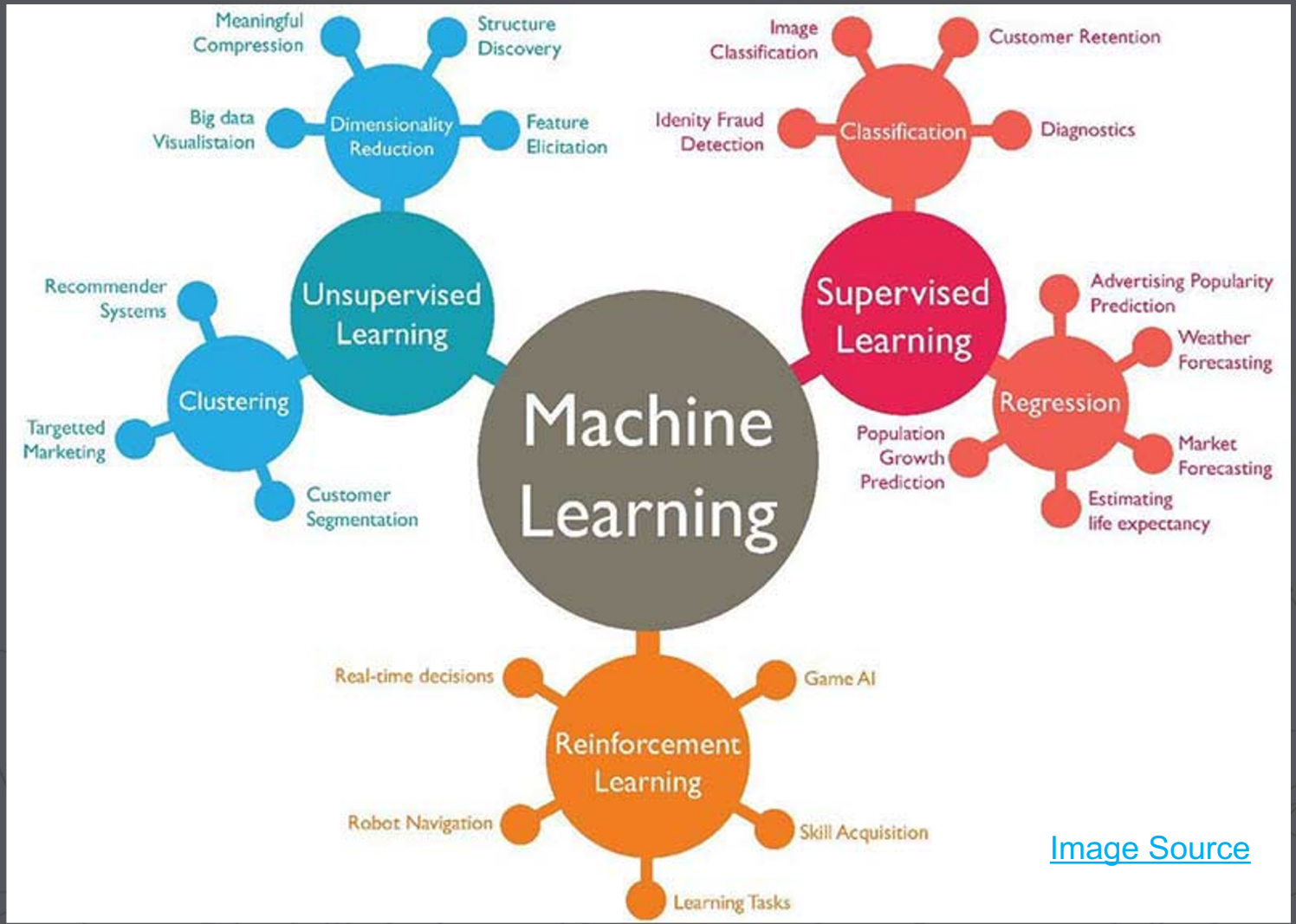
What is Machine Learning

- **Machine learning (ML) is a lot like programing**
  - It's a series of technique for telling a computer how to do something
  - Instead of writing an algorithm with code you create a system that can learn an algorithm from data

- **Often is not the right choice**
  - Training an ML model to add numbers
    - Would take a lot of work
    - And would not be as accurate a

- **Perfect when you have data but no algorithm**

Besides quick coding fingers, look for a personality that can cope with failure. You almost never know what you're doing, even if you think you do.
--Cassie Kozyrkov Chief Decision Intelligence Engineer at Google



What technique depends on the problem

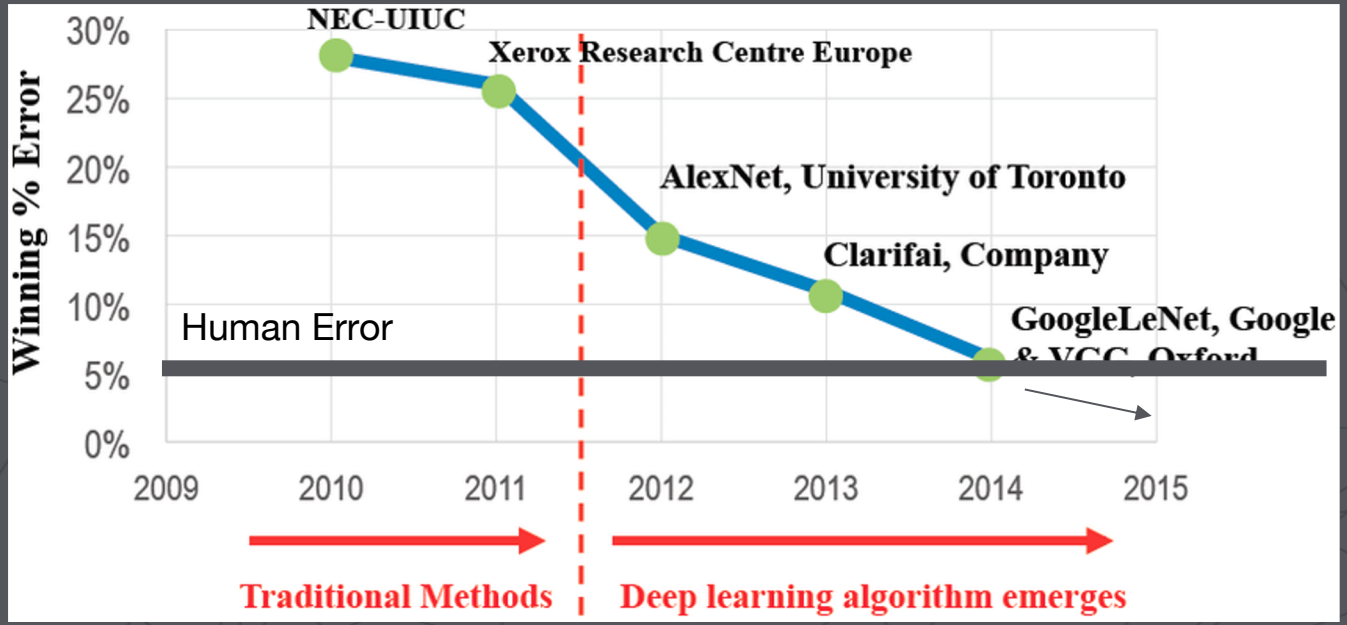
[Image Source]

Thought Experiment

How would you write an algorithm to tell the difference between cats and dogs

Images

Rule based algorithms are difficult to design images, deep learning wins Image-net Challenge: Identify the subject of an image out of 1000 classes



Still an Algorithm

- Algorithms can have bugs
  - Bugs in ML often occur in data

Vocab

- Artificial Intelligence
  - An all encompassing term for a broad field the most promising of which is currently machine learning
  - Machine Learning
    - Deep Learning - Deep Neural Networks of all forms
    - ‘Traditional’ Machine Learning - Pretty much everything else
      - Trees, SVMs, Linear Regression, Naive Bayes...
- X’s = Input variables
- Y’s = Target Variables
- Loss function - Numerical Goal of the Model

Machine Learning

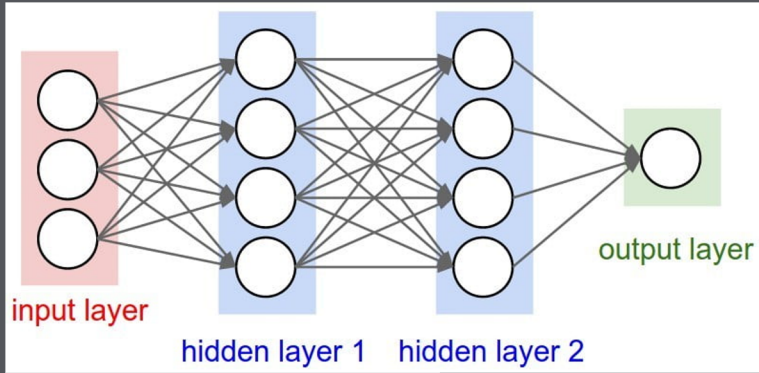
- In different works ML models try to
  - Find f(x) such that f(x) best approximates y

- Examples:
  - Given some pixels (x) tell me the probability it's a cat (y)
  - Given news articles (x) tell me a stocks value (y)

- Important Note: No prediction of causality
- Function outputs can be stochastic

Deep Learning

- Very powerful method used for a host image analysis problems
- Many layers often of different types
- Dense, Convolutional, Dropout



$$a_j^l = \sigma\left(\sum_k w_{jk}^l a_k^{l-1} + b_j^l\right)$$

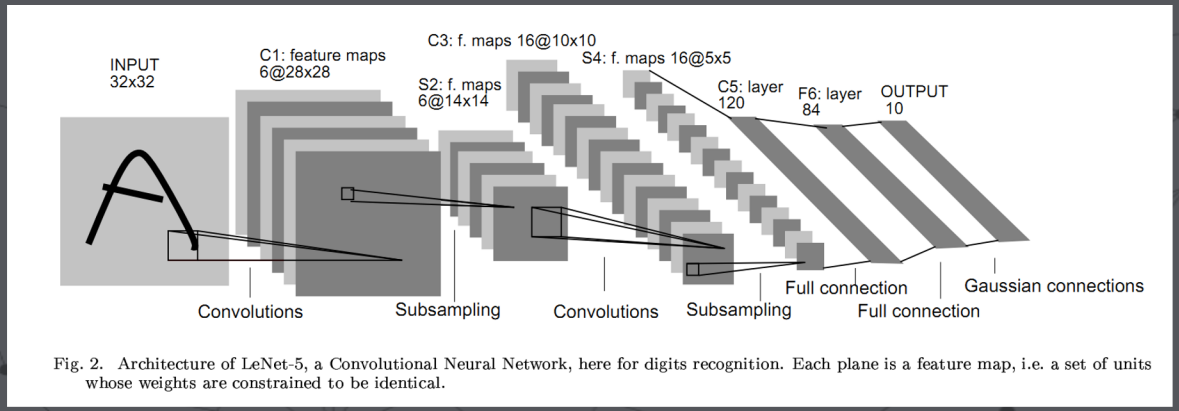
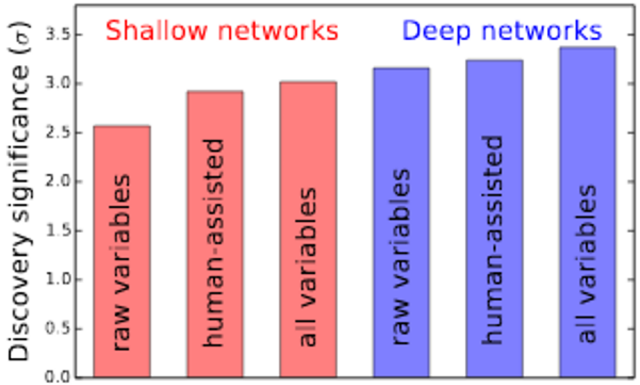


Fig. 2. Architecture of LeNet-5, a Convolutional Neural Network, here for digits recognition. Each plane is a feature map, i.e. a set of units whose weights are constrained to be identical.

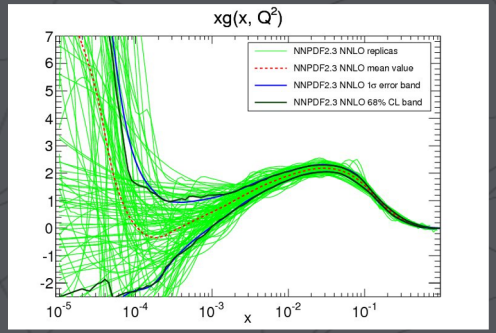
DNN Advantages

- Often can lead to better results than human crafted algorithms
  - Provided the data is sufficient
- Can ingested huge varieties of raw data with limited or no preprocessing
  - Text
  - Images
  - Sounds
  - etc.
- Can estimate uncertainties on fits without assumptions on functional forms
  - Rare due to CPU expense



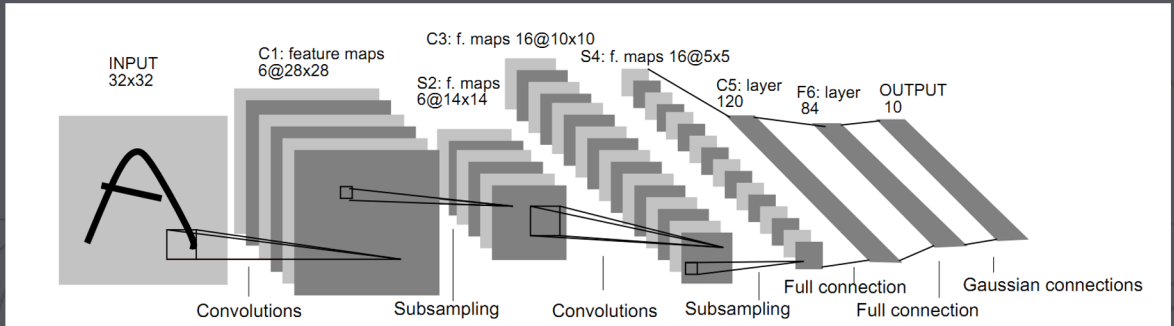
10.1103/PhysRevLett.114.111801

FIG. 5. Comparison of discovery significance for the traditional learning method (left) and the deep learning method (right) using the low-level variables, the high-level variables and the complete set of variables.



Building a Network

- Deep Neural Networks are usually a stack of layers that learn how to transform input data into something useful



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The big two

The two most important blocks we'll introduce throughout the workshop

- Dense Neural Networks
  - Simplest layers and an introduction
- Convolutional neural Networks
  - Layers designed for images

How Does it Work

Software Tools

- Tons of implementations of basic ML tools
  - Matlab
  - R
  - STAT
  - SAS
- All ML research and development is happening in python
  - **Tensorflow**
  - PyTorch
- Deploying ML models in production a bit more diverse

Hardware Tools

- **GPUS**
  - Nvidia GPUs are the primary tools for machine learning
    - Primarily due to CUDA
- **CPUS**
  - Fine for smaller models, can’t compete with GPUS for larger models
- Tensor Cores
  - Next generation of core highly optimized for tensor operations used in Deep Learning
    - Google’s TPUs
    - Nvidia’s RTX/Volta lines
      - FP16 only
- Others
  - FPGAs
  - Graph Cores and other custom chips
- As a user CPUS are a good place to start, and GPUs will be the main workhorse

Engineering

What is ‘right’

- Some things don’t work
- Lots of things work fine
- What works best depends on the dataset
- **When getting started focus on what works**

Not a Good Car Tire

Plenty of Good Car Tries

Machine Learning Cycle

- Create/Get a dataset
- Build a model
- Train your dataset
- Evaluate
- Repeat

Use

How This Workshop Works

- We'll be working through material together with a few exercises
- Work along, and ask lots of questions
- Lets get started:

https://github.com/jsearcy1/DNNWS_2022