Impacts of AI: COMP3800-03
About Artificial Intelligence
Wentworth Institute of Technology

What is your definition of **Artificial Intelligence?**

ARTIFICIAL INTELLIGENCE

Perception *TODAY*

The Matrix

Her

I, Robot

Ex-Machina

Highly influenced by media and entertainment industry

"Our technology, our machines are **part of our humanity.**

We create them to extend ourselves and that is what is unique about human beings"

Ray Kurzweil
Futurist

January 2011: Jeopardy!

Ken, Watson and Brad

AI applications are transforming every industry

Government
Campaign Content and Planning, Citizen Experience, Public Security, Policy Planning Support

Finance
High Frequency Trading, Risk Modeling, Equity Research, Asset Management, Underwriting, Investment Planning, Security

Agriculture
UAV / Satellite Crop Field Analysis, Disease Recognition, Comprehensive Strategic Crop Planning

Energy
Strategic Oil Drilling, Risk Minimization, Geological Analysis, Demand Prediction, Adjustment of Resource Generation

Healthcare
Personalized Healthcare, Diagnostic Tools, Integrated Wellness and Health Systems, Behavior Tracking, Security

Education
Personalized Education, Learning Content Indexing-to-Skill & Search, Custom Teaching Methods, Smart View Devices

Science
Data Analysis, Experiments, Predictive Modeling, Theorem Proving, Deductive Reasoning, Experiment Planning

Business Solutions
Interactive Chatbots that Learn from Experience with Customers, Regulatory Support, Prediction, Marketing

Here is a breakdown of AI…

If I say, **Sky**, you would likely say…. **Blue**

If I say, **grass**, you would likely say…. **Green**

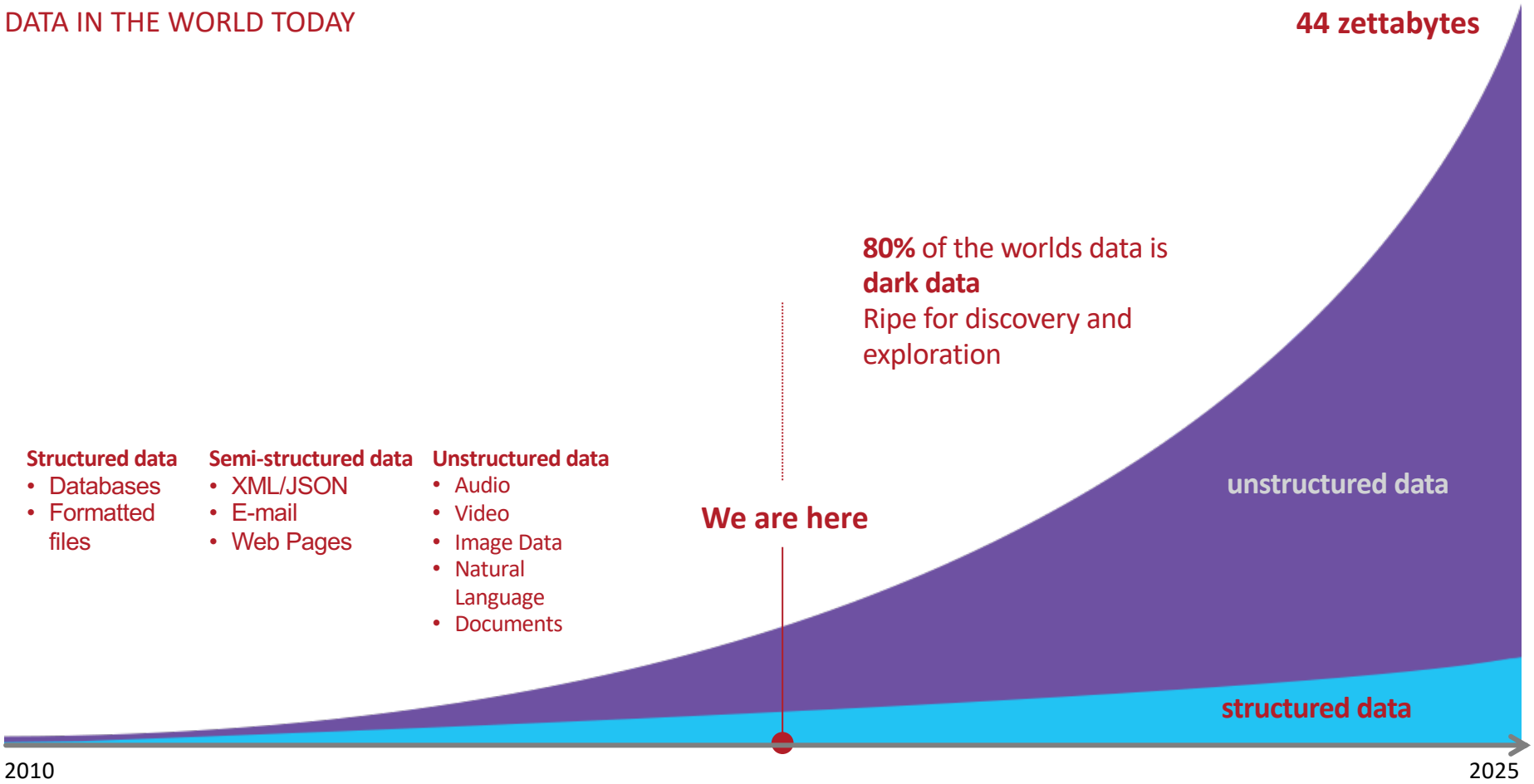
If I say, **AI**, I encourage you to say…. **Machine Learning**

If I say, **machine learning**, I'd like to think… **Prediction / Classification**

1) Supervised learning	**Regression**	**Classification**	**Naïve Bayes**	**KNN**
2) Unsupervised learning	**Apriora**	**K-means**	**Clustering**	
3) Reinforcement learning	**Markov Decision Process**		**Q-learning**	

…and what comprises **algorithms'** favorite food???…. **Data**

DATA IN THE WORLD TODAY



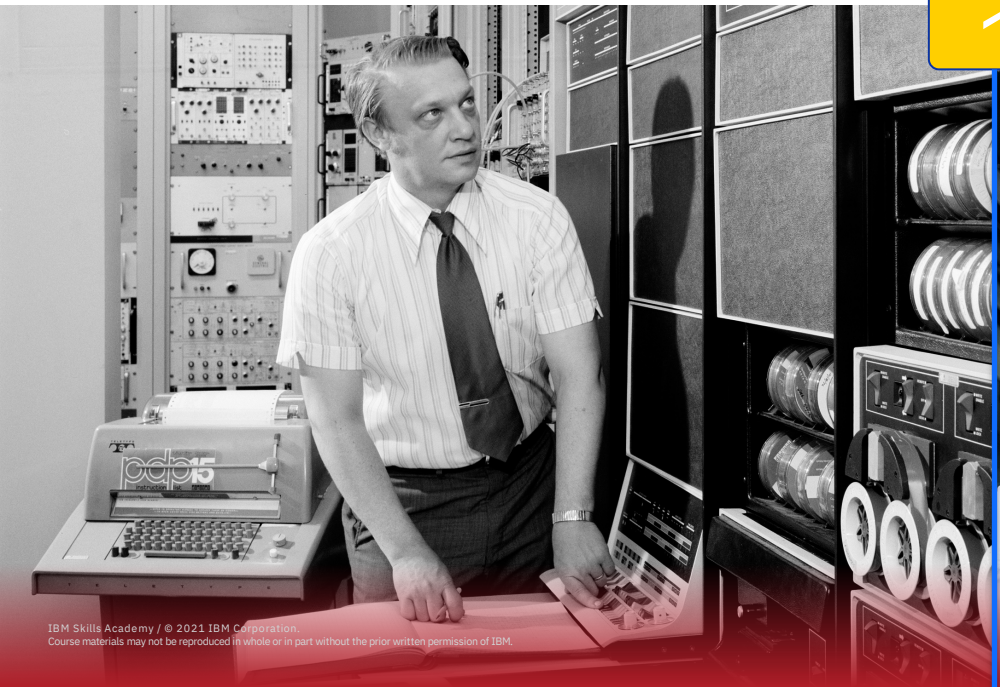
Traditional systems and Cognitive systems

Traditional systems

Deterministic
Static

Cognitive systems

Probabilistic
Self-improving

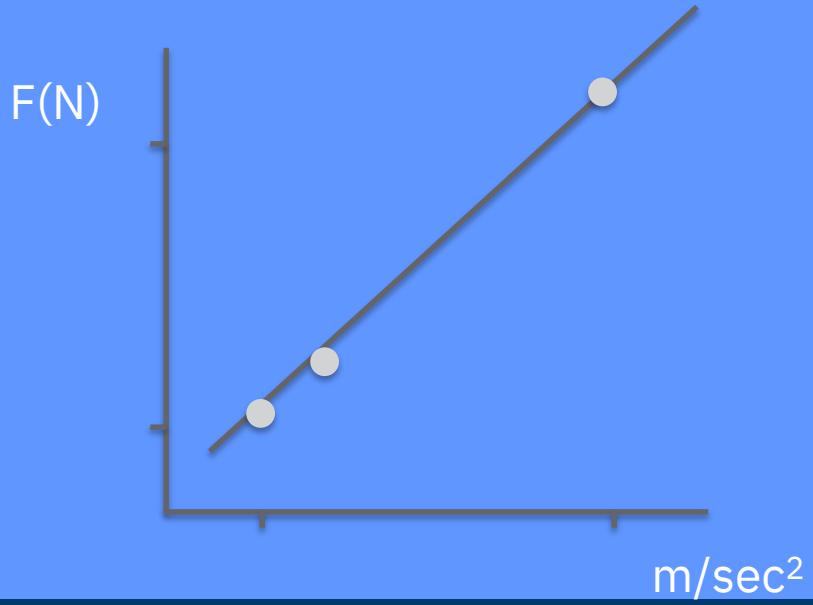


Traditional

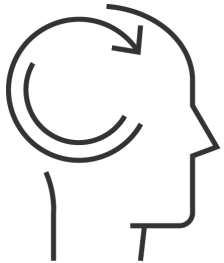
Deterministic Systems

F=ma

C=2Kg



Cognitive Systems understand, reason, learn and interact



Understanding

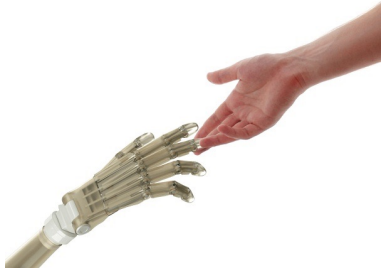
Cognitive systems understand like humans do.

Reasoning

They reason underlying ideas and concepts. They debate. They infer and extract concepts.

Learning

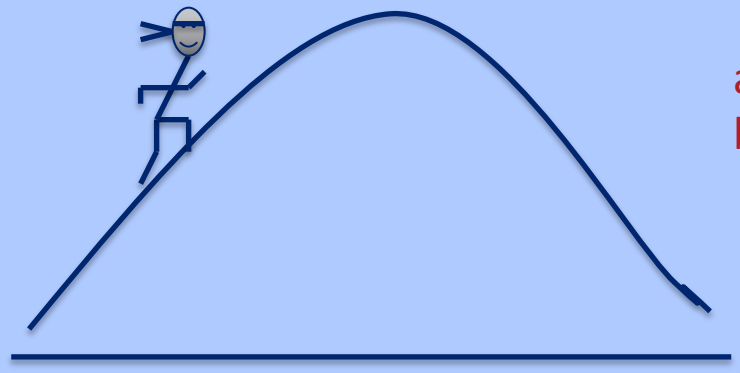
They never stop learning. Advancing with each new piece of information, interaction, and outcome. They develop “expertise.”



Interact

… Allowing them to interact with humans.

Machine learning is blind

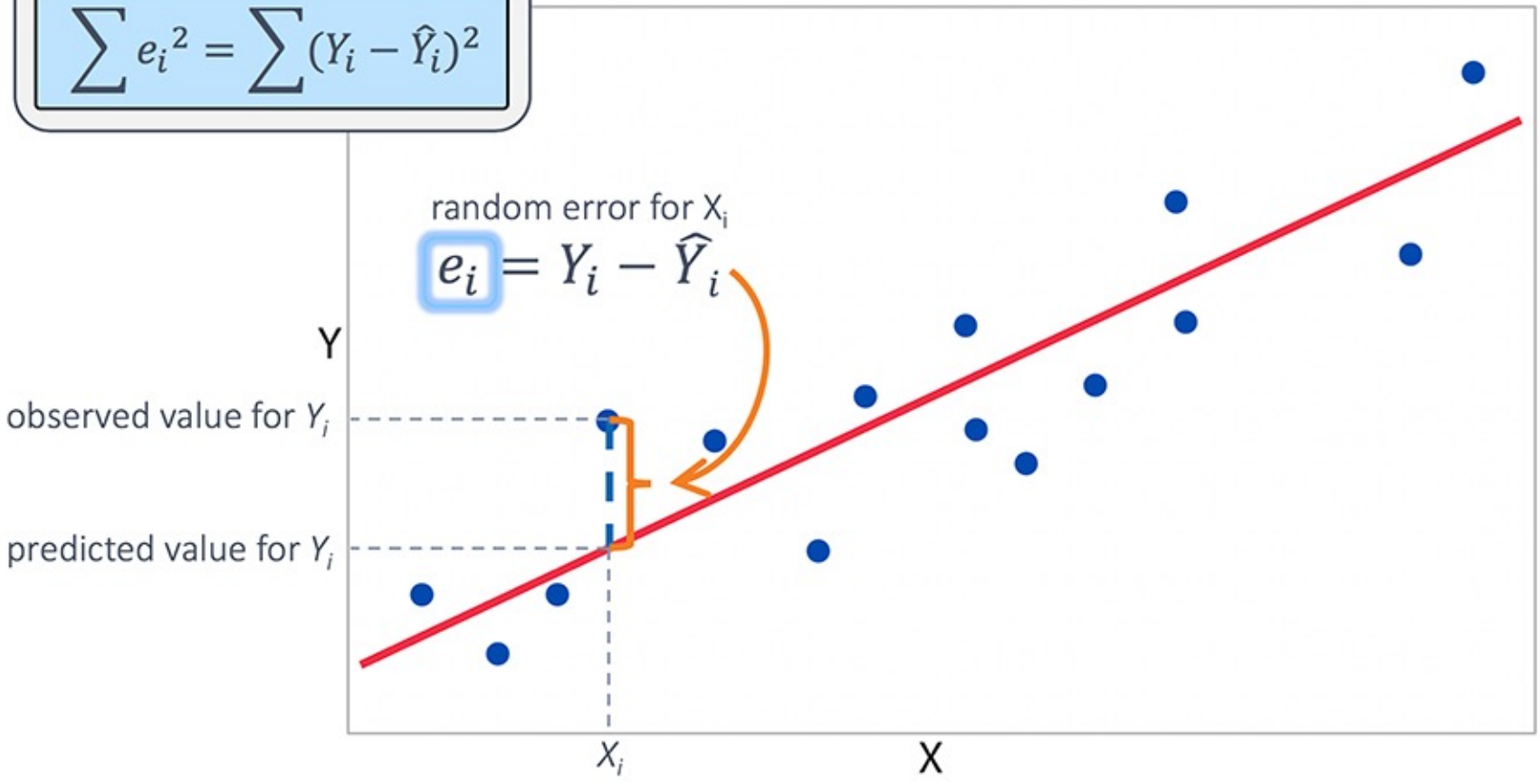


Climb to the top of the hill
Under two conditions:

a) Must do it blindfolded
b) In as minimum steps as possible

Method of Least Squares

$$\sum e_i^2 = \sum (Y_i - \hat{Y}_i)^2$$



Predicting your grades using neural nets

X	hrs study	hrs sleep	Grade	y
	7	5	78	
	6	8	93	
	8	2	67	
	5	5	?	$\hat{y}$

Supervised learning

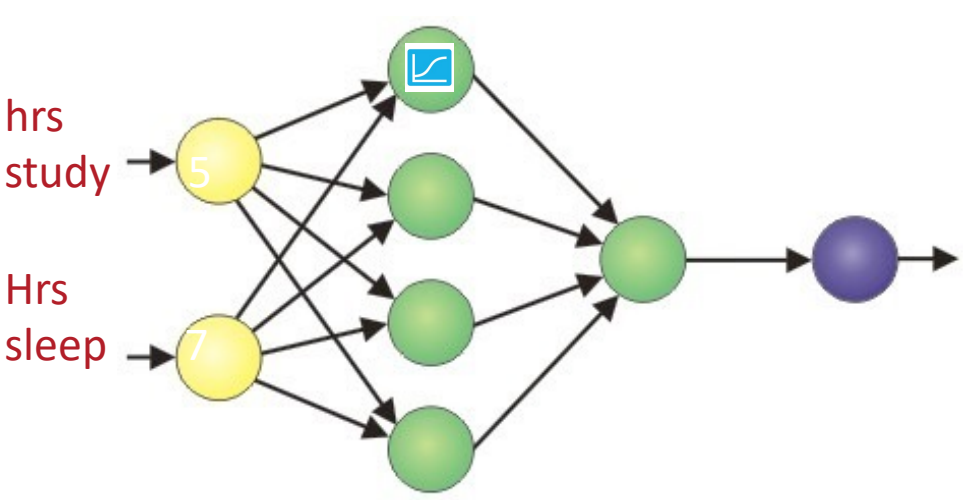
This is a regression problem

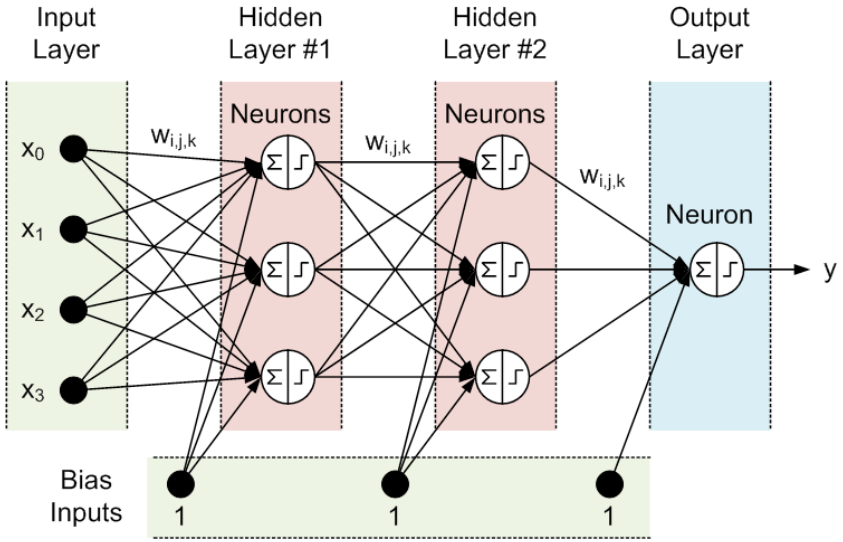
Not a classification problem

$X_{norm} = x / \max(x)$

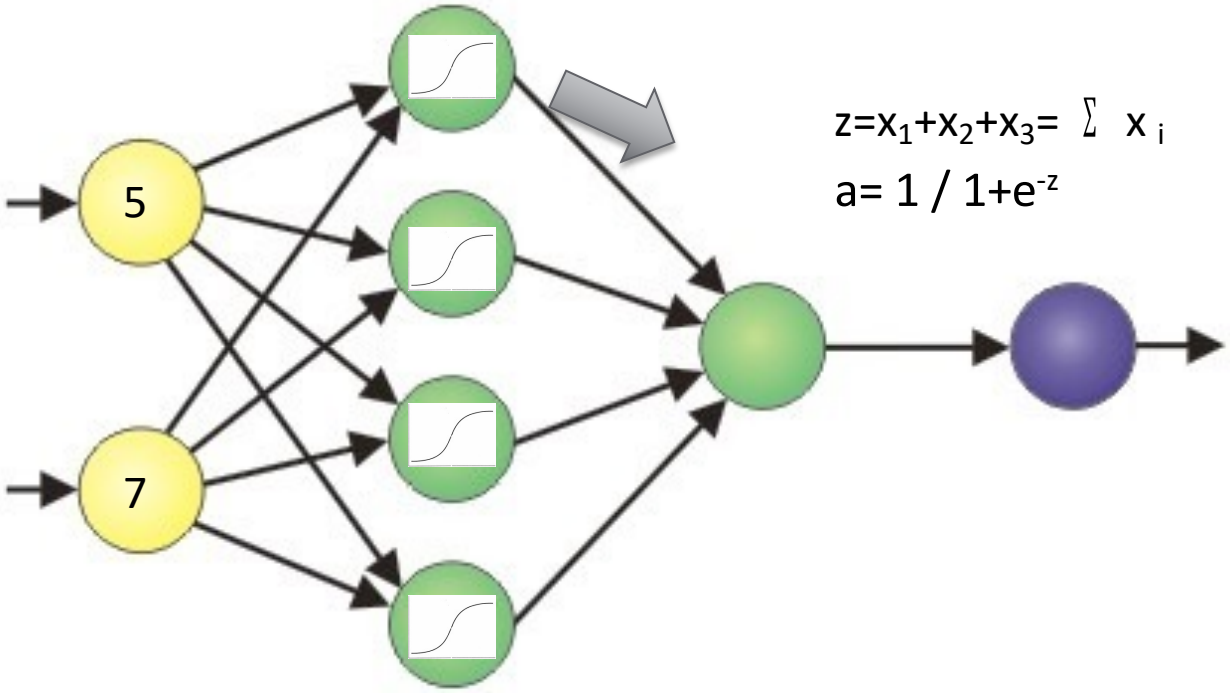
$Y_{norm} = y / \max(y)$

Basic structure of a neural net



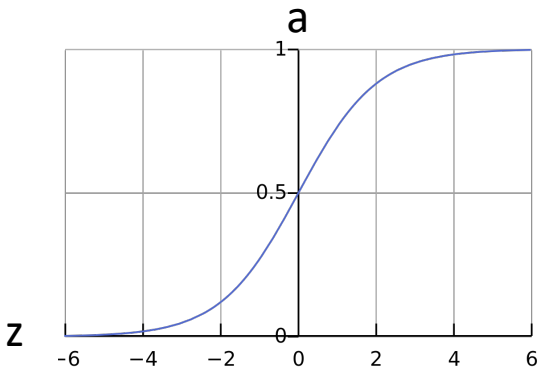


Sigmoid Operation

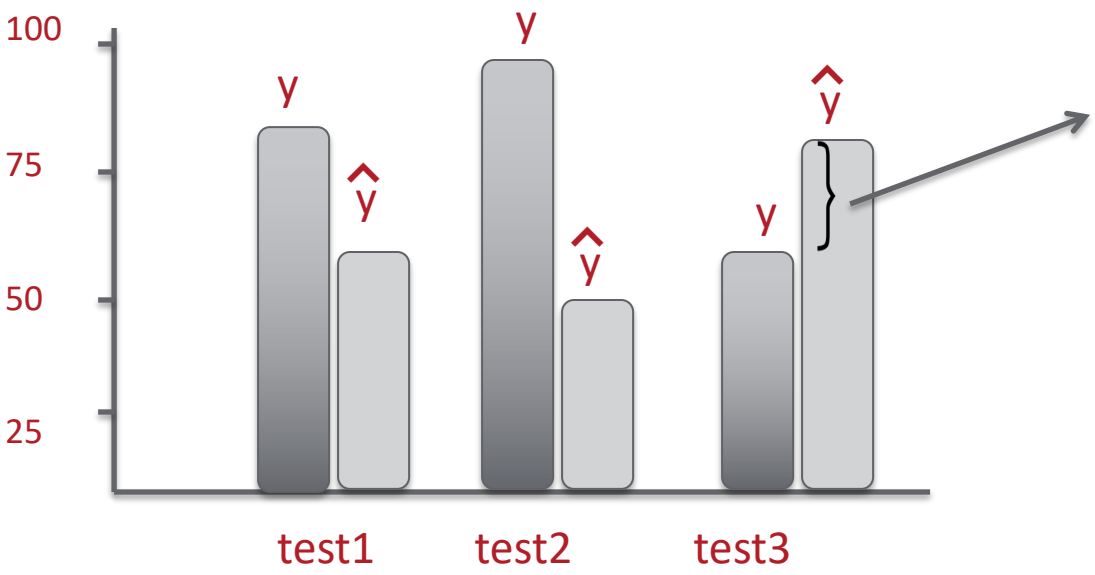


$z = x_1 + x_2 + x_3 = \sum x_i$

$a = 1 / 1 + e^{-z}$



Training neural network = minimizing cost function

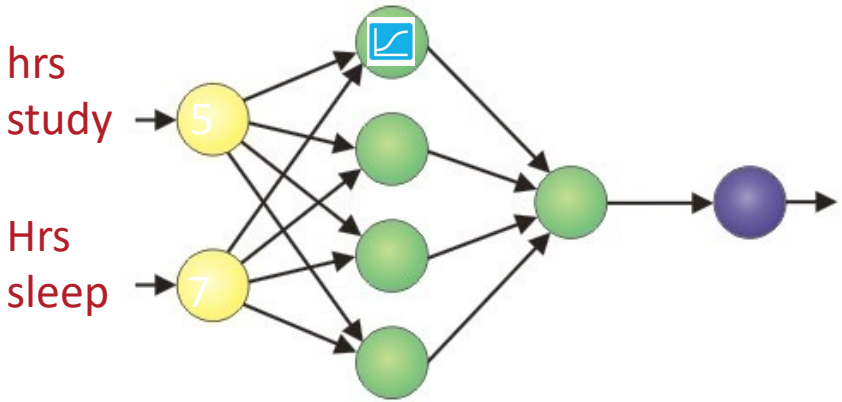


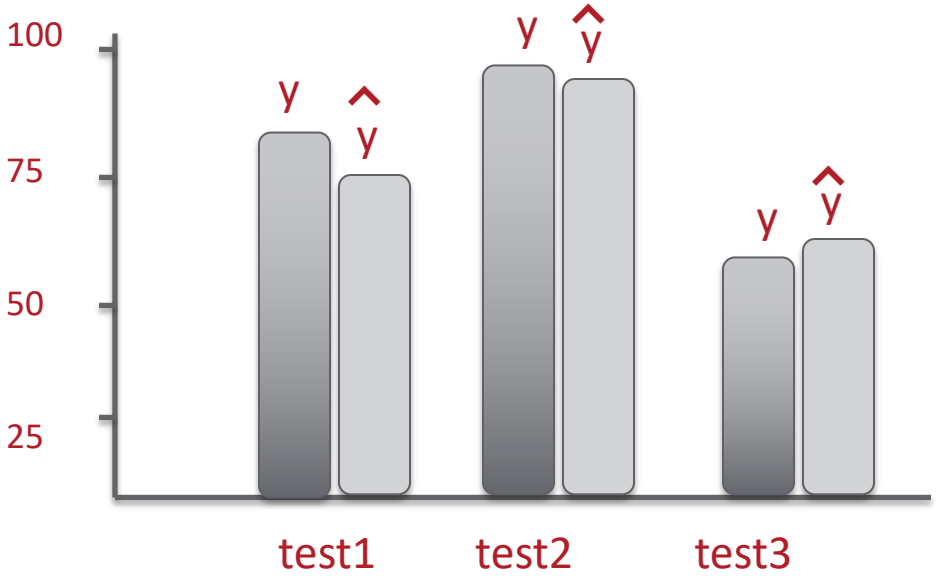
$e = y - \hat{y}$

$j = \text{cost} = e_1^2 + e_2^2 + e_3^2$

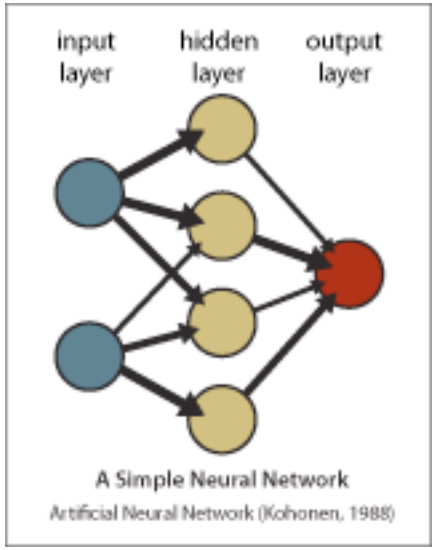
$j = \sum \frac{1}{2} (y - y_{hat})^2$

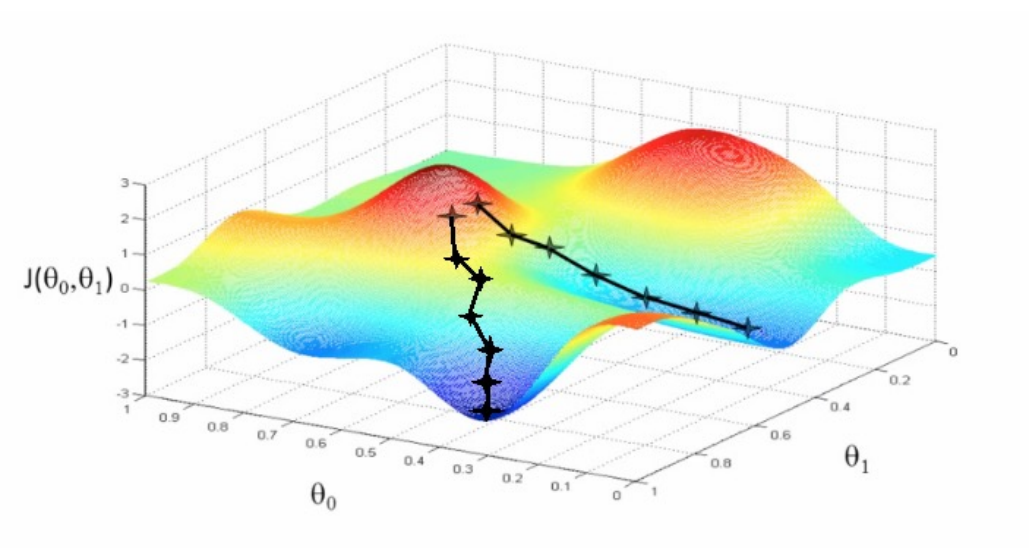
Backpropagation



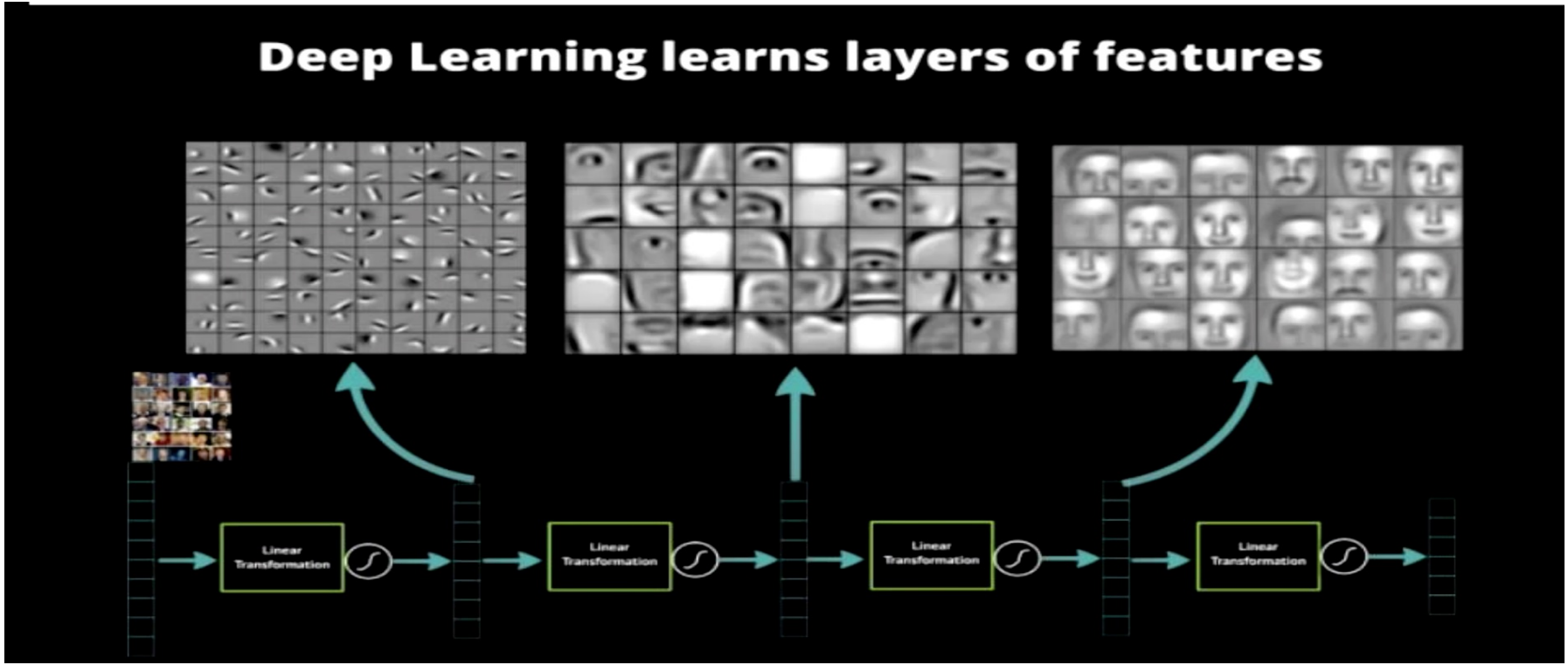


About neural networks





Deep learning is about hidden layers



Brute Statistics versus Artificial Neural Network

Regression takes the data and tries to find the result that minimizes prediction mistakes, maximizing what is called goodness of fit.

A physicist, an engineer and a statistician go on a hunting trip....

Being precisely perfect on average can mean being actually wrong each time. Regression can keep missing several feet to the left or several feet to the right. Even if it averages out to be the correct answer, regression can mean never actually hitting the target.

Unlike regression, **machine learning** predictions might be wrong on average, but when the prediction miss, they often don't miss by much. Statisticians describe this as allowing some bias in exchange for reducing variance.

Inventing a new machine learning method involves proving that it works better in practice. In contrast, inventing a regression method requires first proving that it works in theory, it requires the articulation of a hypothesis.

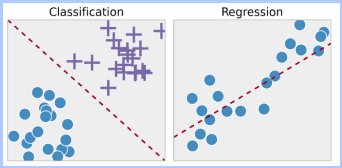
Machine learning has less need to specify in advance what goes into the model and can accommodate the equivalent of much more complex models with many more interactions between variables.

These excerpts are taken from the book **Prediction Machines** by Ajay Agrawal, Josh Gans and AVI Goldfarb

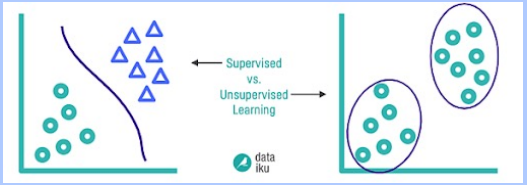
THREE TYPES OF MACHINE LEARNING

What are the three machine learning approaches?

- Supervised learning

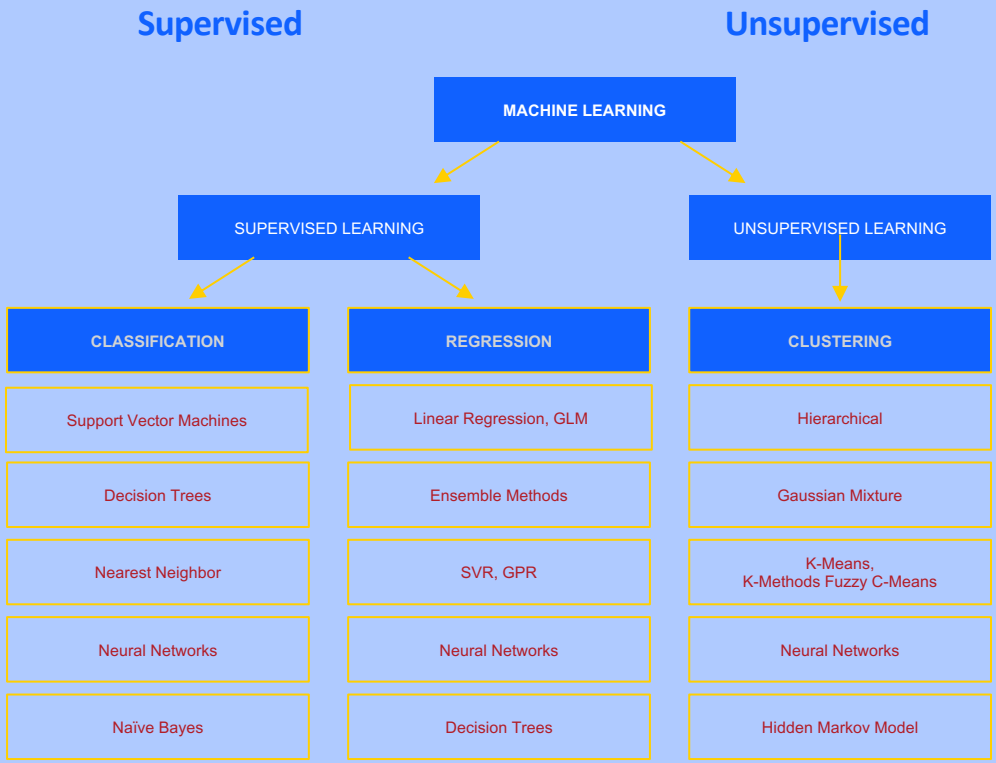


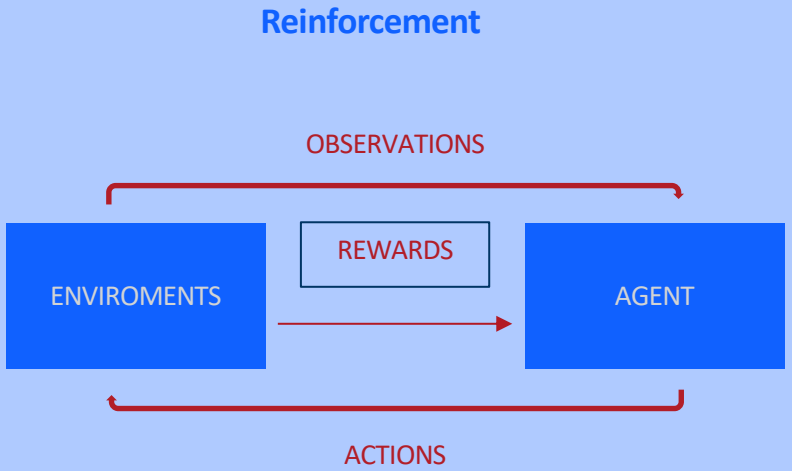
- Unsupervised learning



- Reinforcement learning

Algorithms used with machine learning methods





Supervised vs. Unsupervised Machine Learning

Parameters	Supervised ML techniques	Unsupervised ML techniques
Process	In a supervised learning model, input and output variables are given.	In unsupervised learning model, only input data will be given
Input data	Algorithms are trained using labeled data.	Algorithms are used against data which is not labeled
Algorithms used	Support vector machine, Neural network, Linear and logistics regression, random forest, and Classification trees.	Unsupervised algorithms can be divided into different categories: like Cluster algorithms, K-means, Hierarchical clustering, etc.
Computational complexity	Supervised learning is a simpler method.	Unsupervised learning is computationally complex
Use of data	Supervised learning model uses training data to learn a link between the input and the outputs.	Unsupervised learning does not use output data.
Accuracy of results	Highly accurate and trustworthy method.	Less accurate and trustworthy method.
Real-time learning	Learning method takes place offline.	Learning method takes place in real time.
Number of classes	Number of classes is known.	Number of classes is not known.
Main drawback	Classifying big data can be a real challenge in Supervised Learning.	You cannot get precise information regarding data sorting, and the output as data used in unsupervised learning is labeled and not known.

What is reinforcement learning

- Reinforcement Learning is a feedback-based Machine learning technique in which an agent learns to behave in an environment by performing the actions and seeing the results of actions.
- For each good action, the agent gets positive feedback, and for each bad action, the agent gets negative feedback or penalty.
- In Reinforcement Learning, the agent learns automatically using feedbacks without any labeled data, unlike supervised learning.
- Since there is no labeled data, so the agent is bound to learn by its experience only.

When do I use reinforcement learning

- RL solves a specific type of problem where decision making is sequential, and the goal is long-term, such as **game-playing, robotics**, etc. The agent interacts with the environment and explores it by itself.
- The primary goal of an agent in reinforcement learning is to improve the performance by getting the maximum positive rewards.
- The agent learns with the process of hit and trial, and based on the experience, it learns to perform the task in a better way. Hence, we can say that ***"Reinforcement learning is a type of machine learning method where an intelligent agent (computer program) interacts with the environment and learns to act within that."*** How a Robotic dog learns the movement of his arms is an example of Reinforcement learning.
- The agent continues doing these three things (**take action, change state/remain in the same state, and get feedback**), and by doing these actions, the agent learns and explores the environment.
- The agent learns that what actions lead to positive feedback or rewards and what actions lead to negative feedback penalty. As a positive reward, the agent gets a positive point, and as a penalty, it gets a negative point.

HOW DECISION TREES PREDICT AND CLASSIFY

Predict if Nemra will commute to the office

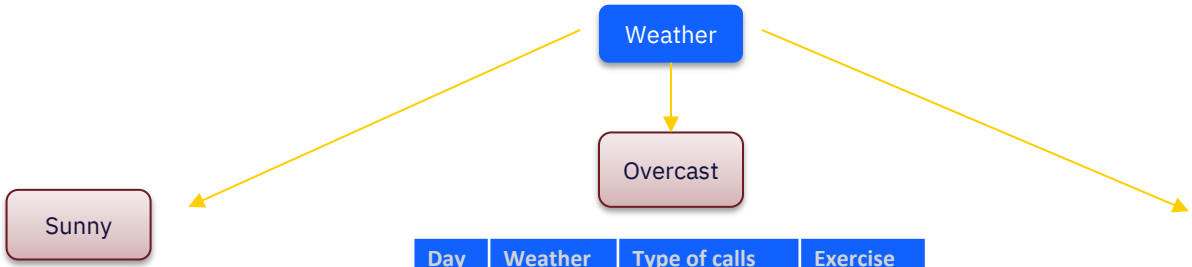
- **Hard to guess under what conditions Nemra will work from home or drive to the office.**
- Let's divide and conquer:
- Split into subsets
- Are the all pure (all yes or all no)
- If yes: stop
- If no: repeat

Day	Weather	Type of calls	Exercise	Commutes
D1	Sunny	Video Conference	Walk	No
D2	Sunny	Video Conference	Gym	No
D3	Overcast	Video Conference	Walk	Yes
D4	Rain	Video Conference	Walk	Yes
D5	Rain	Telephone	Walk	Yes
D6	Rain	Telephone	Gym	No
D7	Overcast	Telephone	Gym	Yes
D8	Sunny	Video Conference	Walk	No
D9	Sunny	Telephone	Walk	Yes
D10	Rain	Telephone	Walk	Yes
D11	Sunny	Telephone	Gym	Yes
D12	Overcast	Video Conference	Gym	Yes
D13	Overcast	Telephone	Walk	Yes
D14	Rain	Video Conference	Gym	No

Day	Weather	Type of calls	Exercise	Commute?
D15	Rain	Video	Walk	?

The Decision Tree

9 yes / 5 no



Day	Weather	Type of calls	Exercise
D1	Sunny	Video	Walk
D2	Sunny	Video	Gym
D8	Sunny	Video	Walk
D9	Sunny	Telephone	Walk
D11	Sunny	Telephone	Gym

2 yes / 3 no
Split further

Day	Weather	Type of calls	Exercise
D3	Overcast	Video	Walk
D7	Overcast	Telephone	Gym
D12	Overcast	Video	Gym
D13	Overcast	Telephone	Walk

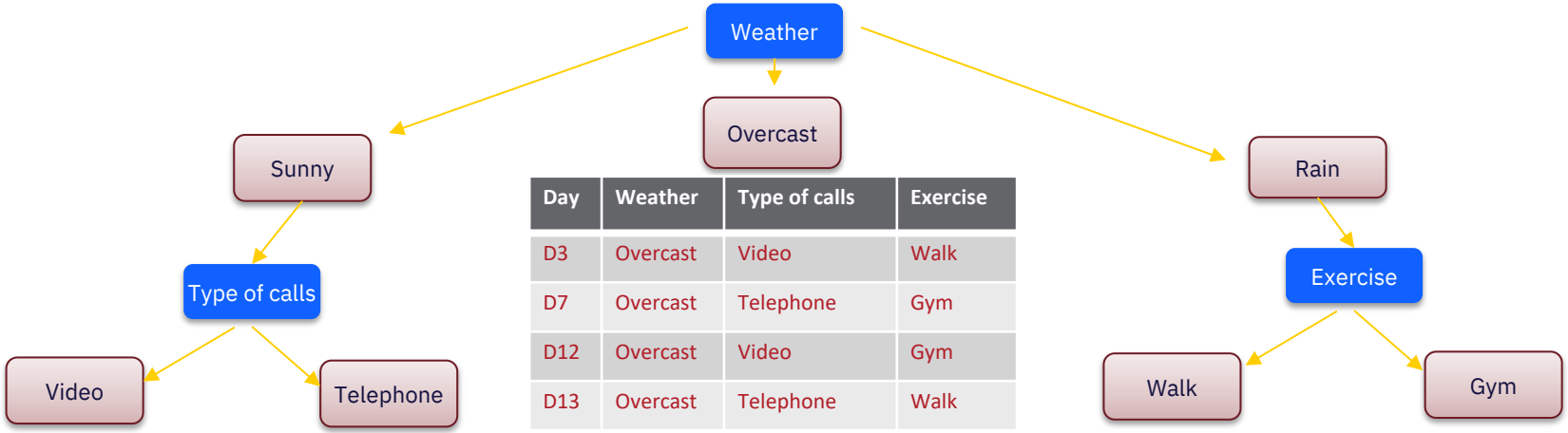
4 yes / 0 no
Pure subset

Day	Weather	Type of calls	Exercise
D4	Rain	Video	Walk
D5	Rain	Telephone	Walk
D6	Rain	Telephone	Gym
D10	Rain	Telephone	Walk
D14	Rain	Video	Gym

3 yes / 2 no
Split further

If Entropy, then branch further

9 yes / 5 no



Day	Weather	Type of calls	Exercise
D3	Overcast	Video	Walk
D7	Overcast	Telephone	Gym
D12	Overcast	Video	Gym
D13	Overcast	Telephone	Walk

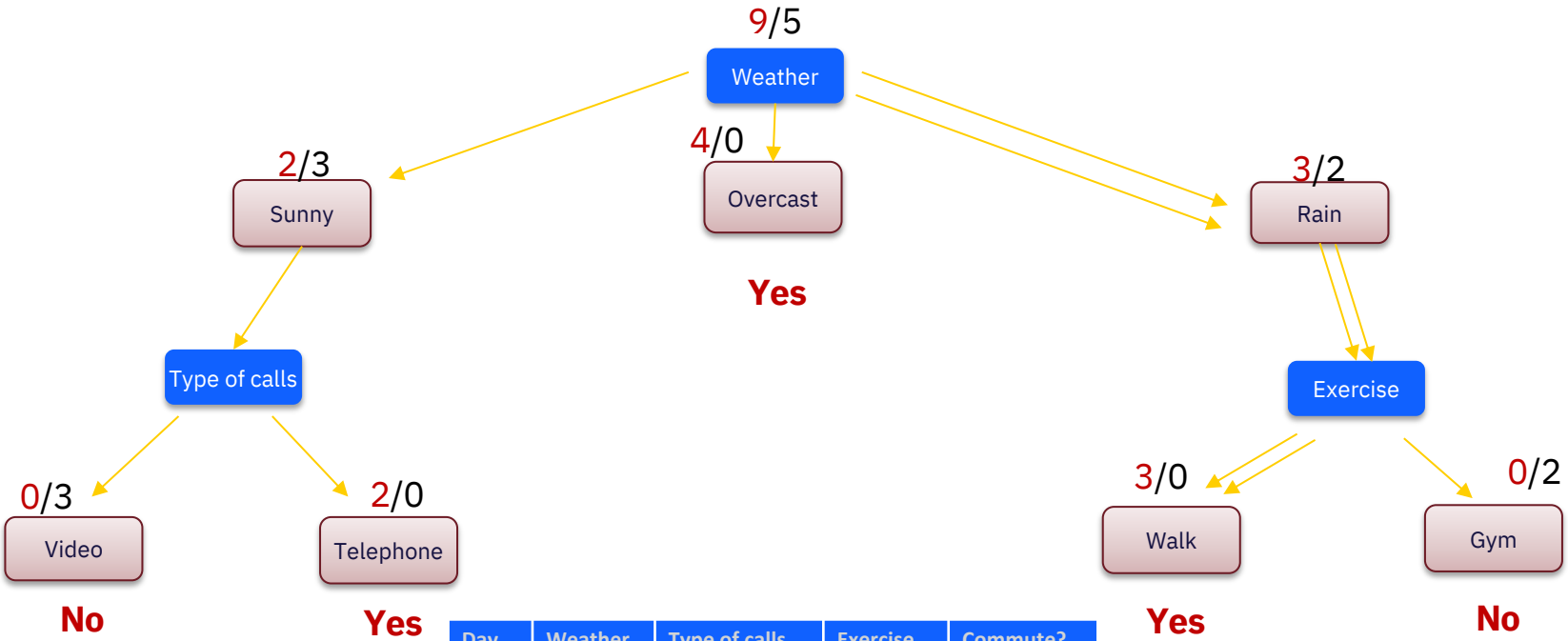
Day	Type of calls	Exercise
D1	Video	Walk
D2	Video	Gym
D8	Video	Walk

Day	Type of calls	Exercise
D9	Telephone	Walk
D11	Telephone	Gym

Day	Type of calls	Exercise
D4	Video	Walk
D5	Telephone	Walk
D10	Telephone	Walk

Day	Type of calls	Exercise
D6	Telephone	Gym
D14	Video	Gym

The Prediction



Day	Weather	Type of calls	Exercise	Commute?
D15	Rain	Video	Walk	? Yes

New data: Day 15

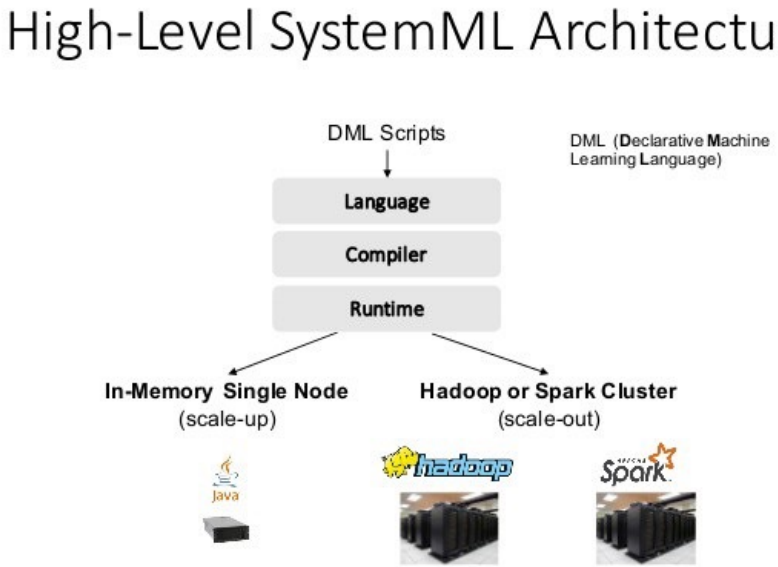
DEEP LEARNING ECOSYSTEM

Deep learning ecosystem

Platform as a Service Providers:
Deep learning services included as part of PaaS solutions. Technologies like IBM Cloud, Microsoft Azure, Amazon AWS or Google Developer Cloud.

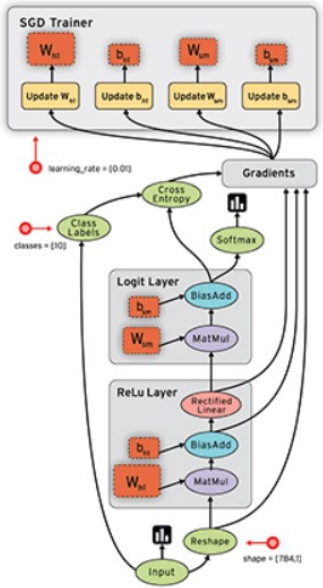
Deep Learning Frameworks:
Libraries and programming models that enable the fundamental constructs to build deep learning applications.

Deep learning framework: Apache SystemML (ML)



- The Apache SystemML language, Declarative Machine Learning (DML), includes linear algebra primitives, statistical functions, and ML-specific constructs that make it easier and more natural to express ML algorithms.
- DML significantly increases the productivity of data scientists by providing full flexibility in expressing custom analytics as well as data independence from the underlying input formats and physical data representations.

Deep learning framework: TensorFlow



- Google's TensorFlow deep learning framework was developed originally by the Google Brain Team for conducting research in machine learning and deep neural networks.
- **The framework's name is derived from the fact that it uses data flow graphs, where nodes represent a computation and edges represent the flow of information — in Tensor form — from one node to another.**

Deep learning framework: Torch

- Torch was based upon the scripting language Lua, which was designed to be portable, fast, extensible, and easy to use with an easy-to-use syntax.
- **Torch features many community-contributed packages, giving Torch a versatile range of support and functionality.**

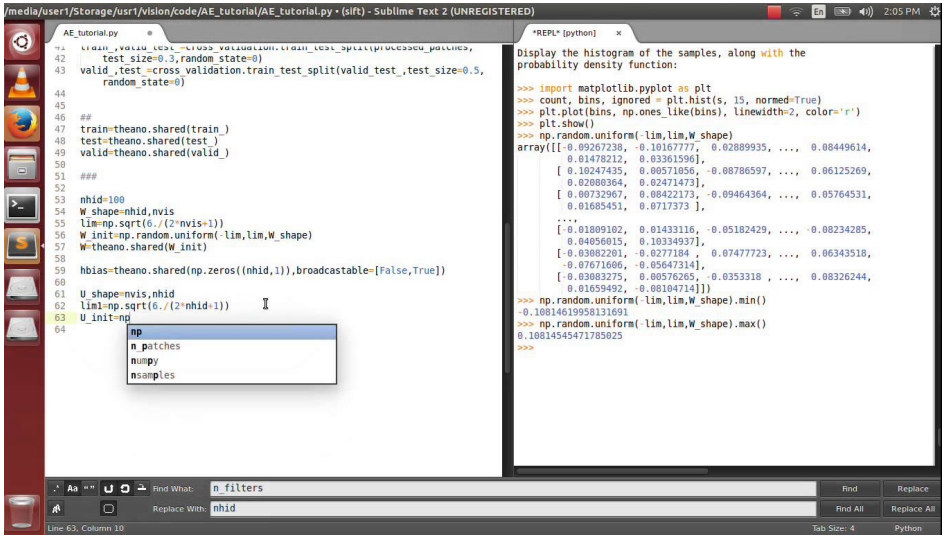
Simple NN in Torch

```
-- create closure to evaluate f(X) -- and df/dX
local feval = function(x)
   -- get new parameters
   if x ~= parameters then
      parameters:copy(x)
   end

   -- reset gradients
   gradParameters:zero()

   -- f is the average of all criterions
   local f = 0
```

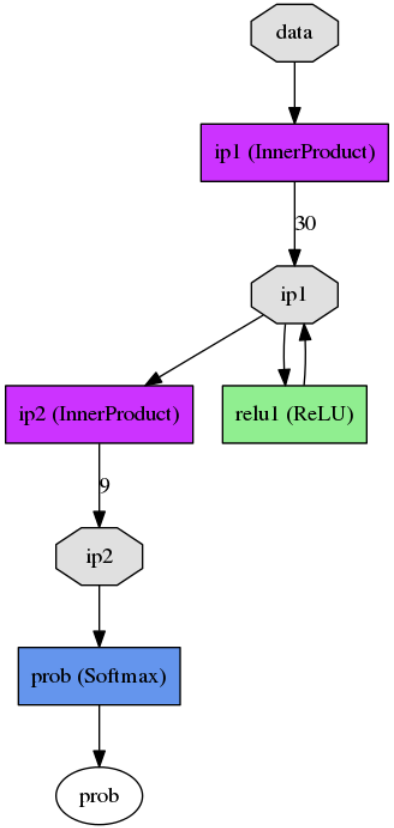
Deep learning framework: Theano



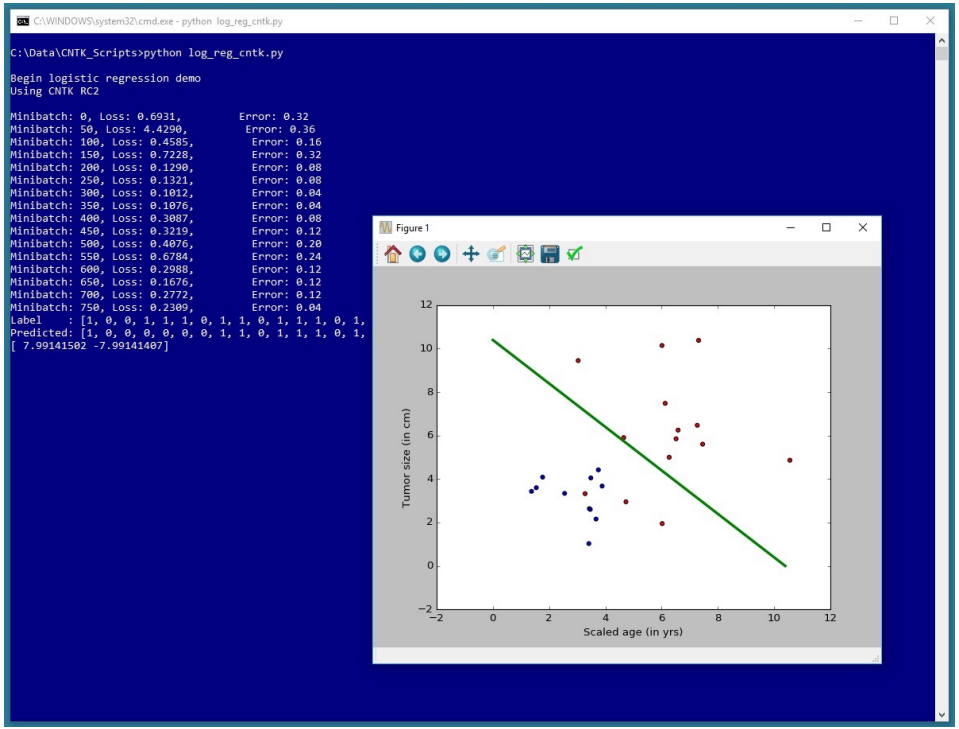
- Very popular within the academic research community, Theano is considered grand-daddy of deep-learning frameworks, which is written in Python.
- **Theano is a library that handles multidimensional arrays, like Numpy. Used with other libraries, it is well suited to data exploration and intended for research.**

Deep learning framework: Caffe

- Caffe is a well-known and widely used machine-vision library that ported Matlab's implementation of fast convolutional nets to C and C++. Caffe was developed at the Berkeley Vision and Learning Center (BVLC).
- **Caffe is useful for performing image analysis (Convolutional Neural Networks, or CNNs) and regional analysis within images using convolutional neural networks (Regions with Convolutional Neural Networks, or RCNNs).**



Deep learning framework: CNTK



- CNTK is Microsoft's open-source deep-learning framework. The acronym stands for "Computational Network Toolkit."
- **While CNTK appears to have a permissive license, it has not adopted one of the more conventional licenses, such as ASF 2.0, BSD or MIT.**

ROLES INTEGRATED ENVIROMENT

[7]
You need framework for **Machine Learning** and likely framework for **Deep Learning**
Scikit, TensorFlow, Keras, Torc, Theano, etc.

[6]
Choose your scientific computing and statistic packages:
SciPy, NumPy are widely utilized

[5]
Choose your visualization and plotting tools:
Matplotlib, PixieDust are top market trends

[4]
Choose your data munging libraries and tools:
Pandas is a very flexible library under the python framework

[3]
Choose your programming language:
python is most versatile, R and **Scala** are mostly specialized statistical packages

[2]
Now you need a development environment.
- Get **Jupyter Notebooks** (julia+python+R)
- Get it from **Anaconda** (www.continiuum.io)

[1]
So you have your collected data:
Is it structured, semi-structured, unstructured, mix?

Text editor	MS Excel	DB2, MS SQL	Hadoop	MongoDB	Watson Studio	Sentiment
CSV	xls	RDBMS	DFS	JSON	images	text

IS AI GOING TO REPLACE ME?

Human advantages over machines

Since AI systems depend on data, then humans have two advantages:

- Humans have world knowledge, hence awareness of self in relation to the environment.
- Humans are better at decision making with little data or in rare circumstances.

Humans have three types of data that machines don’t:

- Data from our senses, smell, taste, touch, hearing and intuition
- We are the ultimate arbitrators of our own preferences
- Privacy concerns restrict the data available to machines

When to Apply Machine Learning

- **Human expertise is absent** (e.g. Navigating on Mars)
- **Humans are unable to explain their expertise** (e.g. Speech recognition, vision, language)
- **Solution changes with time** (e.g. Tracking, temperature control, preferences)
- **Solution needs to be adapted to particular cases** (e.g. Biometrics, personalization)
- **The problem size is too vast for our limited reasoning capabilities**
  (e.g. Calculating webpage ranks, matching ads to Facebook™ pages)

Three major AI calibers

Artificial Narrow Intelligence (ANI):

Sometimes referred to as *Weak AI*, Artificial Narrow Intelligence is AI that specializes in *one* area. ANI can beat Jeopardy! World champion. Ask it to figure out a better way to store data on a hard drive, and it'll look at you blankly.

Artificial General Intelligence (AGI):

Sometimes referred to as *Strong AI*, or *Human-Level AI*, Artificial General Intelligence refers to a computer that is as smart as a human *across the board*—a machine that can perform any intellectual task that a human being can.

Artificial Superintelligence (ASI):

Oxford philosopher and leading AI thinker Nick Bostrom defines superintelligence as "an intellect that is much smarter than the best human brains in practically every field, including scientific creativity, general wisdom and social skills." Artificial Superintelligence ranges from a computer that's just a little smarter than a human to one that's trillions of times smarter—across the board.

Median Expert Prediction for AGI (2040)

Median Expert Prediction for ASI (2060)

1900

2000

Today

2100

waitbutwhy.com