Machine Learning

How Smart Can It Really Be?

March 11, 2019

Speaker

Shayne Champion

CISO

Conversant Group

Overview: Today's Agenda

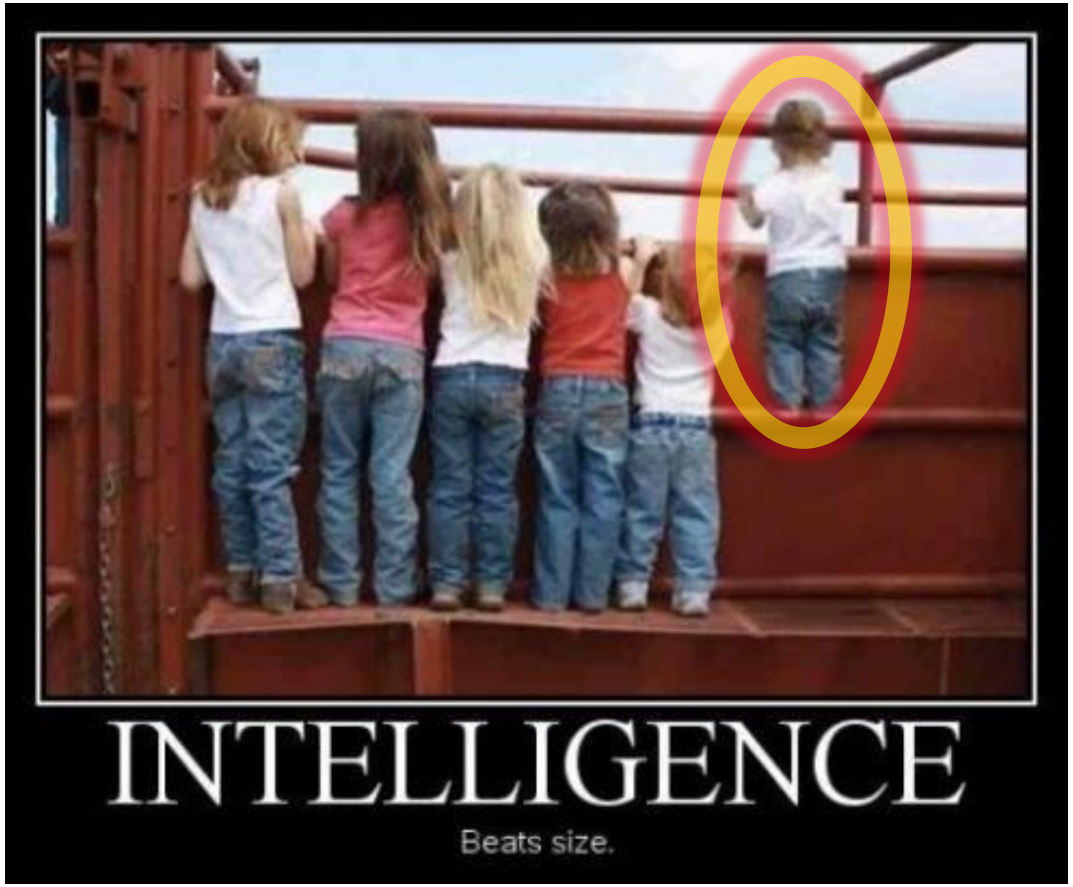
1) Definitions
2) Machine Learning
3) Neural Networks
4) Pitfalls
5) Cyber Applications

Definitions

What is Learning?

learn·ing /ˈlərniNG/ *noun*

The <u>ability</u> to acquire and apply knowledge and skills.



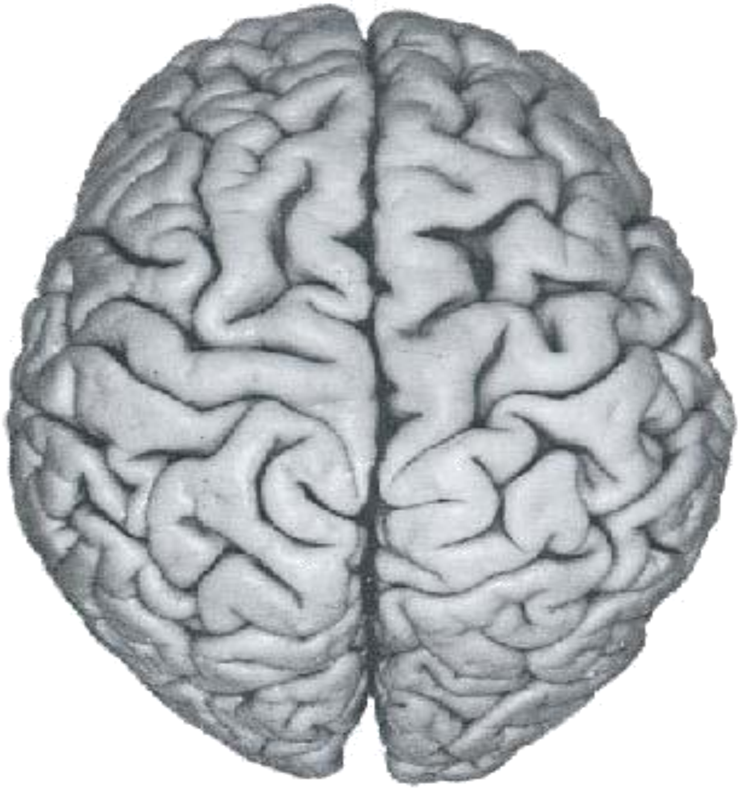
Source: google.com “define learning”; Machine Learning: For Beginners

What is Intelligence?

in·tel·li·gence /inˈteləjəns/ *noun*

The acquisition of knowledge or skills through experience, study, or by being taught.

Change influenced by previous experience



Source: google.com “define intelligence”

Artificial Intelligence (AI)

Machines that can perform tasks that are characteristic of **human intelligence**

(e.g., planning, understanding language, recognizing objects and sounds, learning, and problem solving)

Two types of AI

a) **General AI**:
Has *all* of the characteristics of human intelligence

b) **Narrow (Specific) AI**:
Exhibits *some* facet(s) of human intelligence, and can do that facet extremely well, but is lacking in other areas

Machine Learning

The Turing Test

The exhibition of natural intelligence in a machine a machine would be indistinguishable from a human being in natural language conversation.

Source: Machine Learning: For Beginners

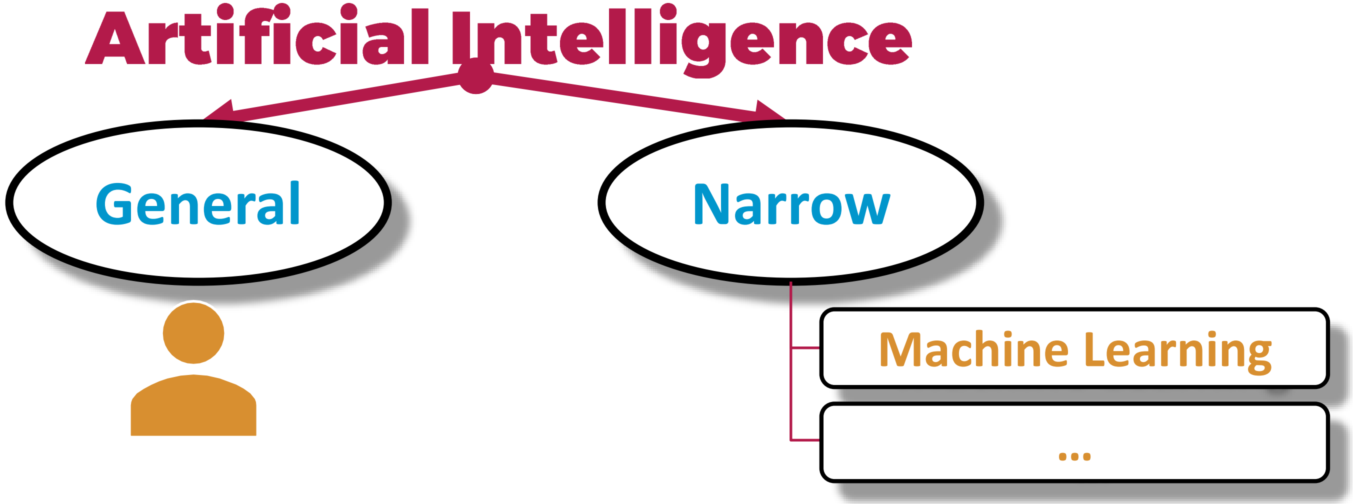
Recap: Artificial Intelligence

Intelligence:

The ***ability*** to acquire and apply knowledge and skills

Learning:

The ***acquisition*** of knowledge or skills


Artificial Intelligence

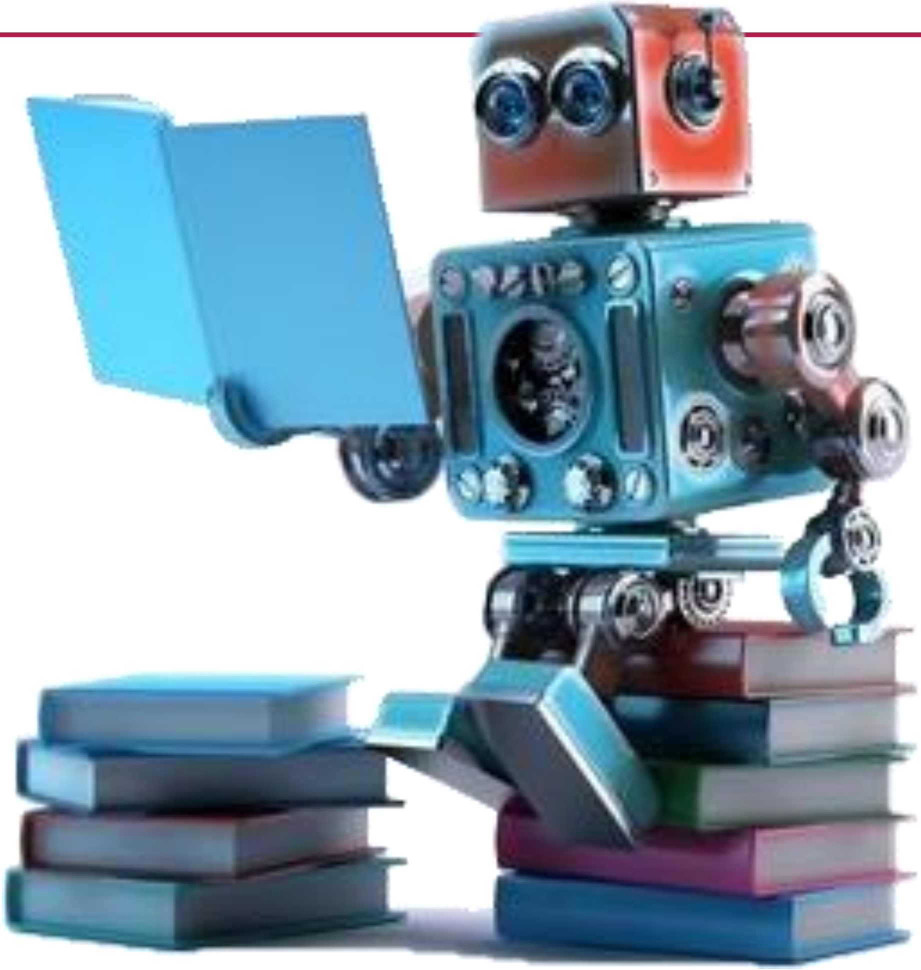
General

Narrow

Machine Learning

...

Machine Learning



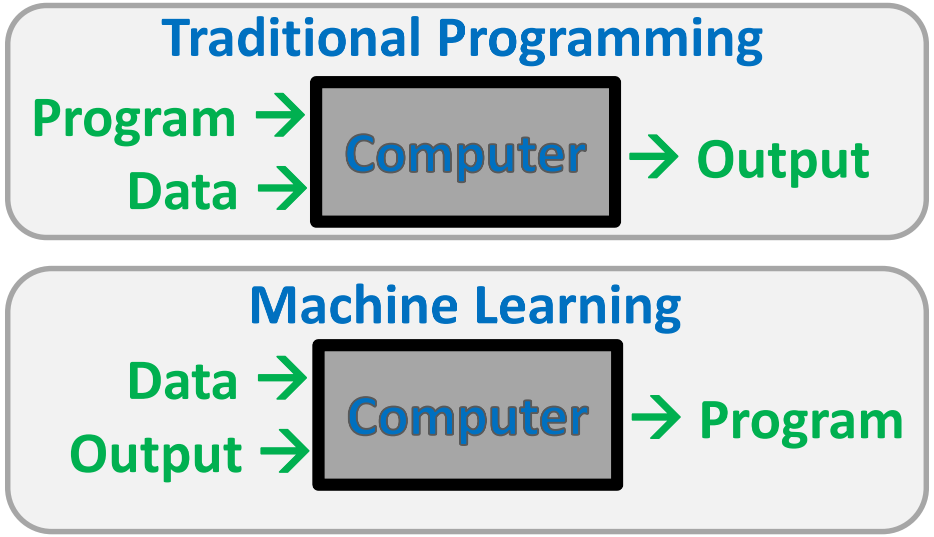
Machine Learning (ML)

Algorithms that receive data and apply statistical analysis to predict the output data within an acceptable range.

Goals of ML

a) Adapt and change from previous experience based on **pattern recognition** & **iteratively** adjust response without human intervention (the algorithm outputs become new inputs)

b) Standardize' the development of AI… 'without programming'



Traditional Programming

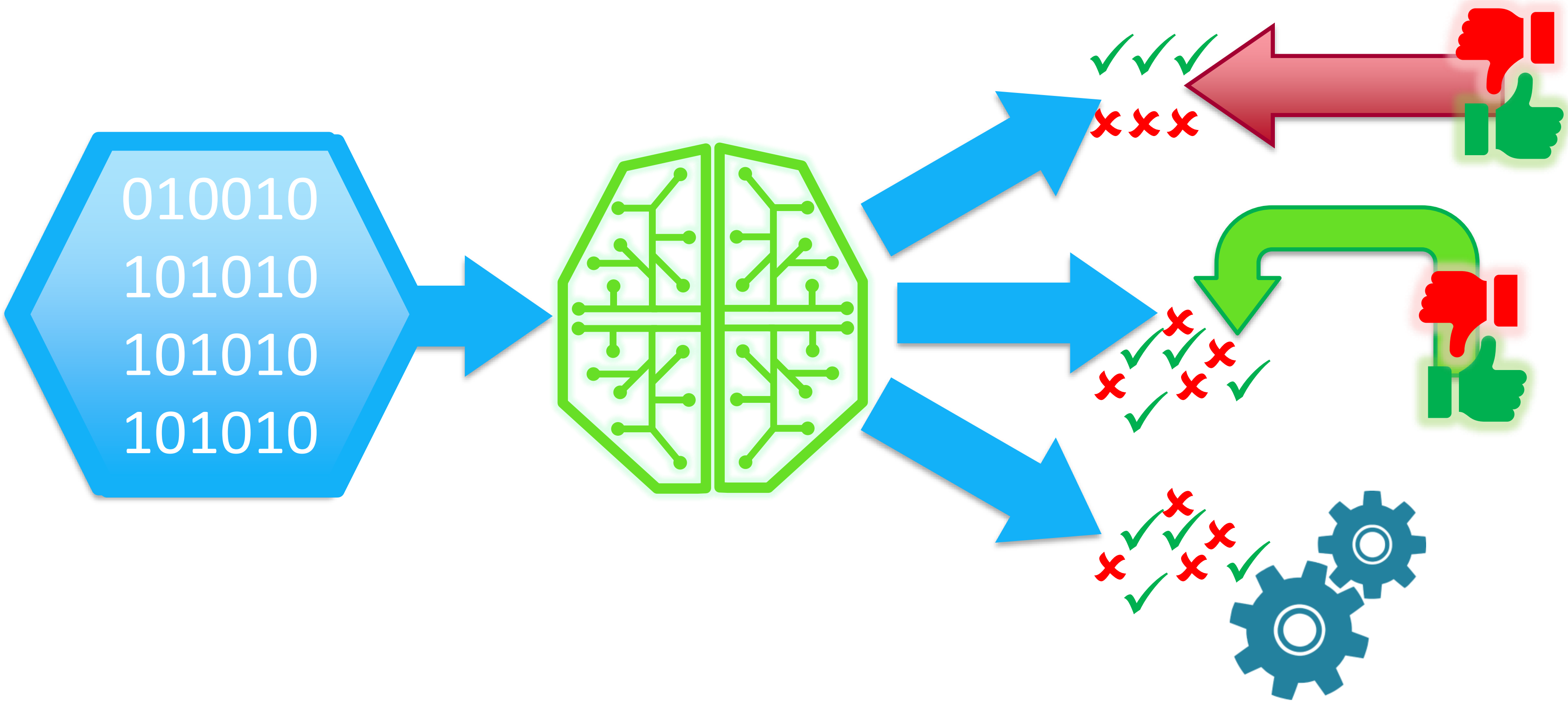
Program → Data → Computer → Output

Machine Learning

Data → Output → Computer → Program

Source: Machine Learning: For Beginners, How will AI and machine learning impact CSPs? https://inform.tmforum.org/data-analytics-and-ai/2017/08/will-ai-machine-learning-impact-csps/

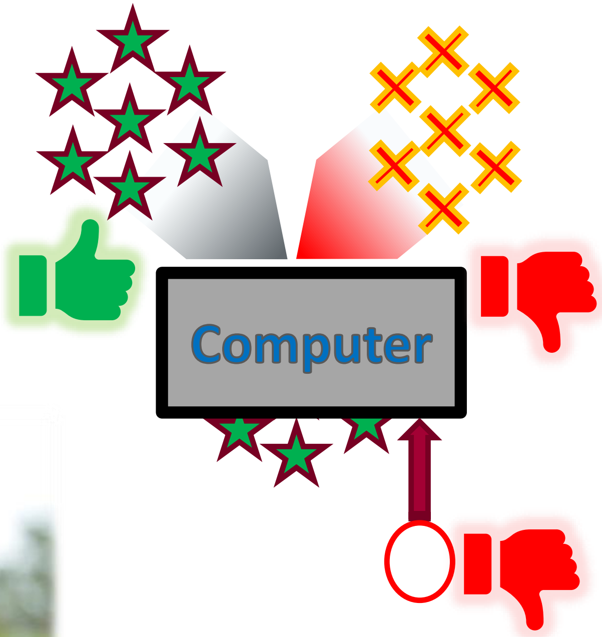
ML Types



Machine Learning Types

1) Supervised

- Regression (numeric)
- Classification (class || tag)



EXAMPLE:

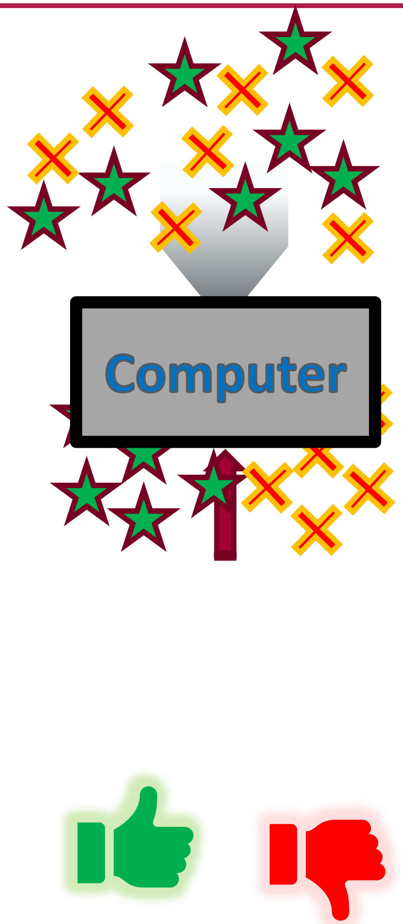
Source: Machine Learning: For Beginners, http://cdn2.hubspot.net/hubfs/305377/Supervised_vs_Unsupervised_ML.png

Machine Learning Types

1) Supervised

2) Re-enforced Learning

EXAMPLE:



Source: Machine Learning: For Beginners, http://cdn2.hubspot.net/hubfs/305377/Supervised_vs_Unsupervised_ML.png

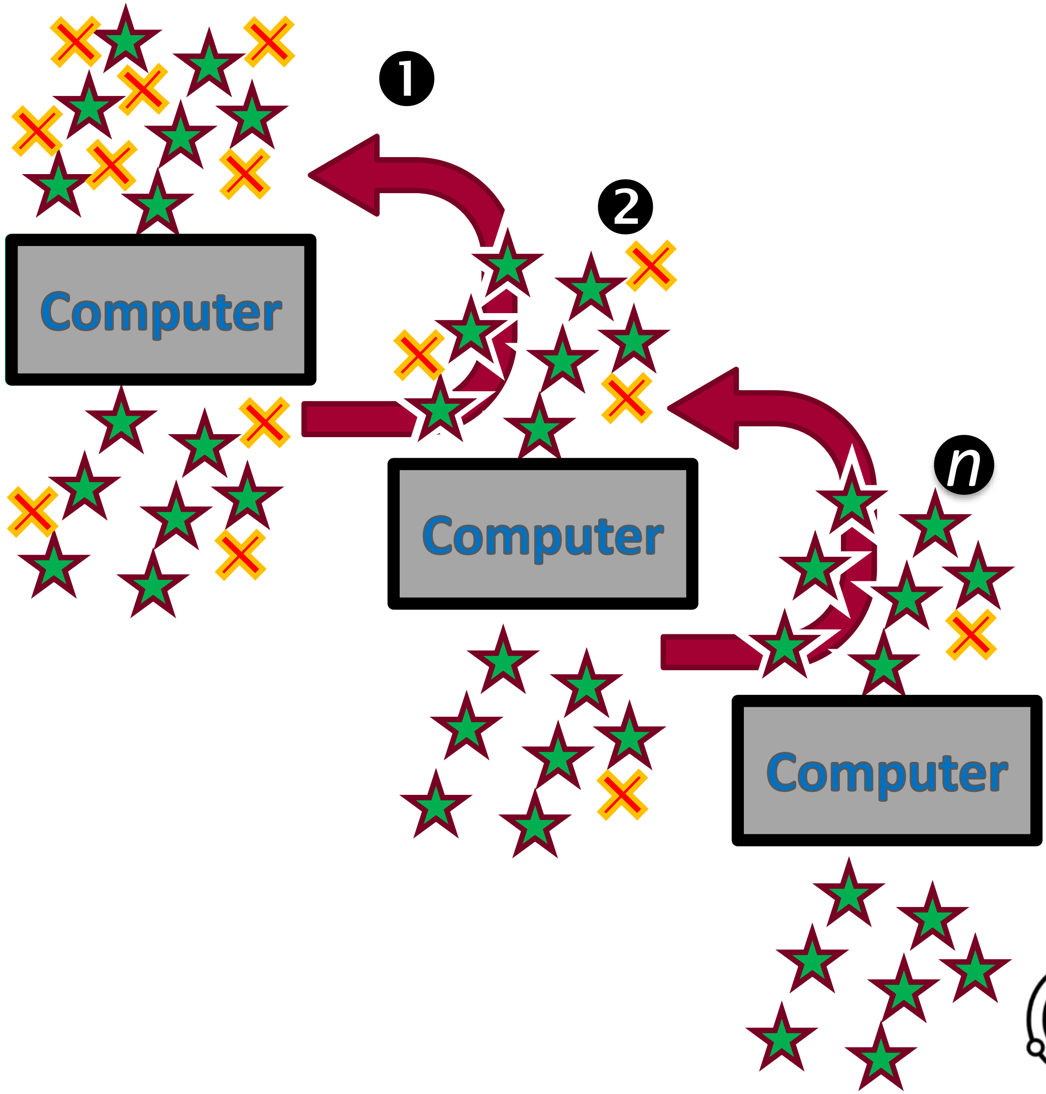
Machine Learning Types

1) Supervised

2) Re-enforced Learning

3) Unsupervised

Deep Learning



Source: Machine Learning: For Beginners, http://cdn2.hubspot.net/hubfs/305377/Supervised_vs_Unsupervised_ML.png

Machine Learning Types

1) Supervised

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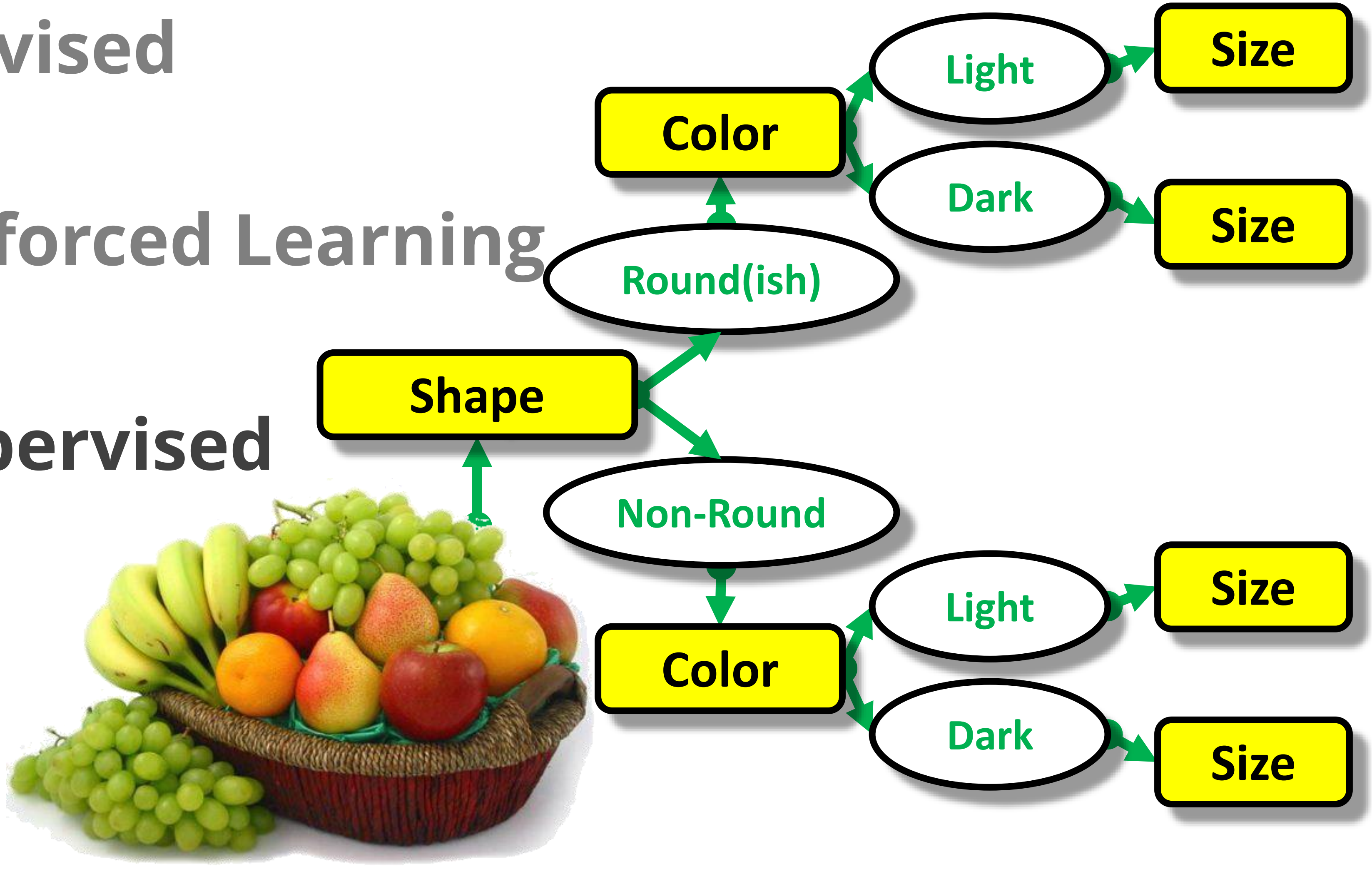
EXAMPLE:



Source: Machine Learning: For Beginners, http://cdn2.hubspot.net/hubfs/305377/Supervised_vs_Unsupervised_ML.png

Machine Learning Types

1) Supervised

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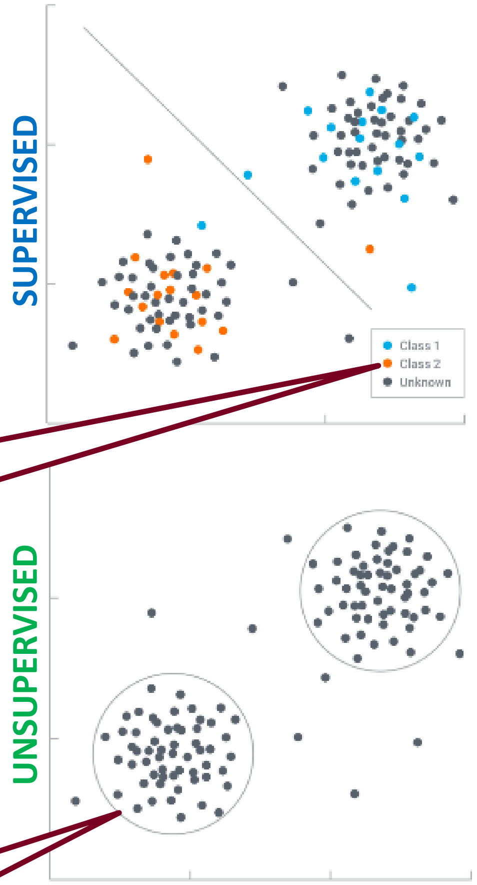
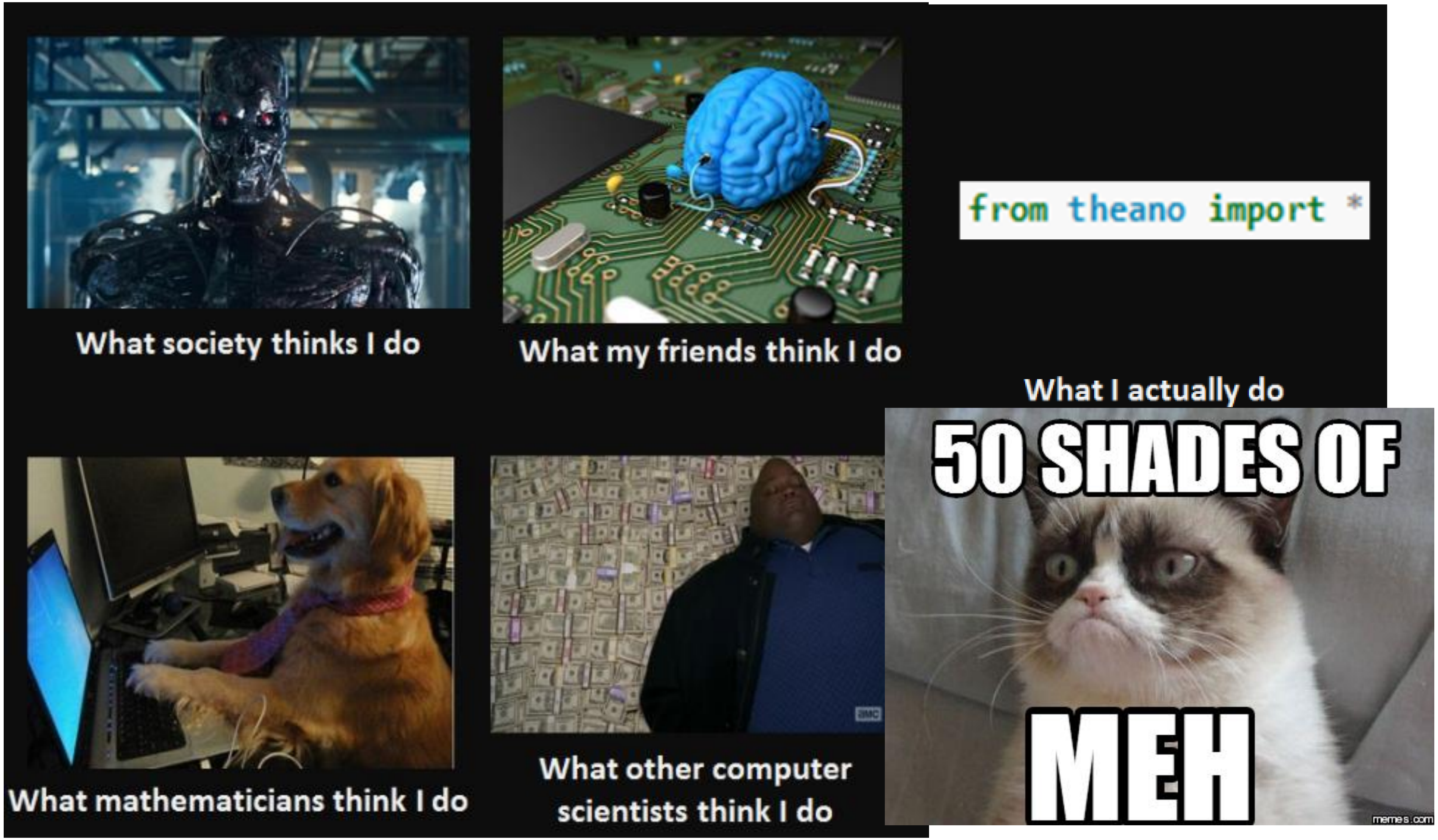


These are <CLASS>
(human defined)

These are Similar
(no value judgements)

Source: Machine Learning: For Beginners, http://cdn2.hubspot.net/hubfs/305377/Supervised_vs_Unsupervised_ML.png

Deep Learning


What society thinks I do
What my friends think I do
What I actually do
What mathematicians think I do
What other computer scientists think I do
50 SHADES OF
MEH
memes.com

```
from theano import *
```

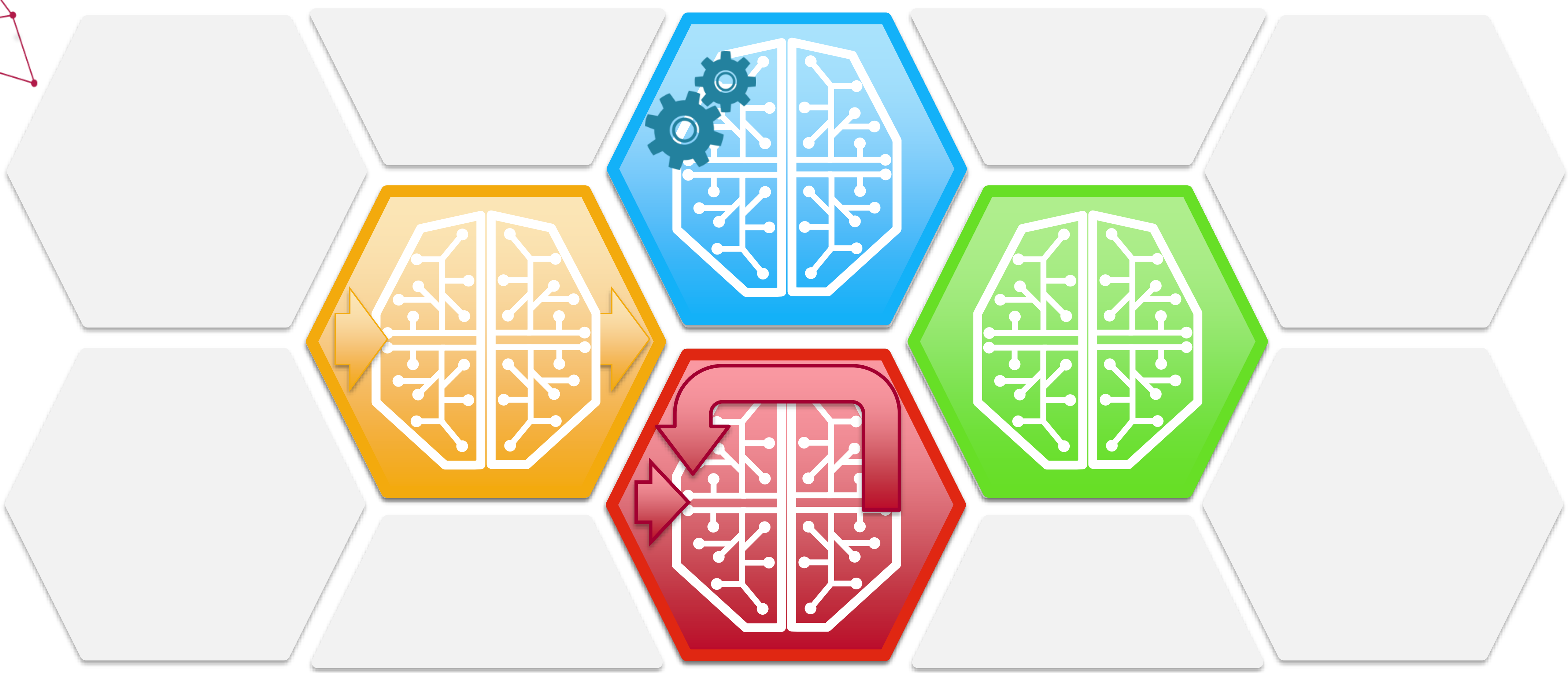
Recap: ML Types

1) Supervised
2) Re-enforced Learning
3) Unsupervised

INPUT	OUTPUT	FEEDBACK
Human Sorted	Human Review	Human
Unsorted	**Human Review**	**Human**
Unsorted	**Algorithm**	**Algorithm**

- **Unsupervised is more extensible**
- **Unsupervised cannot make value judgements**

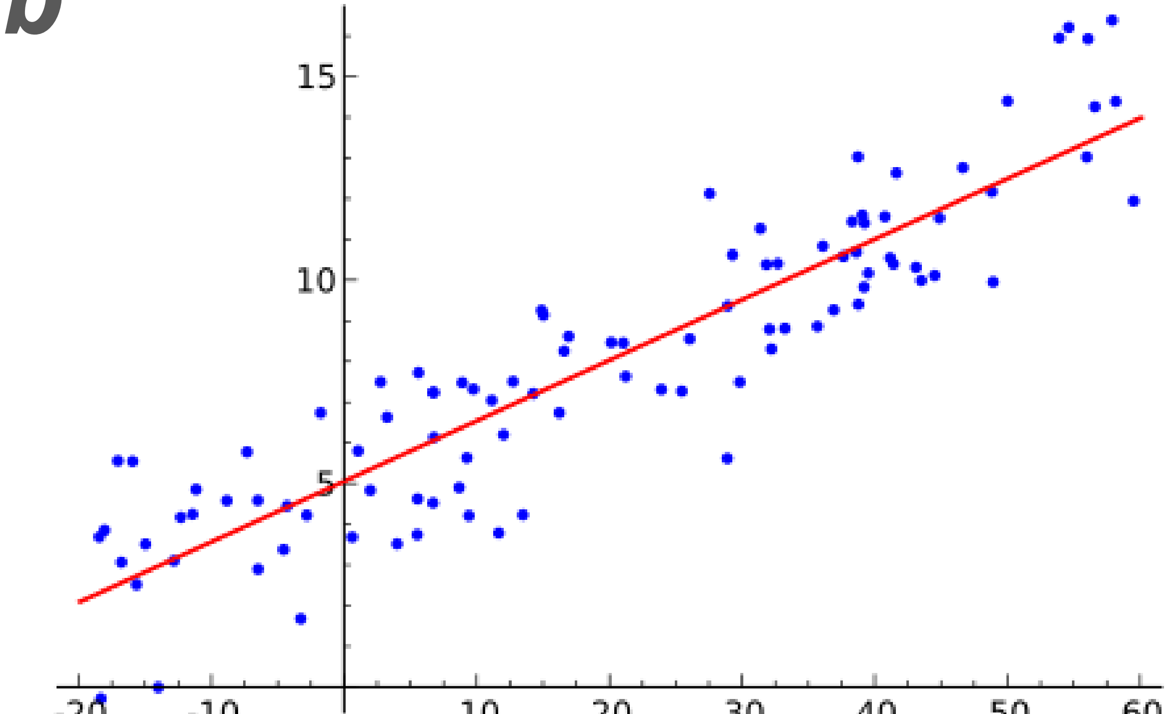
ML Methods



ML Methods: Linear Regression

A model of the relationship between a scalar **dependent variable** *Y* and **one or more explanatory variables** (or independent variables) denoted *X*.

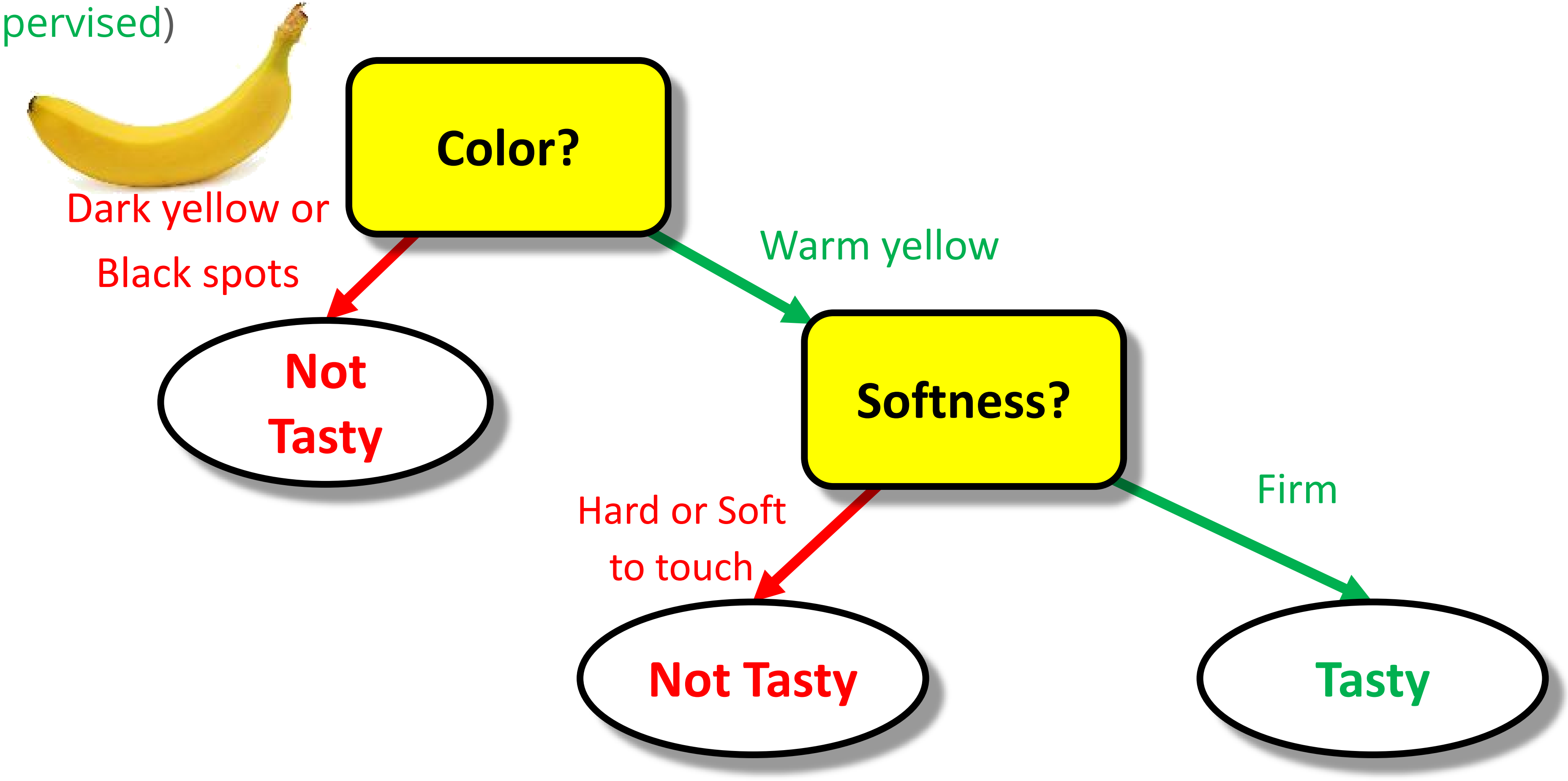
$$y = mx + b$$



Source: https://en.wikipedia.org/wiki/Linear_regressio

ML Methods: Decision Trees

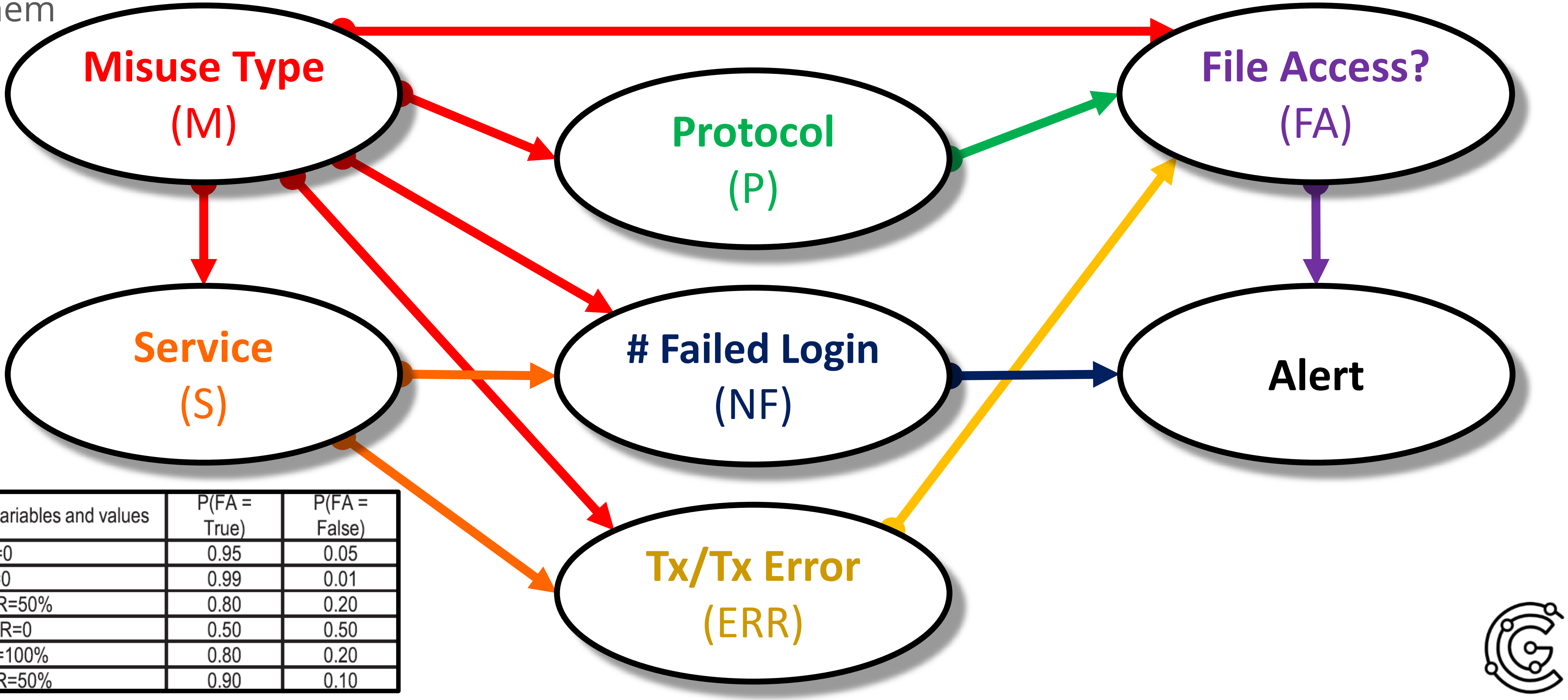
Data is continuously split according to certain parameters based on human input. (Supervised)



Source: Types of Machine Learning Algorithms, http://www.intechopen.com/books/new-advances-in-machinelearning

ML Methods: Bayesian Networks

A **probabilistic** graphical model representing **variables** and the **relationships** between them

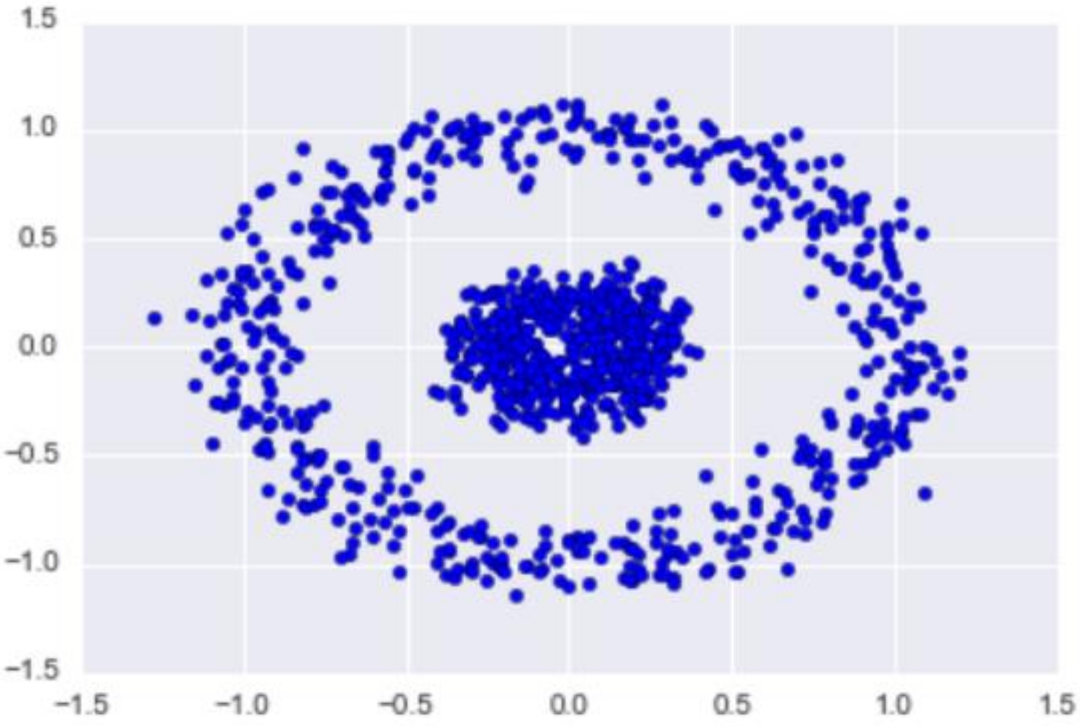


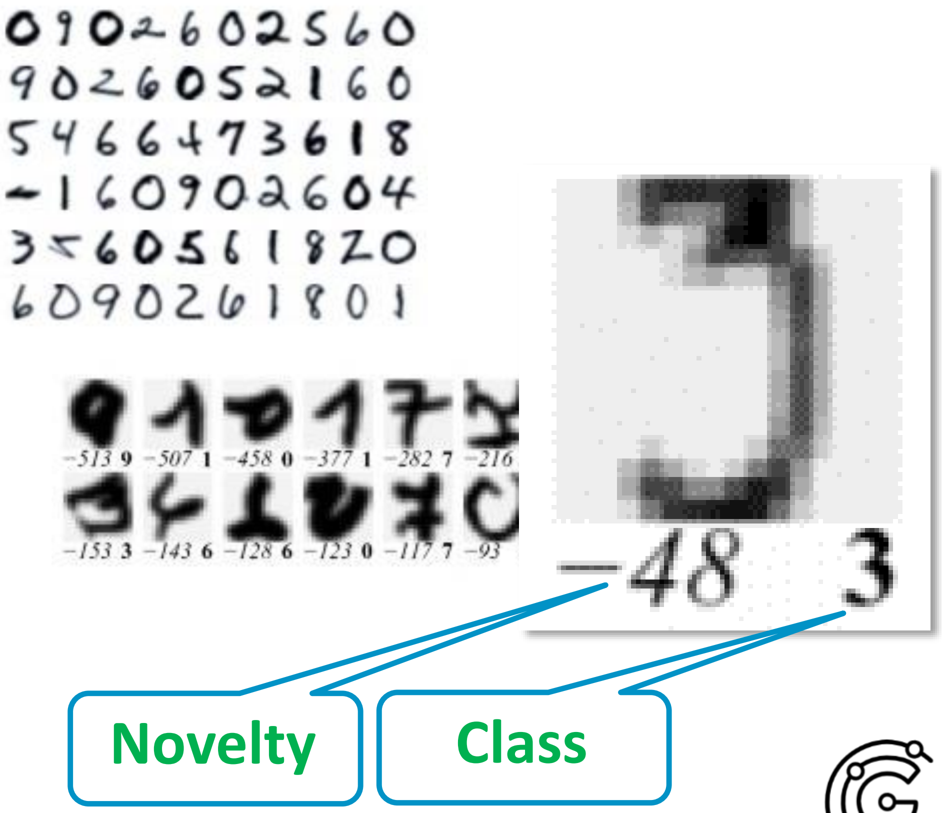
File Access state input variables and values	P(FA = True)	P(FA = False)
M=R2H, PT=NSF, ERR=0	0.95	0.05
M=R2H, PT=FTP, ERR=0	0.99	0.01
M=Probe, PT=none, ERR=50%	0.80	0.20
M=Probe, PT=PING, ERR=0	0.50	0.50
M=DoS, PT=POP, ERR=100%	0.80	0.20
M= DoS, PT=HTTP, ERR=50%	0.90	0.10

Source: : "A Survey of Data Mining and Machine Learning Methods for Cyber Security Intrusion Detection."

ML Methods: Clustering

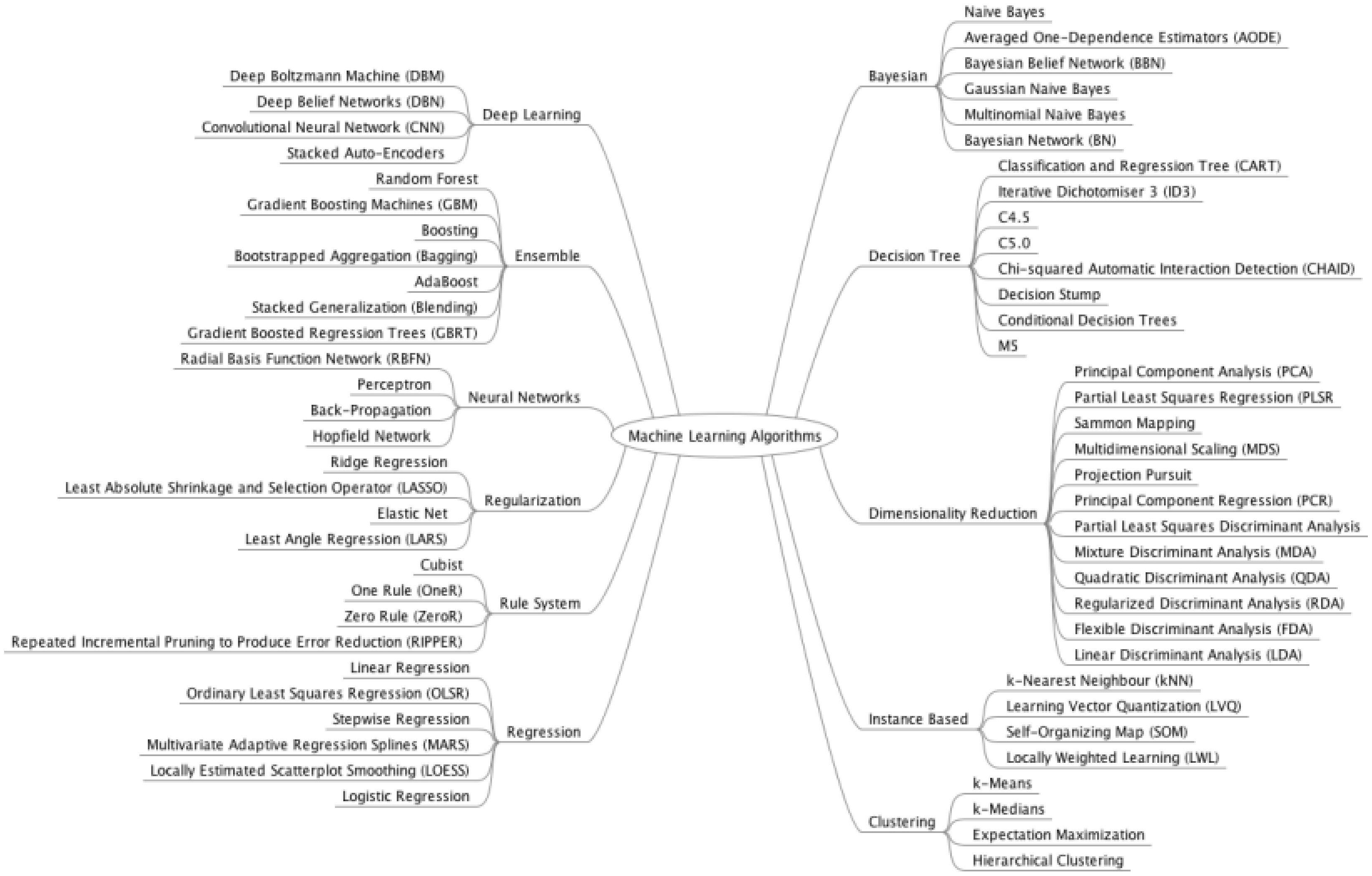
Grouping a set of objects in such a way that objects in the same group (called a ‘cluster’) are **more similar** (in some sense) to each other **than to those in other groups**.





Source: https://en.wikipedia.org/wiki/Cluster_analysis, Introduction to Machine Learning, https://github.com/sinanuozdemir/sfdat28/blob/master/notebooks/06_logistic_regression.ipynb

Just Covering the Basics



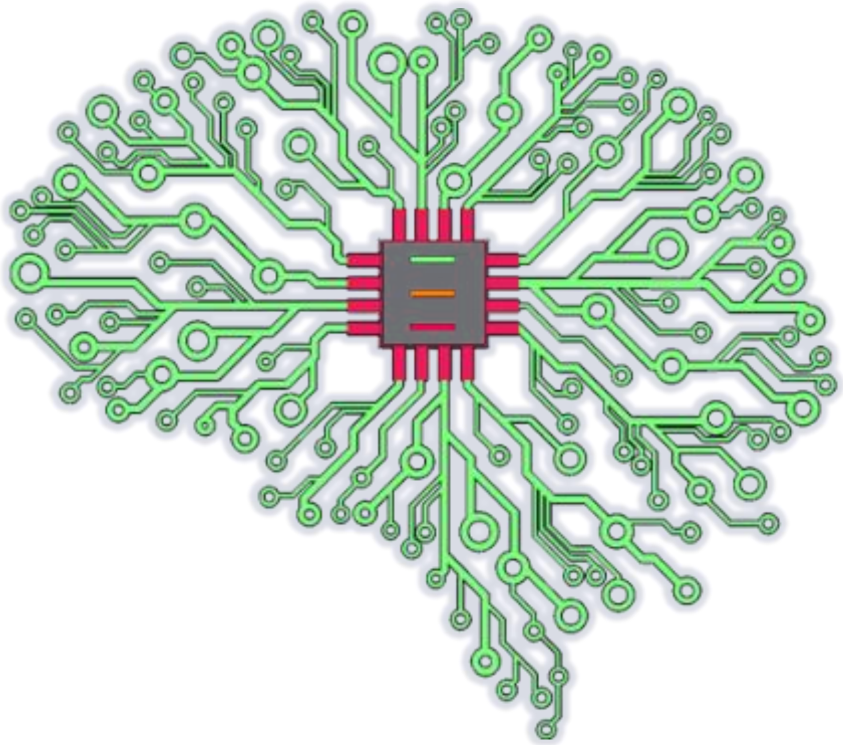
Machine Learning Algorithms

- Deep Learning
  - Deep Boltzmann Machine (DBM)
  - Deep Belief Networks (DBN)
  - Convolutional Neural Network (CNN)
  - Stacked Auto-Encoders
- Ensemble
  - Random Forest
  - Gradient Boosting Machines (GBM)
  - Boosting
  - Bootstrapped Aggregation (Bagging)
  - AdaBoost
  - Stacked Generalization (Blending)
  - Gradient Boosted Regression Trees (GBRT)
- Neural Networks
  - Radial Basis Function Network (RBFN)
  - Perceptron
  - Back-Propagation
  - Hopfield Network
- Regularization
  - Ridge Regression
  - Least Absolute Shrinkage and Selection Operator (LASSO)
  - Elastic Net
  - Least Angle Regression (LARS)
- Rule System
  - Cubist
  - One Rule (OneR)
  - Zero Rule (ZeroR)
  - Repeated Incremental Pruning to Produce Error Reduction (RIPPER)
- Regression
  - Linear Regression
  - Ordinary Least Squares Regression (OLSR)
  - Stepwise Regression
  - Multivariate Adaptive Regression Splines (MARS)
  - Locally Estimated Scatterplot Smoothing (LOESS)
  - Logistic Regression
- Bayesian
  - Naive Bayes
  - Averaged One-Dependence Estimators (AODE)
  - Bayesian Belief Network (BBN)
  - Gaussian Naive Bayes
  - Multinomial Naive Bayes
  - Bayesian Network (BN)
- Decision Tree
  - Classification and Regression Tree (CART)
  - Iterative Dichotomiser 3 (ID3)
  - C4.5
  - C5.0
  - Chi-squared Automatic Interaction Detection (CHAID)
  - Decision Stump
  - Conditional Decision Trees
  - M5
- Dimensionality Reduction
  - Principal Component Analysis (PCA)
  - Partial Least Squares Regression (PLSR
  - Sammon Mapping
  - Multidimensional Scaling (MDS)
  - Projection Pursuit
  - Principal Component Regression (PCR)
  - Partial Least Squares Discriminant Analysis
  - Mixture Discriminant Analysis (MDA)
  - Quadratic Discriminant Analysis (QDA)
  - Regularized Discriminant Analysis (RDA)
  - Flexible Discriminant Analysis (FDA)
  - Linear Discriminant Analysis (LDA)
- Instance Based
  - k-Nearest Neighbour (kNN)
  - Learning Vector Quantization (LVQ)
  - Self-Organizing Map (SOM)
  - Locally Weighted Learning (LWL)
- Clustering
  - k-Means
  - k-Medians
  - Expectation Maximization
  - Hierarchical Clustering

Source: https://jixta.wordpress.com/2015/07/17/machine-learning-algorithms-mindmap/

And Your Point...?

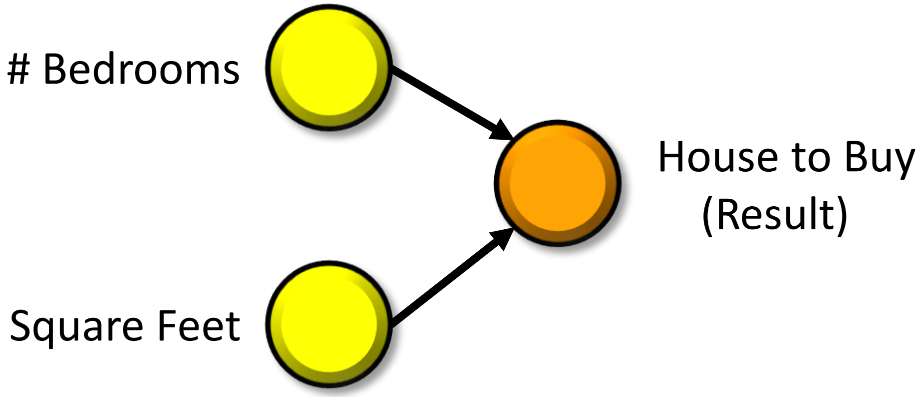
Neural Networks



Automated Neural Networks (ANN)

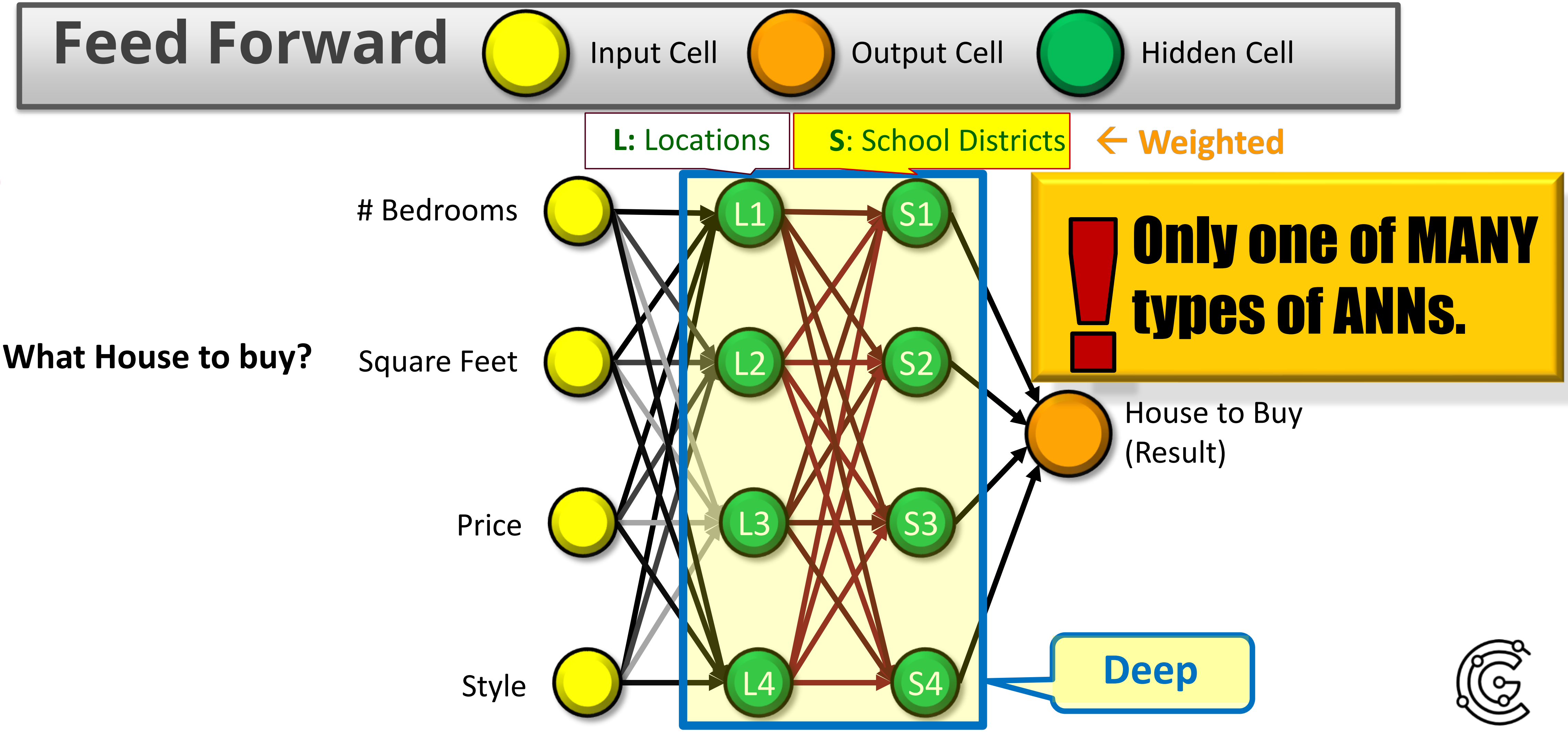
● Input Cell ● Output Cell

What House to buy?



Source: https://towardsdatascience.com/the-mostly-complete-chart-of-neural-networks-explained-3fb6f2367464

Neural Network Example



Only one of MANY types of ANNs.

Source: https://towardsdatascience.com/the-mostly-complete-chart-of-neural-networks-explained-3fb6f2367464

Recap: AL & ML Terms

- **Artificial Intelligence:**
  When Machines act like a real person; “General” AI
  (In all aspects)

- **Machine Learning:**
  Uses algorithms to predict patterns; all current AI is “Specific”
  (Type of AI – limited application [like a savant])

- **Deep Learning**
  Algorithm that uses Neural Networking
  (Type of ML, multiple levels of variables)

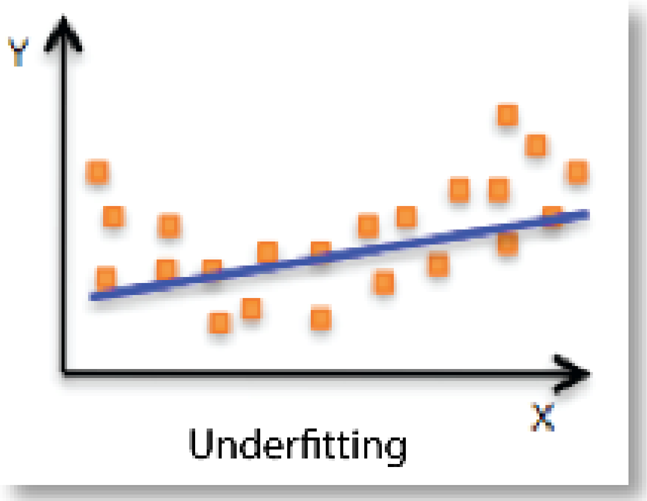
Pitfalls

Training Errors

Getting good training data can be freaking HARD.

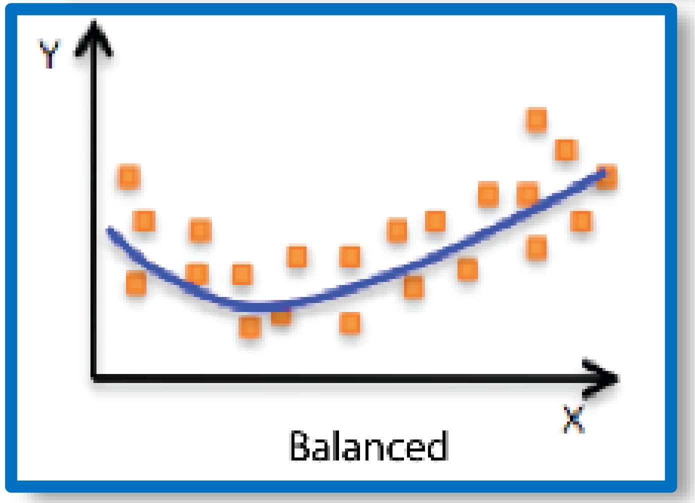
Underfitting

Model performs poorly



High bias, low variance

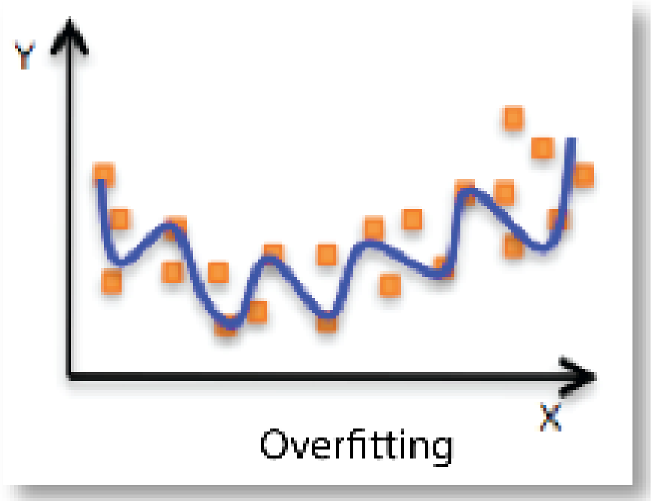
- *More features*
- *Decrease data regularization*



Still some false positives

Overfitting

Model performs too well

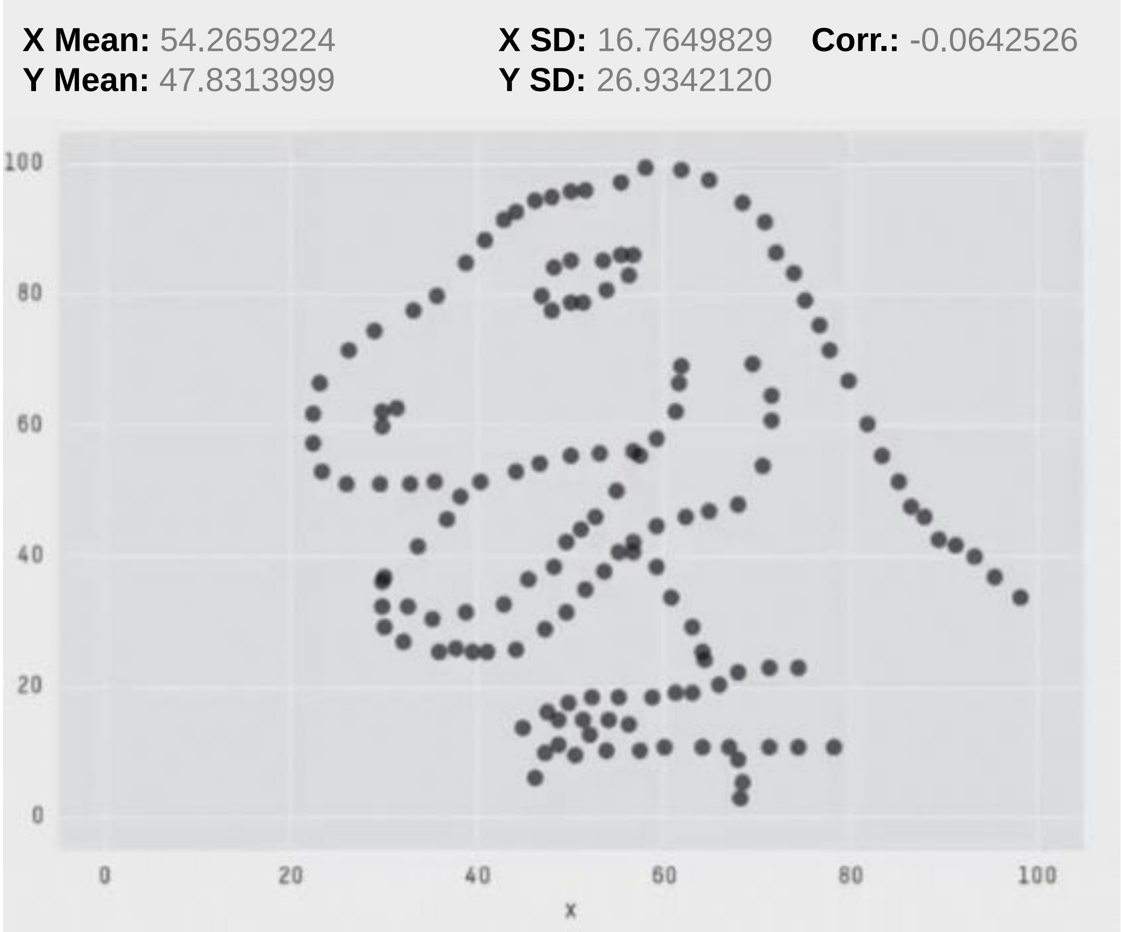


Low bias, high variance

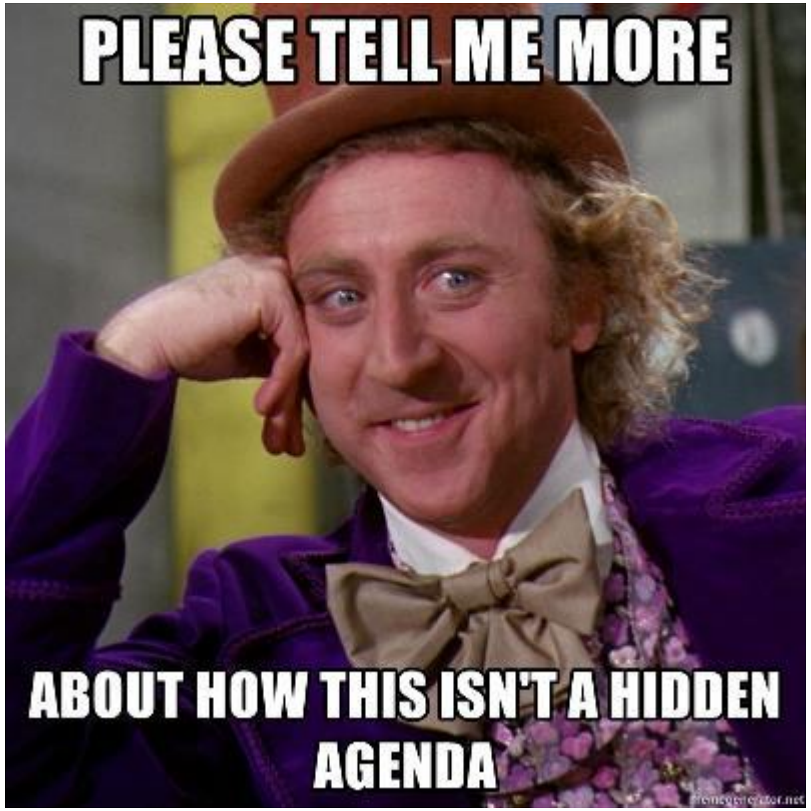
- *Reduce feature count*
- *Trim/normalize data*

Source: https://docs.aws.amazon.com/machine-learning/latest/dg/model-fit-underfitting-vs-overfitting.html

Manipulation Biases



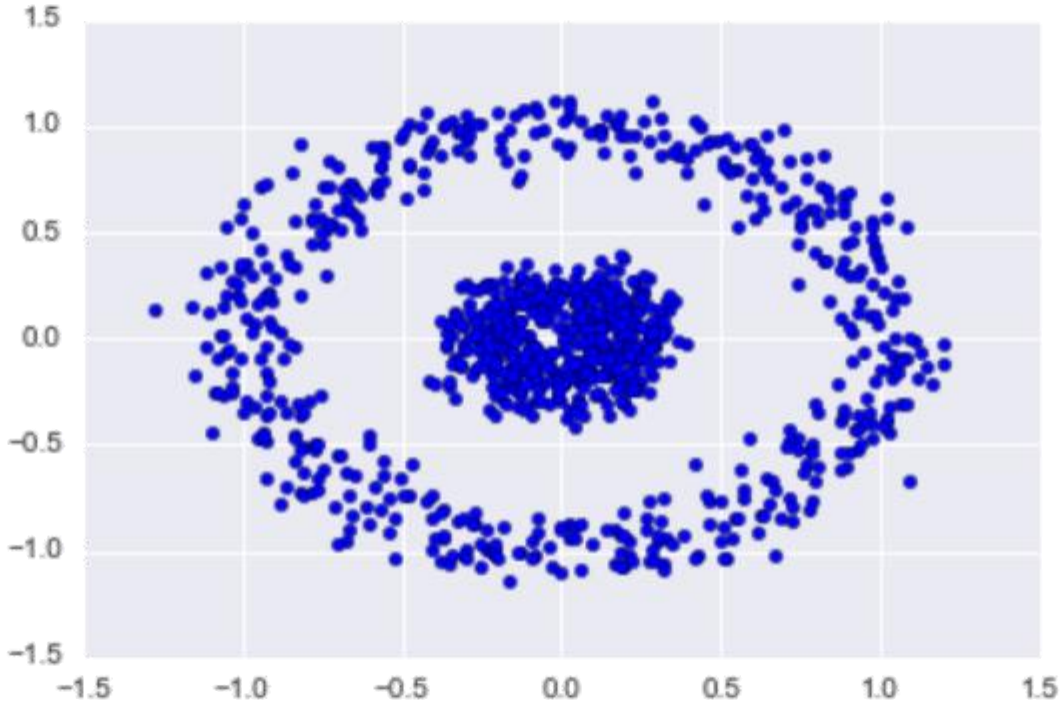
X Mean: 54.2659224 **X SD:** 16.7649829 **Corr.:** -0.0642526
Y Mean: 47.8313999 **Y SD:** 26.9342120



Source: https://github.com/stephlocke/lazyCDN/blob/master/DinoSequential.gif?raw=true

Manipulation Biases

Clustering Example

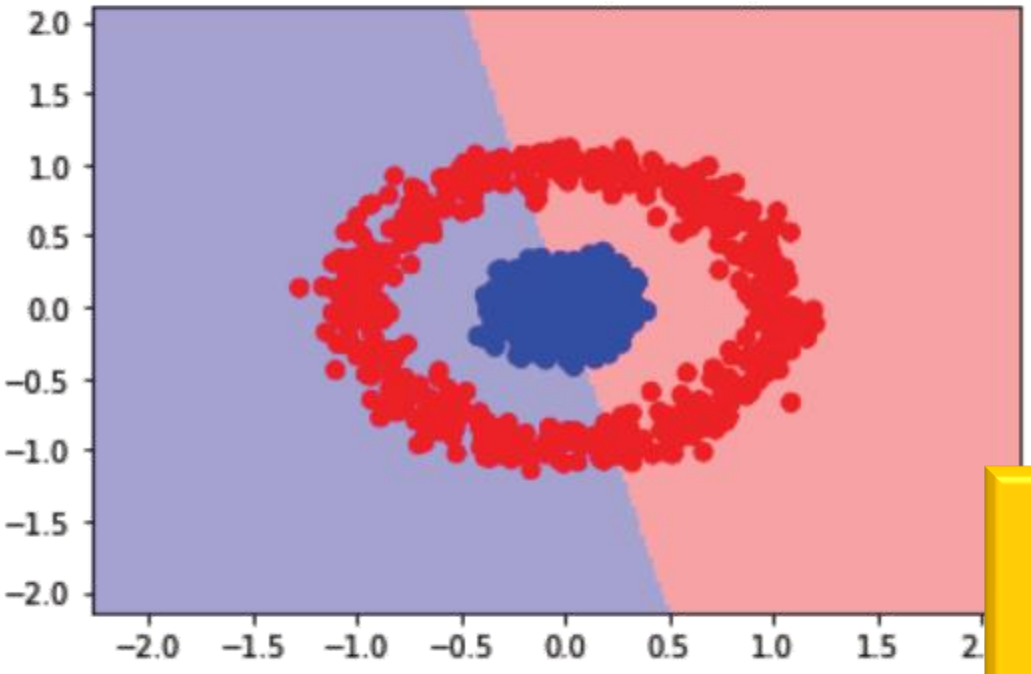


Source: https://github.com/sinanuozdemir/sfdat28/blob/master/notebooks/06_logistic_regression.ipynb,

Not all Algorithms are the Same

Parametric

Circle classification Logistic Regression



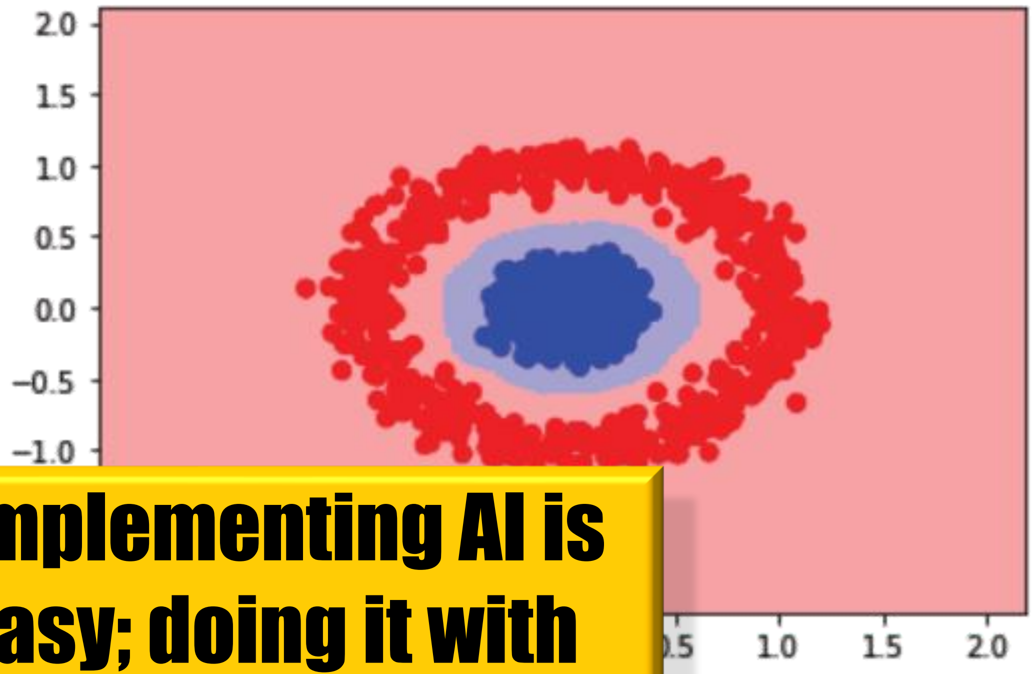
Assumes normally distributed data

🟪 G1

🟥 G2

Non-Parametric

Circle classification (k=9)

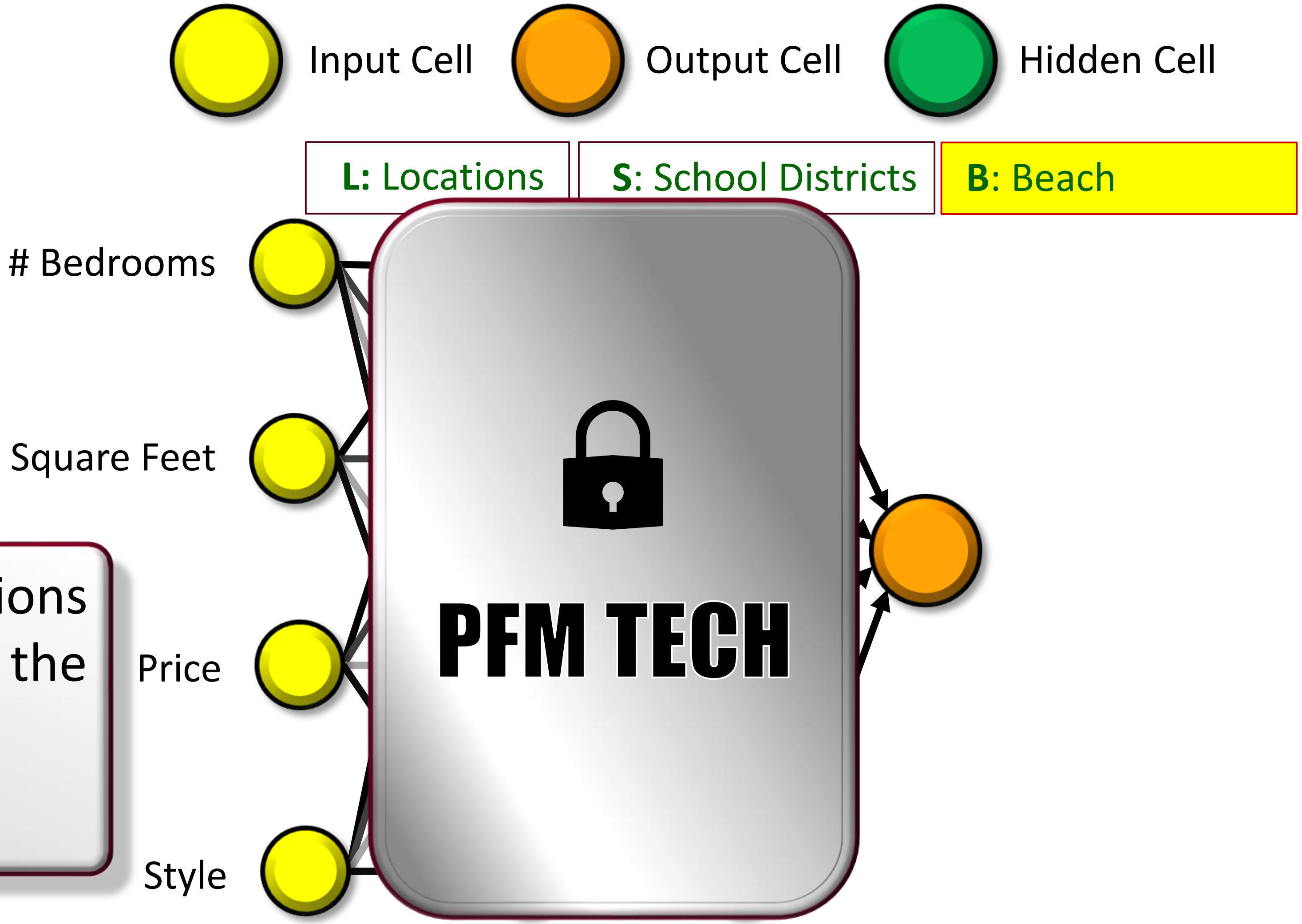


! **Implementing AI is easy; doing it with intelligence is not.**

Source: https://github.com/sinanuozdemir/sfdat28/blob/master/notebooks/06_logistic_regression.ipynb,

Neural Network Assumptionns

What House to buy?

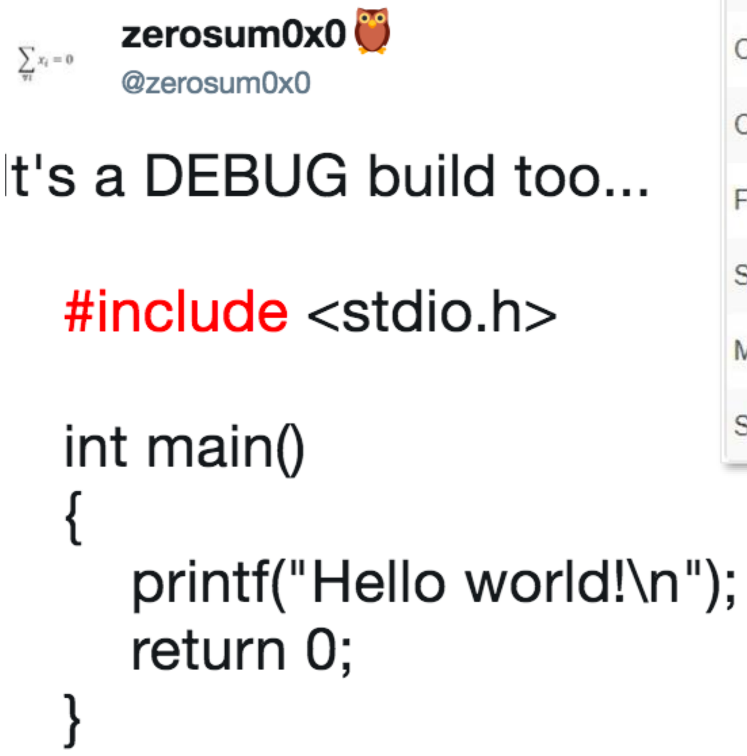


> ”…many times, organizations have a **lack of control** over the AI output and outcome.”
>
> - *Matt Sanchez*
>   *(CTO and co-founder of CognitiveScale)*

Source: https://towardsdatascience.com/the-mostly-complete-chart-of-neural-networks-explained-3fb6f2367464

More “A” than “I”…

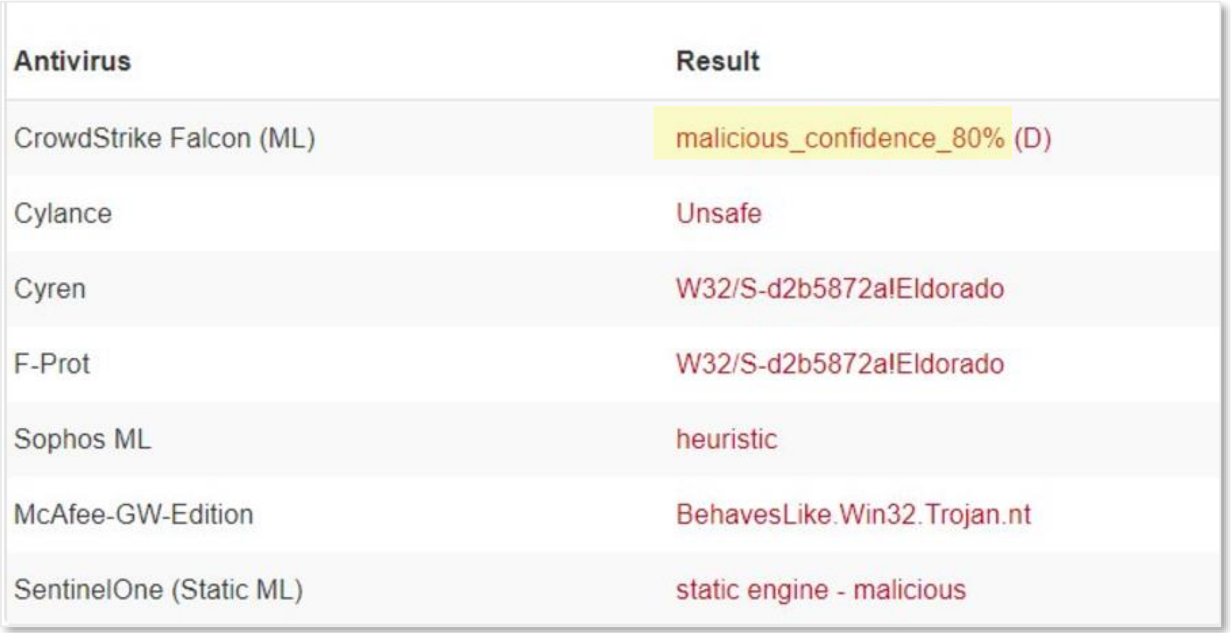
Malicious Code



zerosum0x0🦉
@zerosum0x0

It's a DEBUG build too...

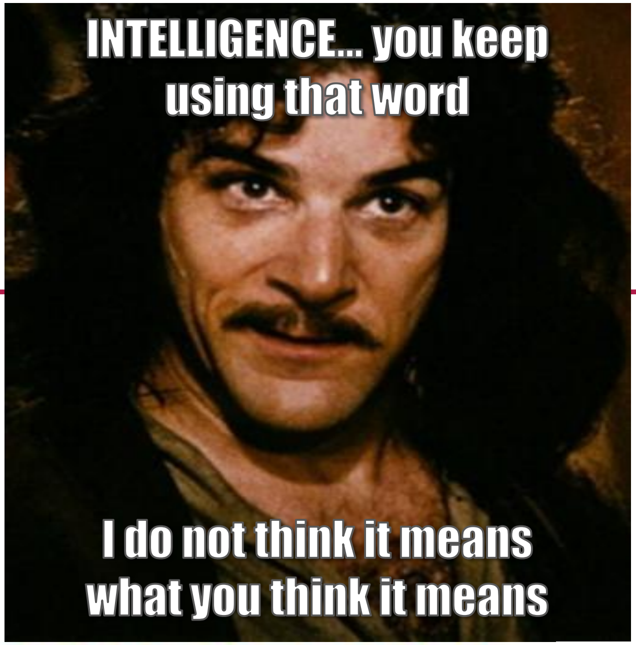
```
#include <stdio.h>

int main()
{
    printf("Hello world!\n");
    return 0;
}
```

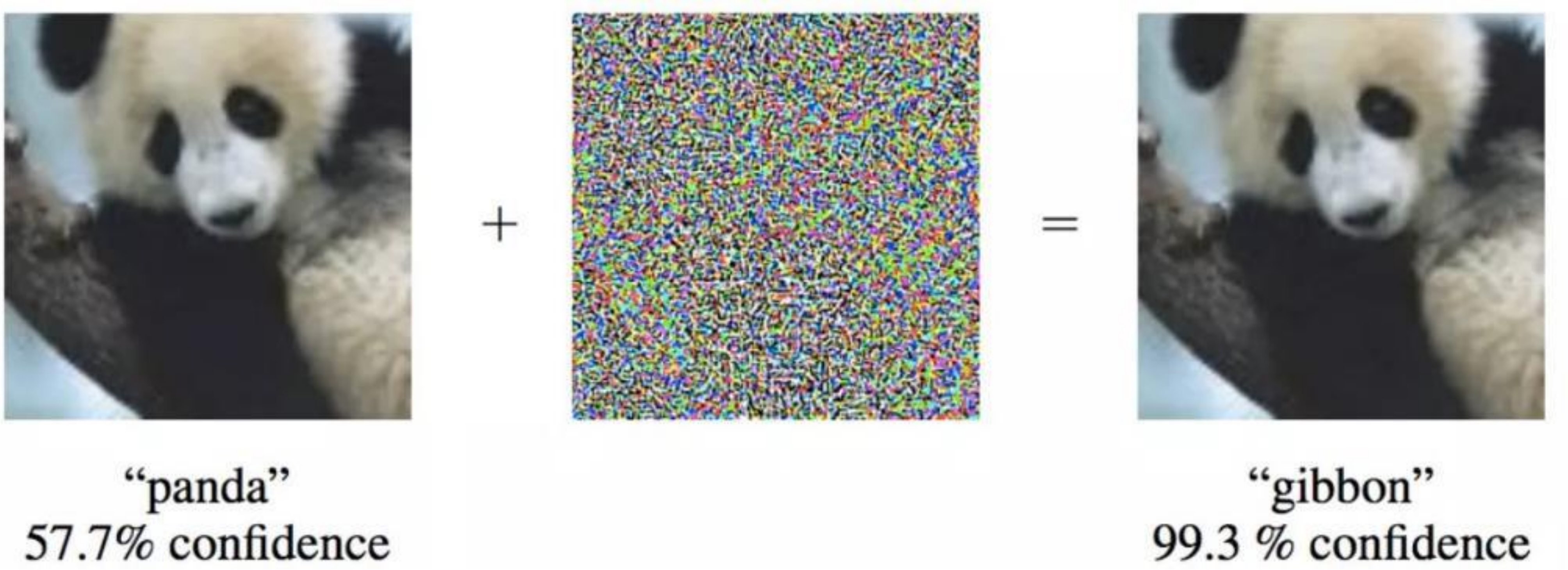


Antivirus	Result
CrowdStrike Falcon (ML)	malicious_confidence_80% (D)
Cylance	Unsafe
Cyren	W32/S-d2b5872a!Eldorado
F-Prot	W32/S-d2b5872a!Eldorado
Sophos ML	heuristic
McAfee-GW-Edition	BehavesLike.Win32.Trojan.nt
SentinelOne (Static ML)	static engine - malicious

Source: https://arxiv.org/abs/1412.6572ificial-intelligence, “Deep Learning with Python”

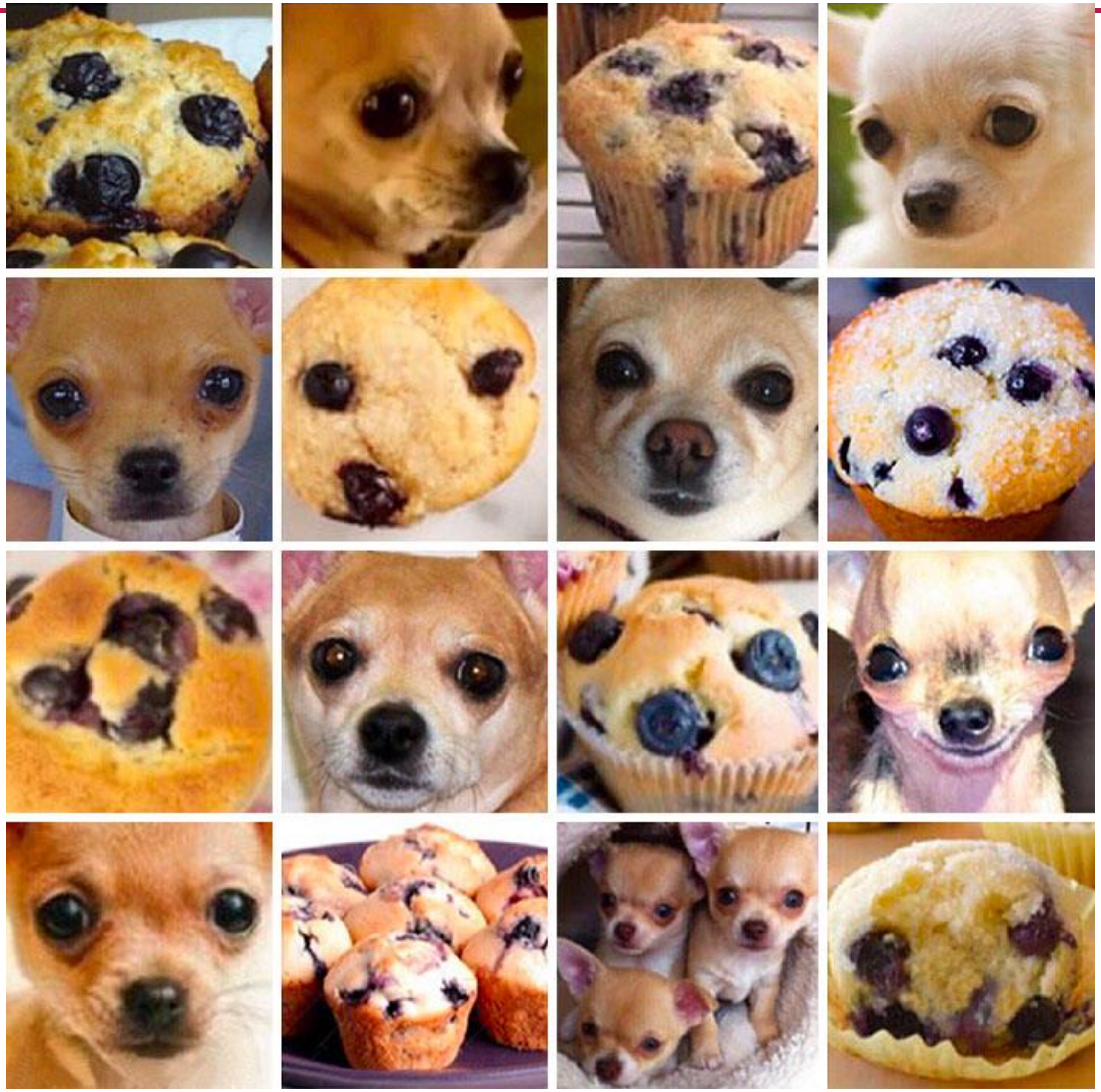
AI-n’t Perfect


INTELLIGENCE... you keep using that word
I do not think it means what you think it means



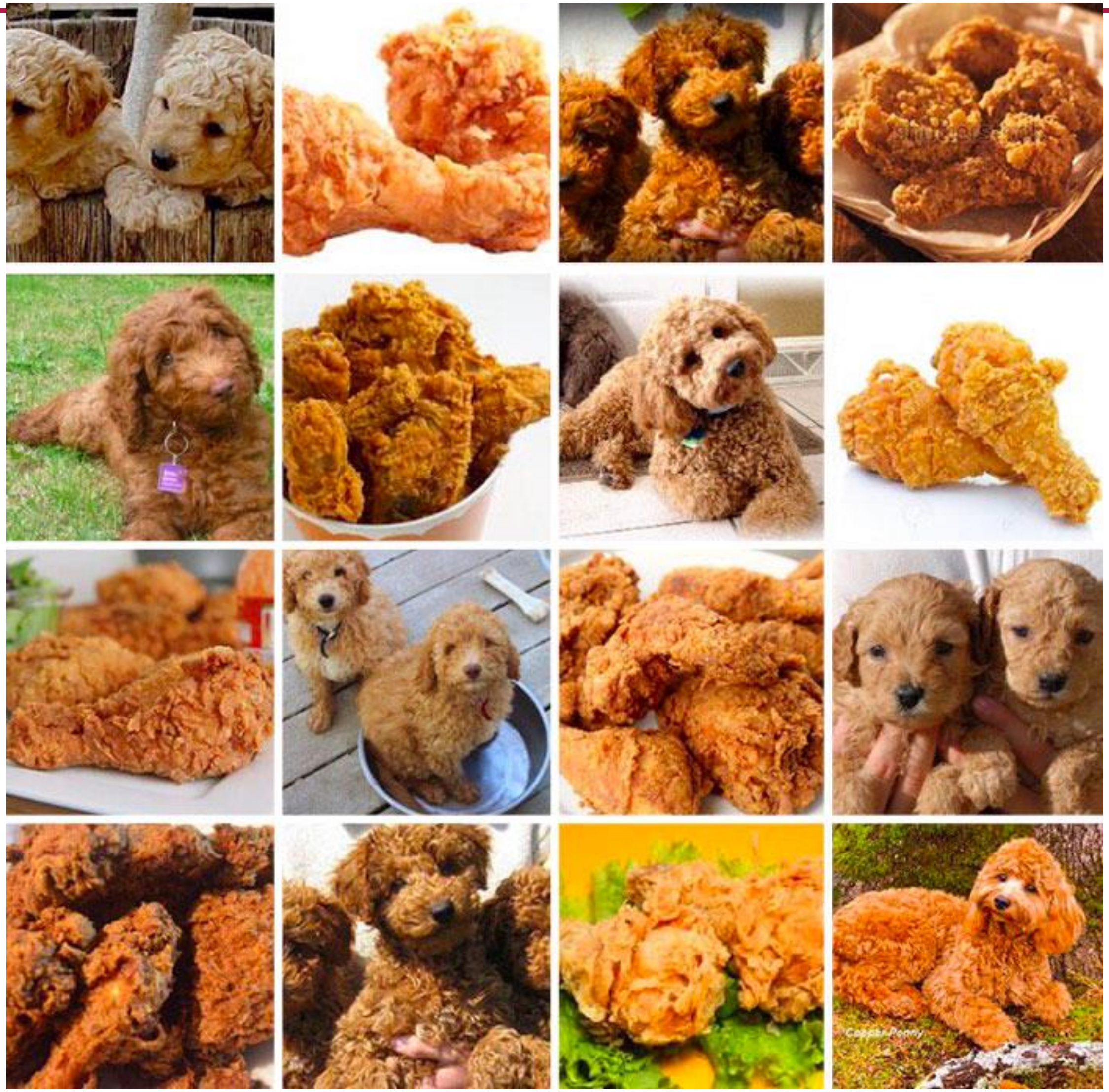
Source: https://www.theverge.com/2017/4/12/15271874/ai-adversarial-images-fooling-attacks-artificial-intelligence

AI-n't Perfect: Chihuahua or chocolate chip muffin?



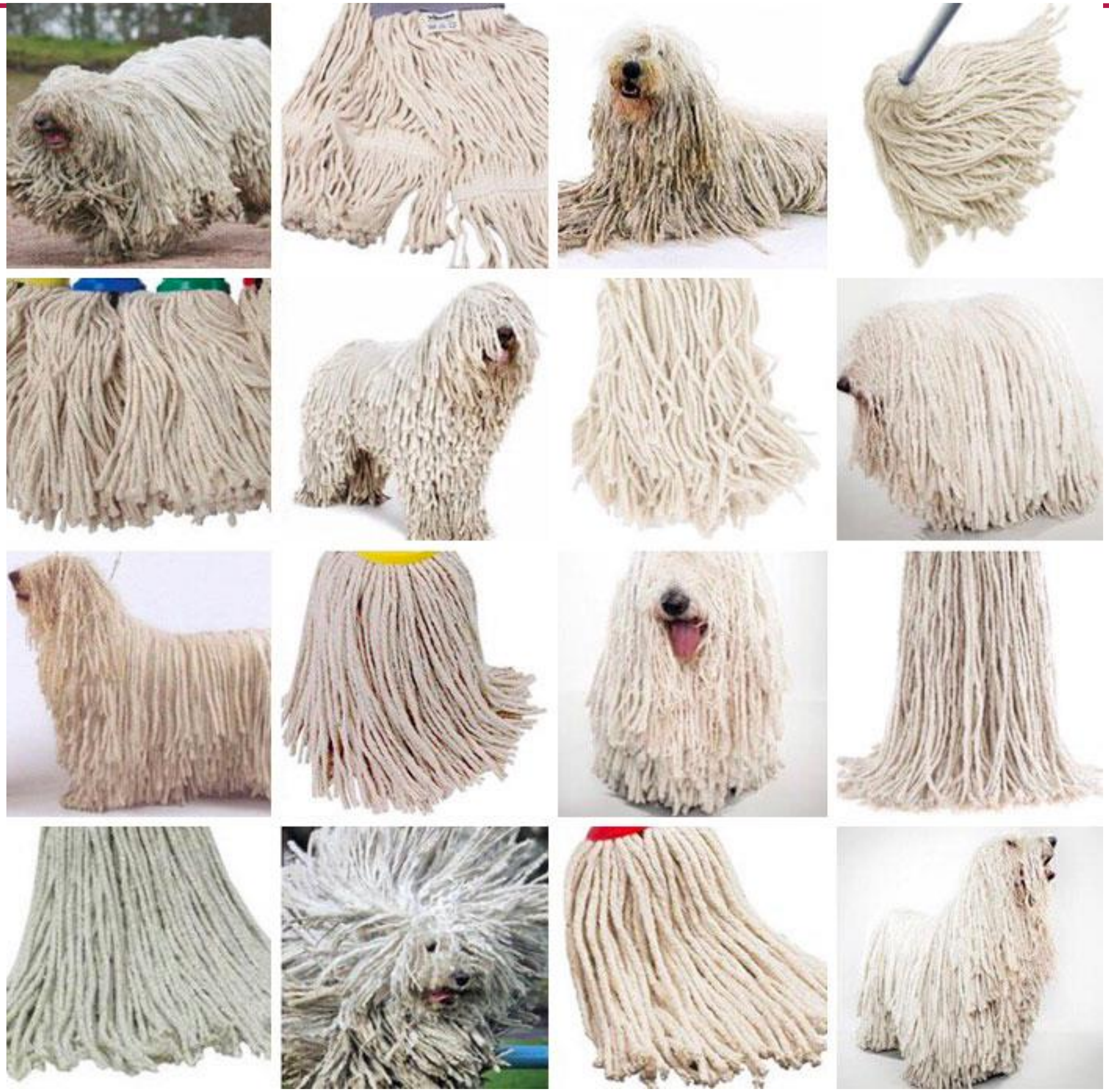
http://imgur.com/a/K4RWn

AI-n't Perfect: Labradoodle or fried chicken?



http://imgur.com/a/K4RWn

AI-n't Perfect: Sheepdog or Mop?

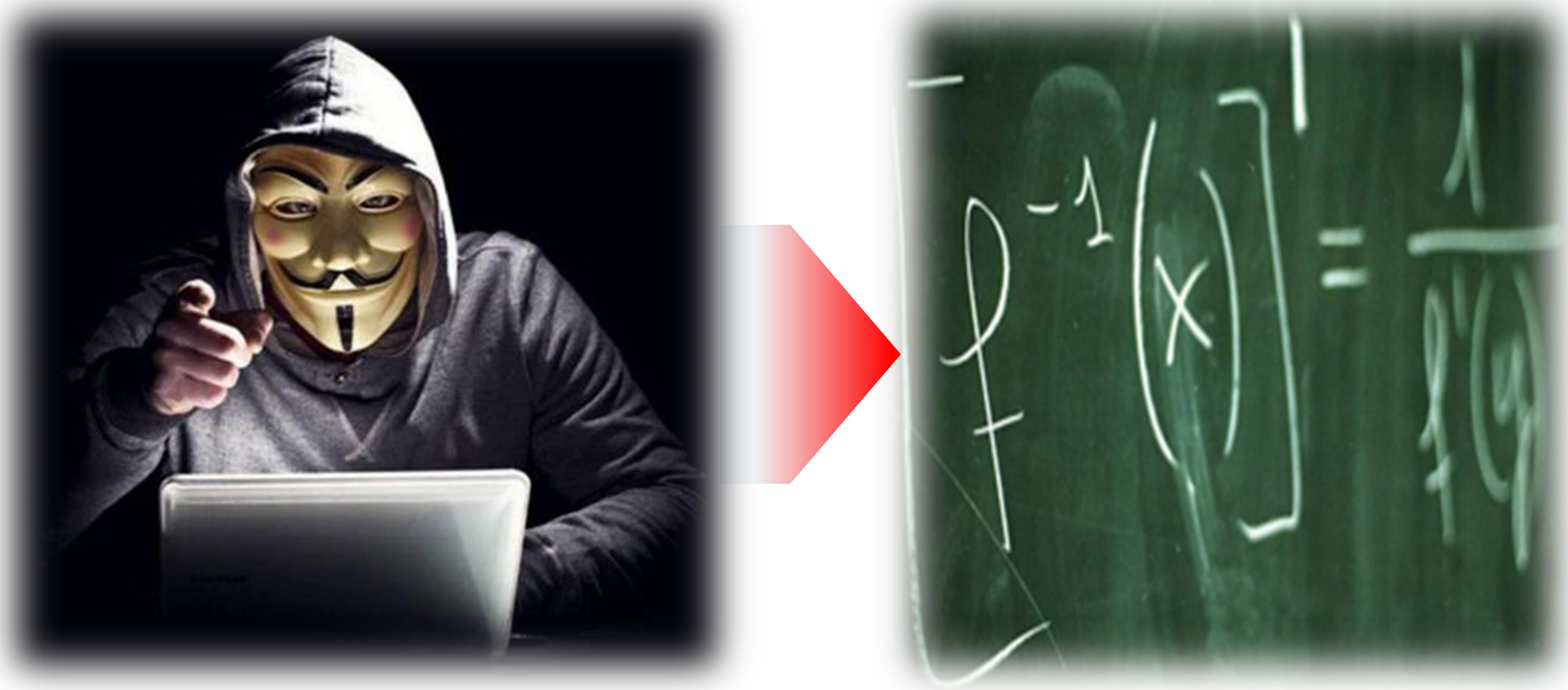


http://imgur.com/a/K4RWn

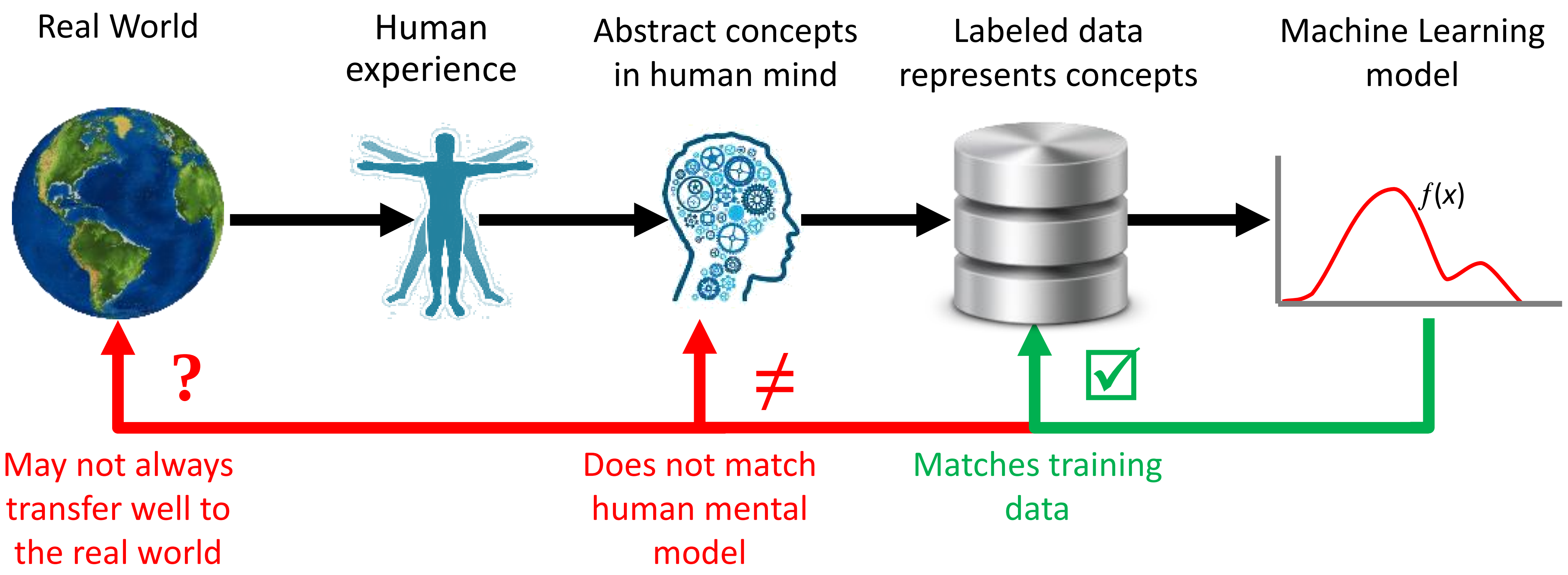
AI is easily confused

- ≠ Intuition
- ≠ Instinct
- ≠ ‘6th Sense’
- ≠ Morality

Abstraction Modeling



The Problem with Abstraction



Real World

Human experience

Abstract concepts in human mind

Labeled data represents concepts

Machine Learning model

May not always transfer well to the real world

Does not match human mental model

Matches training data

Source: “Deep Learning with Python”

AI Failures: Real-World

First death due to self-driving car

March 18, 2018

Source: https://www.nytimes.com/2018/03/23/technology/uber-self-driving-cars-arizona.html

Pitfalls: Summary

- Training
  - –Test data
  - –Over & under fitting
- Abstraction
- Bias & hidden weighting
- Data assumptions
- Errors
- Perturbation

”…**we have to bias our algorithms** so that you never trust any one individual or any one team. It is a careful(ly) controlled dance to build these types of systems to produce general purpose, general results that applies to all organizations.”

-Greg Martin, JASK (jask.ai)

If ‘cloud computing’ is just someone else’s data center, most Machine Learning is just someone else’s assumptions.

Cyber Applications

White Hat AI

> ”…while AI systems can exceed human performance in many ways, they **can also fail in ways that a human never would**.”
>
> *-The Malicious Use of Artificial Intelligence: Forecasting, Prevention, and Mitigation*

- Network Management
- Data: Visualization, Log patterns, UBA
- First-Level SOC analysis?
- Augment (not replace) the Human
- Reverse Engineering (GHIDRA)
- IoT = ANN ‘sense’ organs

It **IS NOT** a silver bullet!

Source: The Malicious Use of Artificial Intelligence: Forecasting, Prevention, and Mitigation
https://www.wired.com/story/nsa-ghidra-open-source-tool/

White Hat AI: 5 Questions to Ask

1) Technical Components
2) Flexibility
3) Applications
4) AI/ML Updates
5) Your Security Team's Skillset

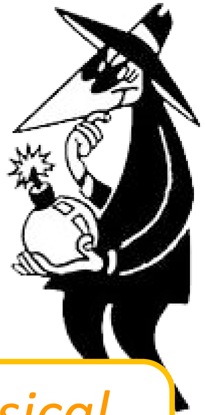
Source: https://www.darkreading.com/vulnerabilities---threats/cutting-through-the-jargon-of-ai-and-ml-5-key-issues/a/d-id/1333595

Black Hat AI

> "AI systems and the knowledge of how to design them can be put toward both … beneficial and harmful ends … **artificial intelligence is dual-use in the same sense that human intelligence is.**"
>
> *-The Malicious Use of Artificial Intelligence: Forecasting, Prevention, and Mitigation*

- Data Poisoning
- Scales the Attack (#, speed, & targets)
- Discover New Attack Vectors – *FAST*
- Exploit AI Vulnerabilities
- Increase anonymity & psychological distance

Including physical, voice, images…



Unique Data

Source: The Malicious Use of Artificial Intelligence: Forecasting, Prevention, and Mitigation

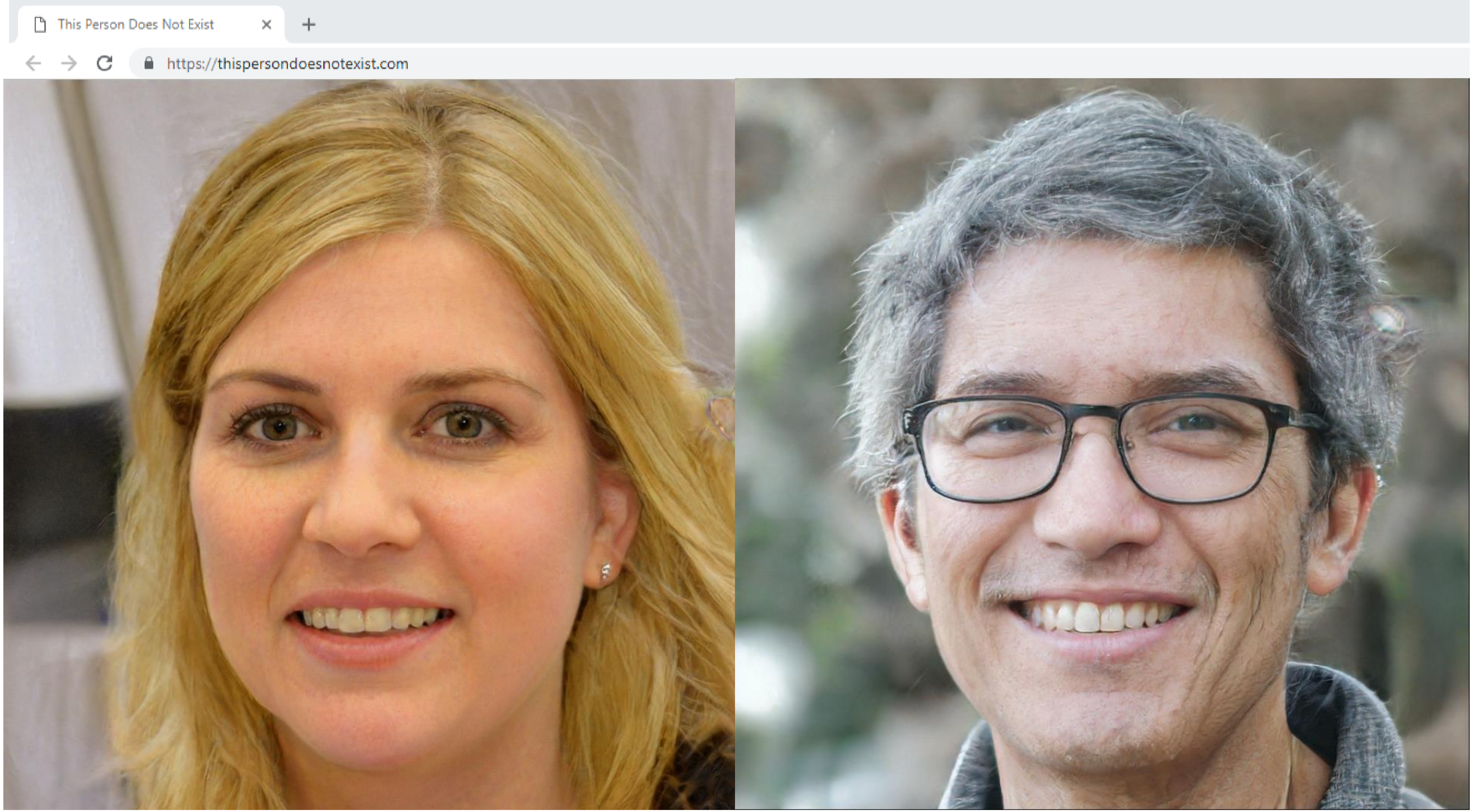
AI/ML Musts

- AI must be able to explain '*why*'
  (for Audit and Compliance)

- Plan for & design continuous learning feedback loops

- Governance processes
  = assurance/guardrails for AI insights & recommendations

Source: https://dzone.com/articles/artificial-intelligence-will-automate-business-pro


This Person Does Not Exist
https://thispersondoesnotexist.com

Source: https://thispersondoesnotexist.com

Cyber Applications: Summary

- Good at similar, predictable data
- Good at sifting data w/ patterns
- Assist – *not* replace – the human
- Speeds everything up – including bad guys & how fast we break crap
- New & faster exploits
- Increase of psychological distance

In Review...

Review: What We Covered Today

1) Definitions

2) Machine Learning
   - Types
   - Methods

3) Neural Networks

4) Pitfalls
   - Errors
   - Assumptions
   - Biases

5) Cyber Applications

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Machine Learning

How Smart Can It Really Be?

This presentation will evaluate Machine Learning (ML), Deep Learning (DL), and Artificial Intelligence (AI) as used within cyber security. During the session we will explore the difference between ML, DL, and AI, and show how these technologies work - as well as their shortcomings. Finally, we will discuss how these tools could work to help reduce risk and how to apply them in your security environment.

- Definitions
- Machine Learning
  - Types
  - Methods
- Neural Networks
- Errors
  - Assumptions
  - Biases
  - Pitfalls
- Cyber Applications