

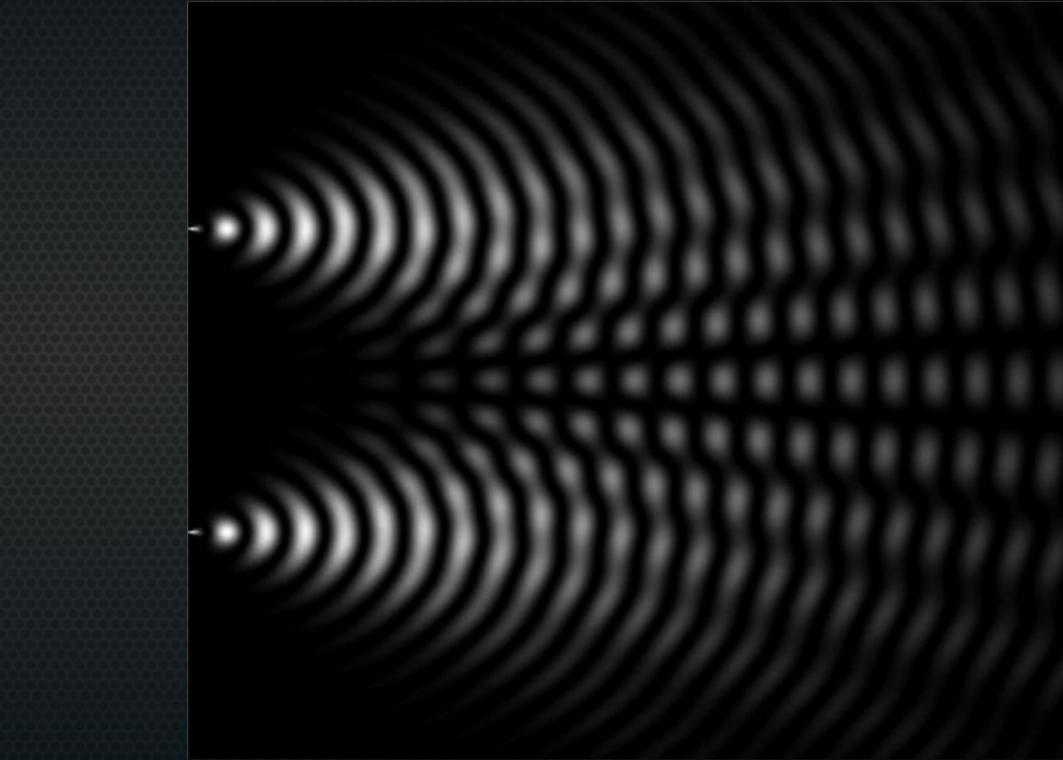
# Machine Learning

## A broad overview

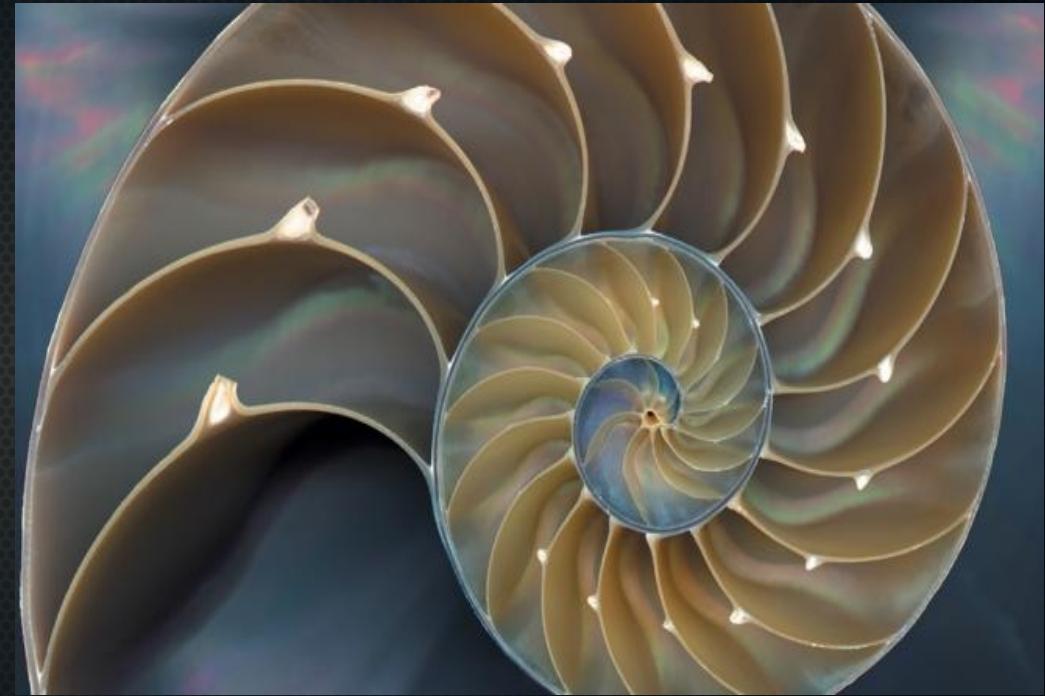
Arun Aniyan

SKA South Africa / Rhodes University  
[arun@ska.ac.za](mailto:arun@ska.ac.za)

# Laws of Physics generates patterns

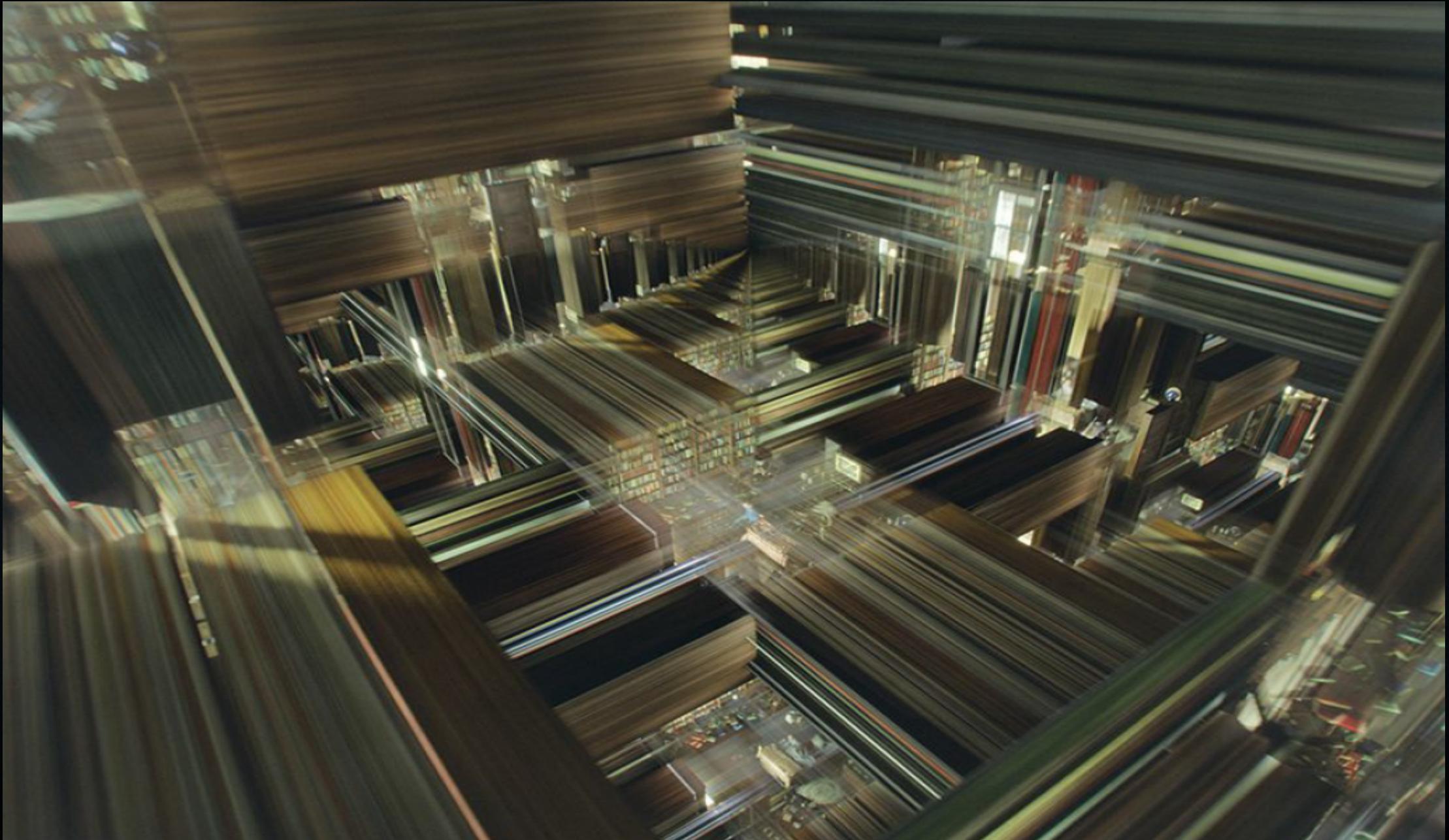


# Laws of Physics generates patterns



And humans have a tendency to find patterns everywhere !

# Not all patterns are human comprehensible



Science is all about finding those patterns

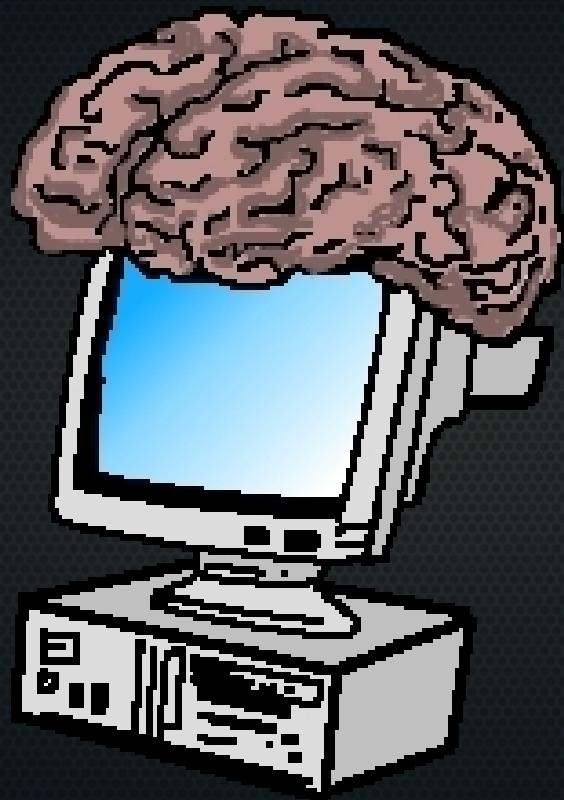
Our whole life is an optimization problem



## Real analogy : Cricket



# Machine Learning



Teaching Computers to mimic human ability to learn and make decisions

# Machine Learning

Machine learning is the field of study that gives computers the ability to learn without being explicitly being programmed.

Arthur Samuel  
(1959)

Knowledge representation

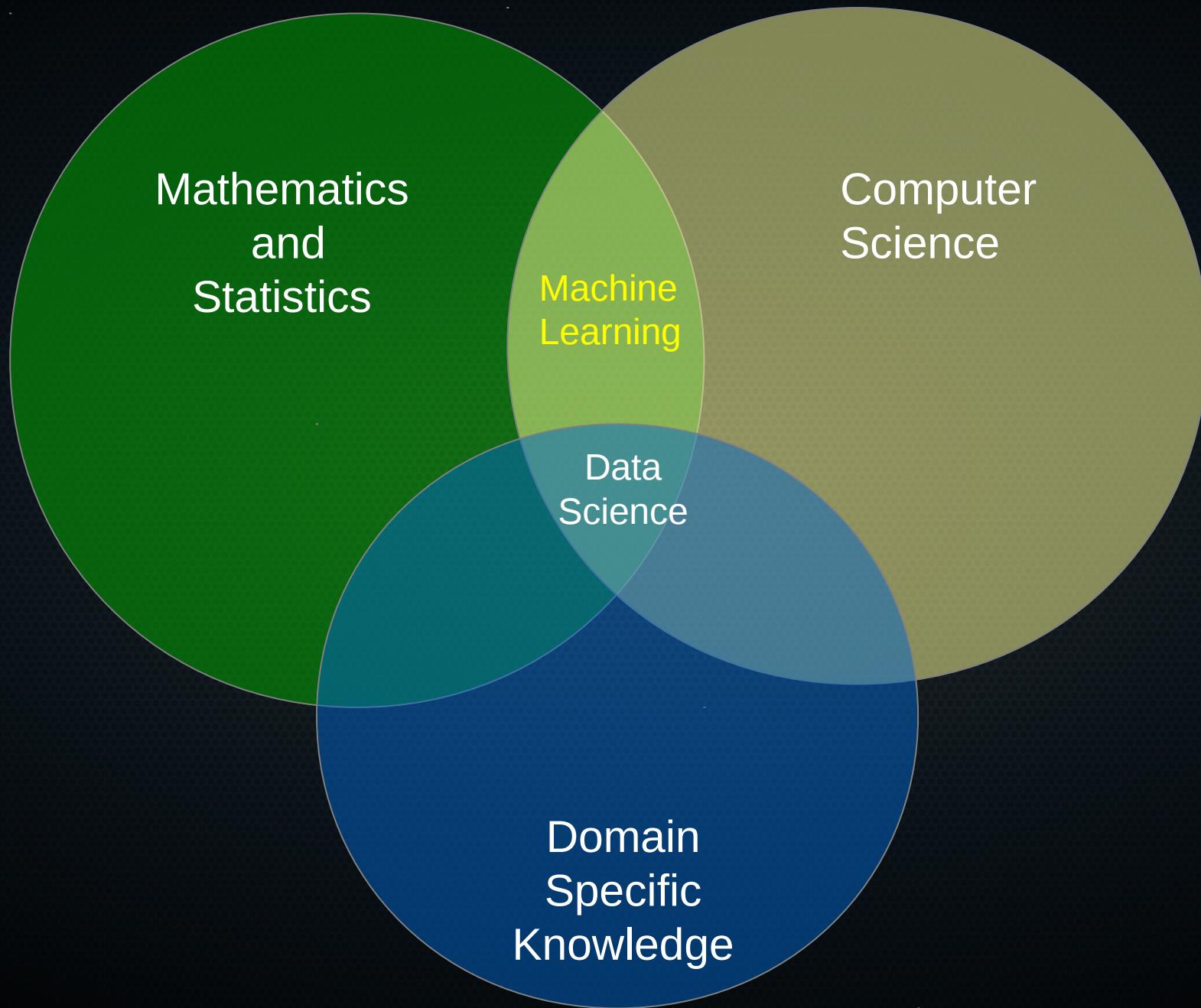
Computer Vision

# Artificial Intelligence

Machine Learning

Natural Language  
Processing

# Where does it belong ?





# Checkers Game

First intelligent program

# Machine Learning (ML)

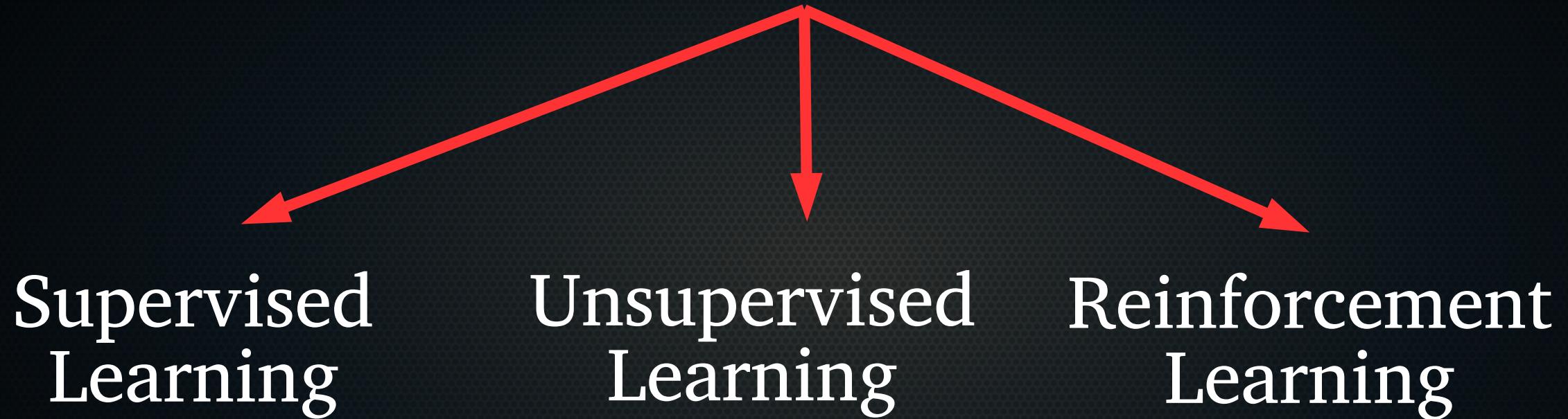


Classification

Regression

Two problems which ML generally solve

# Machine Learning (ML)



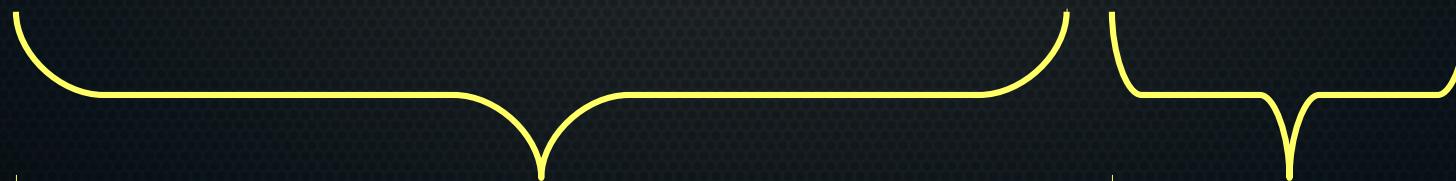
# Supervised Learning



Agent assists and evaluates every stage of learning.

# Supervised Learning

<u>Mean</u>	<u>Slope</u>	<u>Stetson J</u>	<u>Class</u>
0.56	3.4	4.5	Supernova
0.23	1.2	12.6	RR Lyrae



Features

Labels

# Unsupervised Learning

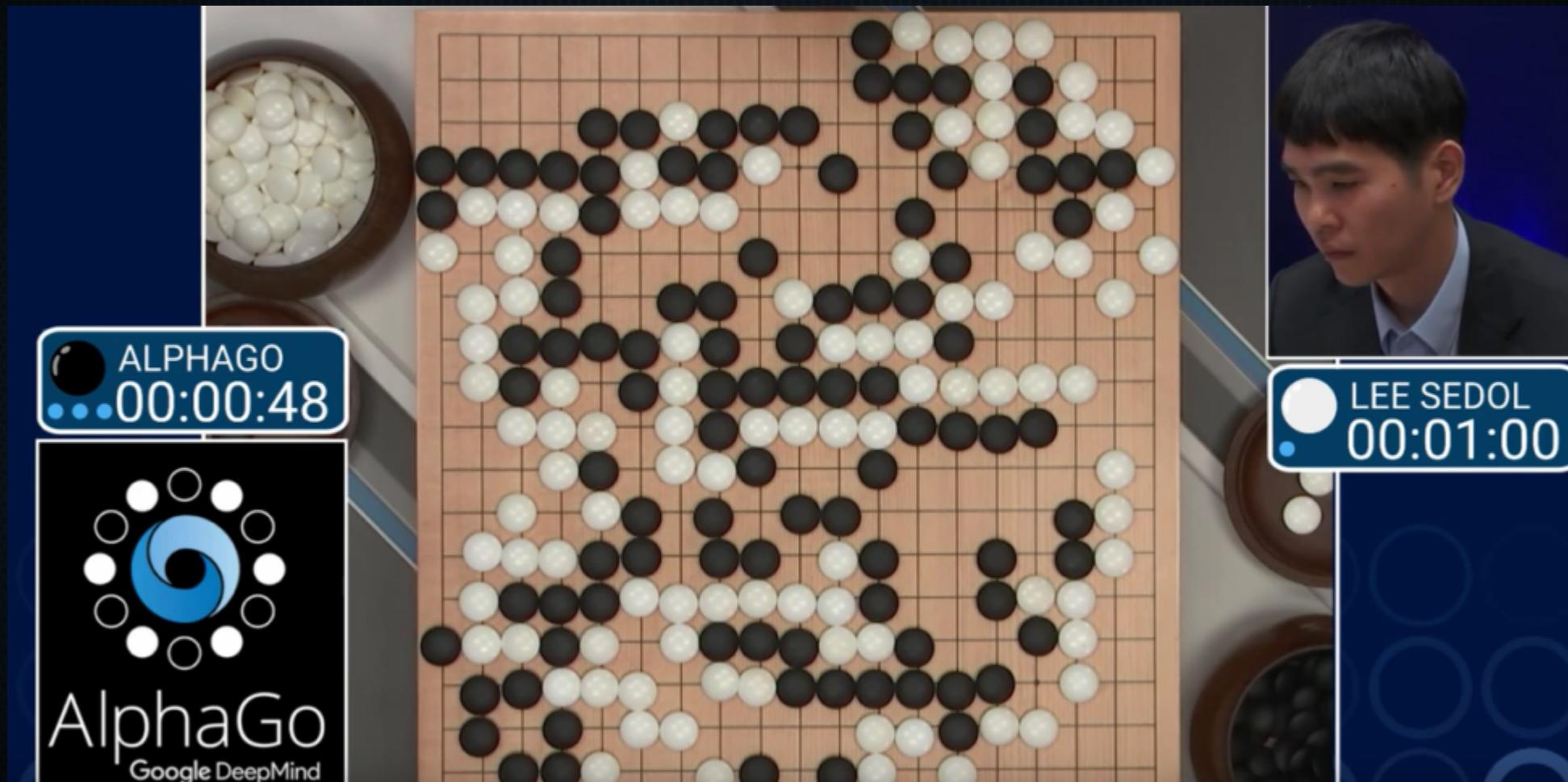


# Unsupervised Learning

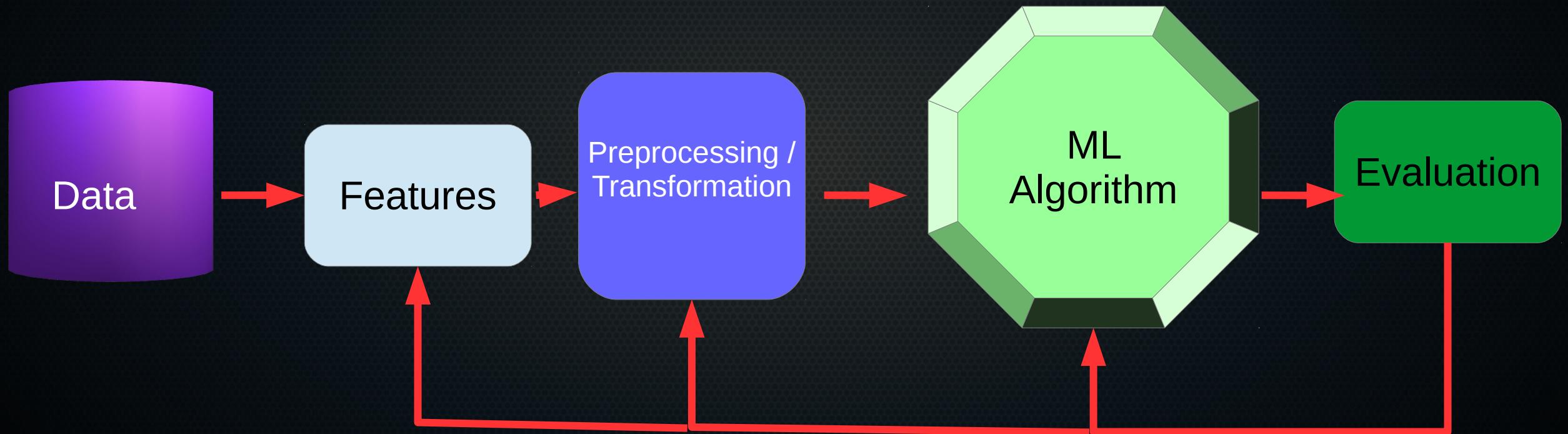
<u>Mean</u>	<u>Slope</u>	<u>Stetson J</u>	<u>Class</u>
0.56	3.4	4.5	?
0.23	1.2	12.6	?

You ask the computer to find the class labels / groups

# Reinforcement Learning



# The ML Workflow

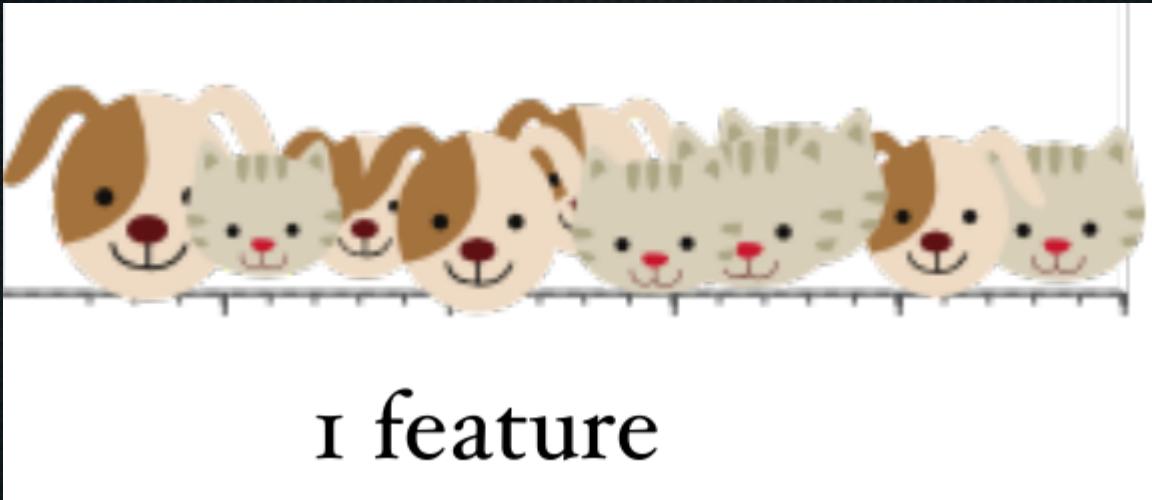


# The ML Workflow

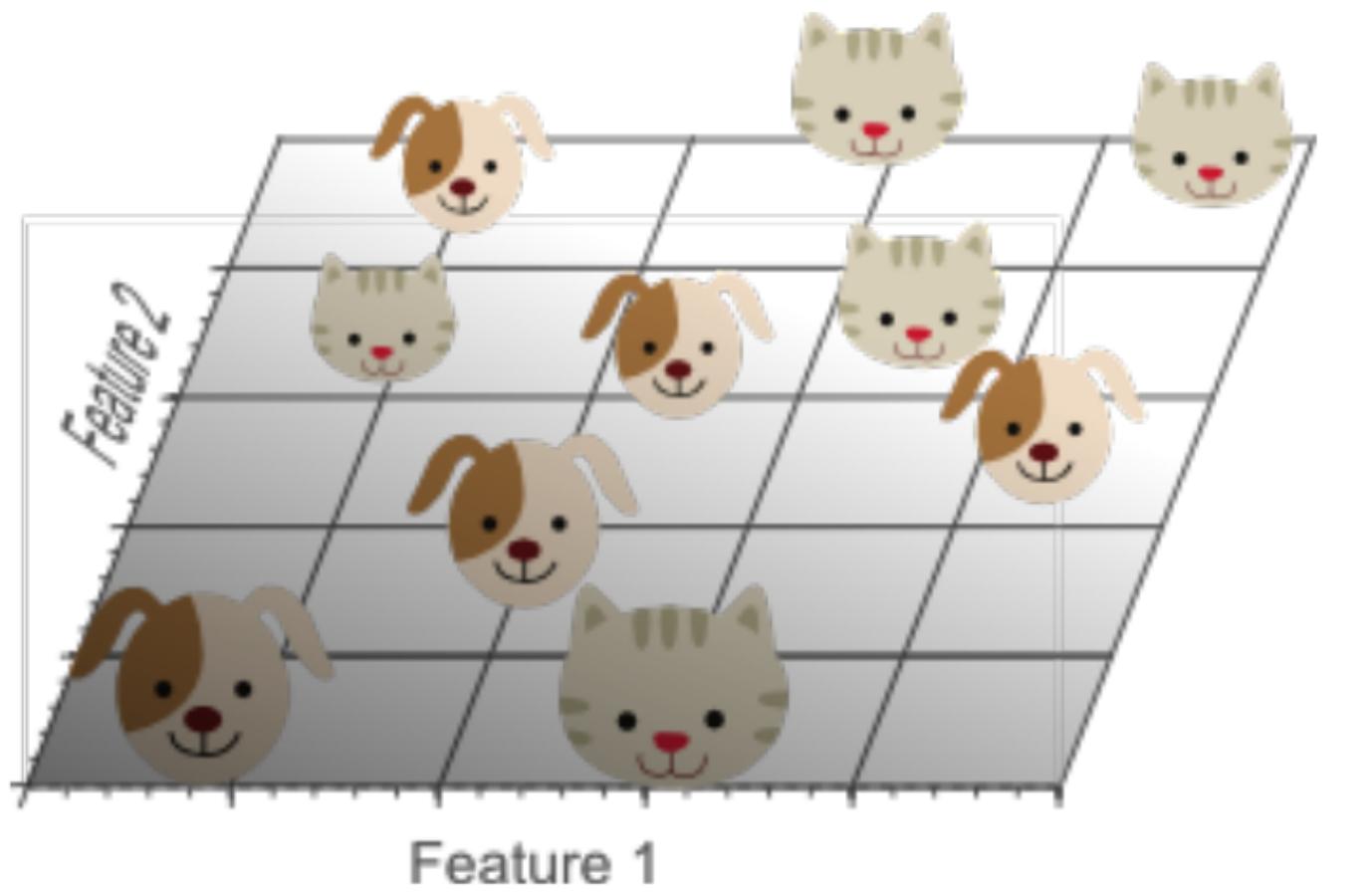
## Features

- # They represent specific properties of your data.
- # Representative for a specific class
- # Invariant to rotation and transilation

# Features

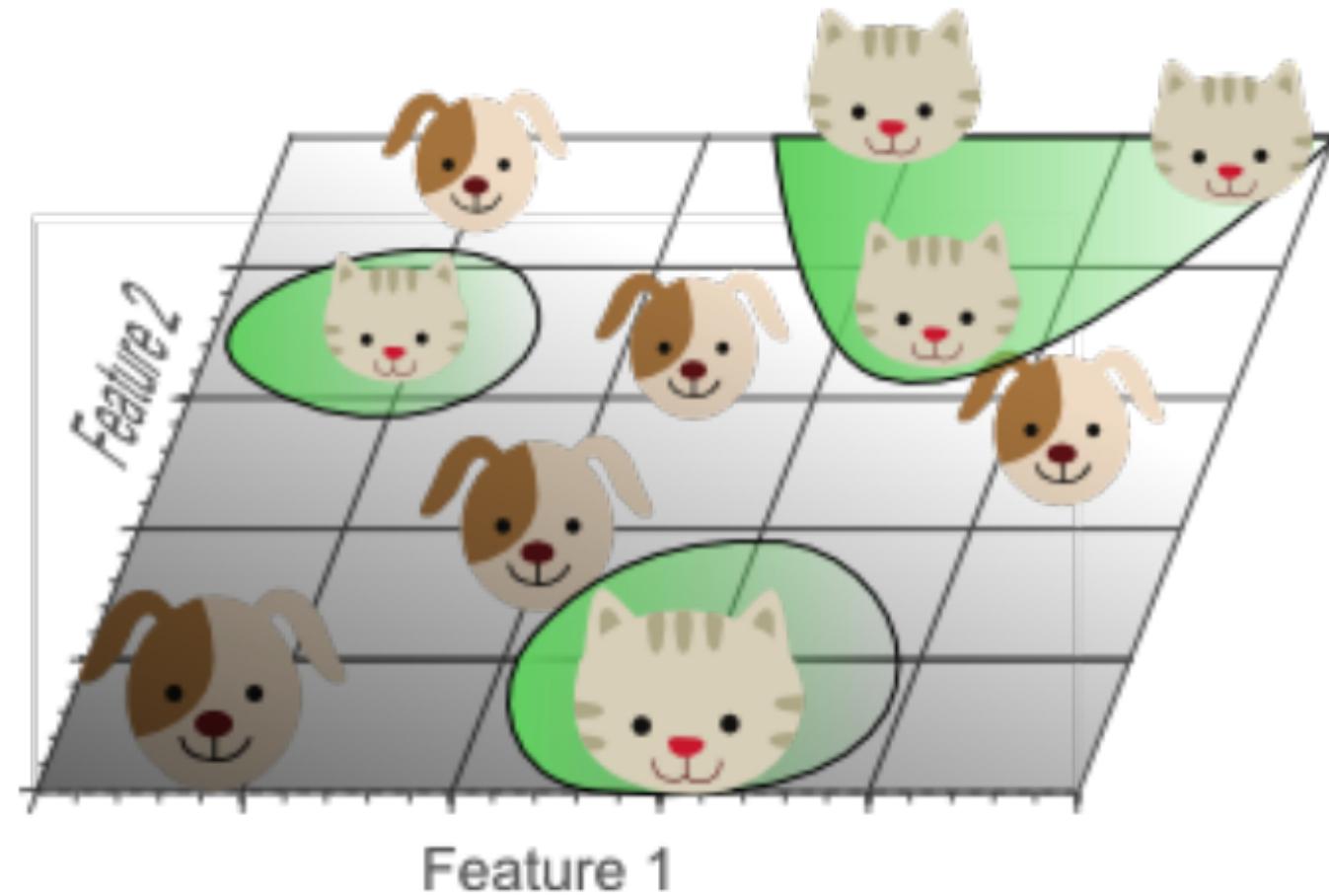


# Features



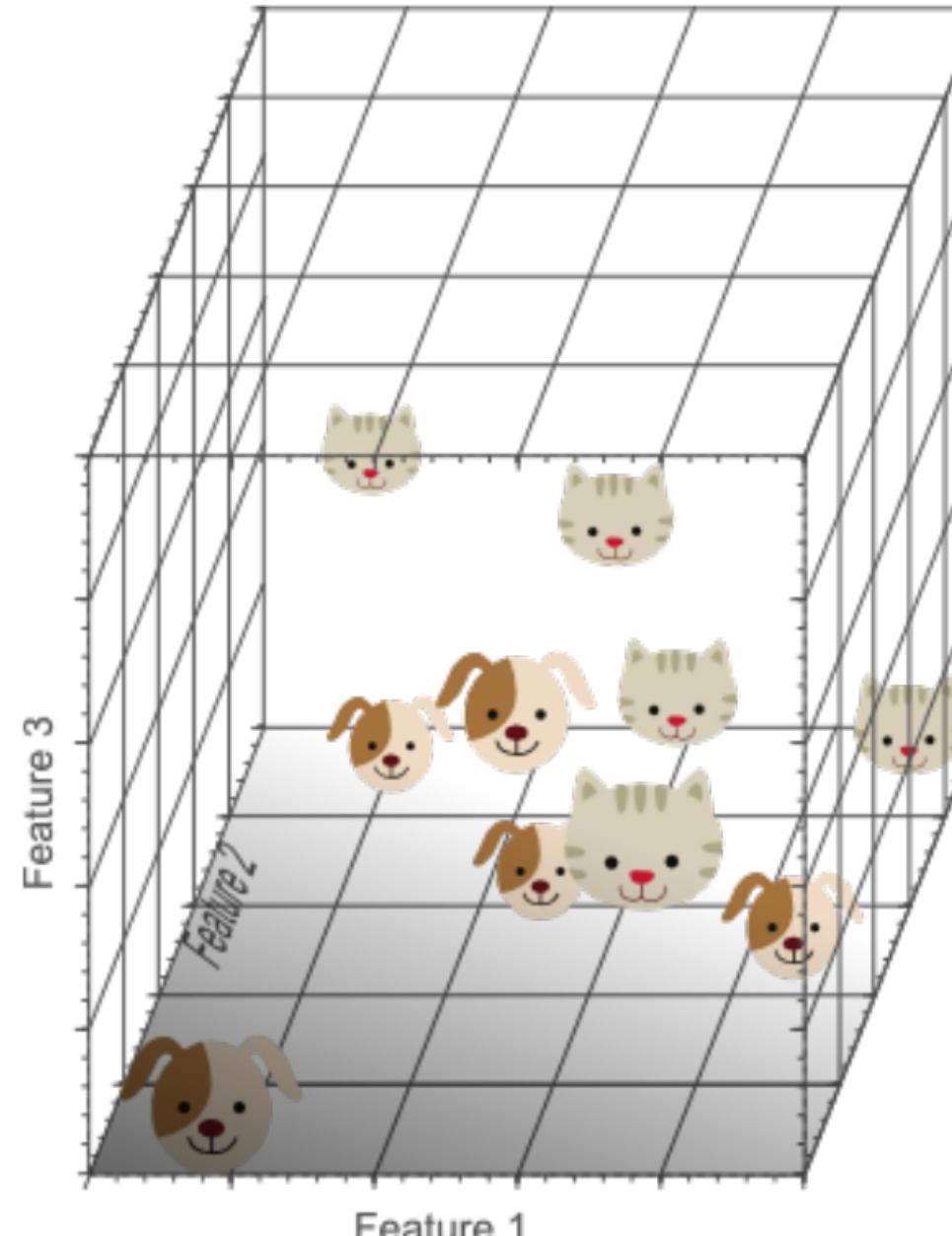
2 features

# Features



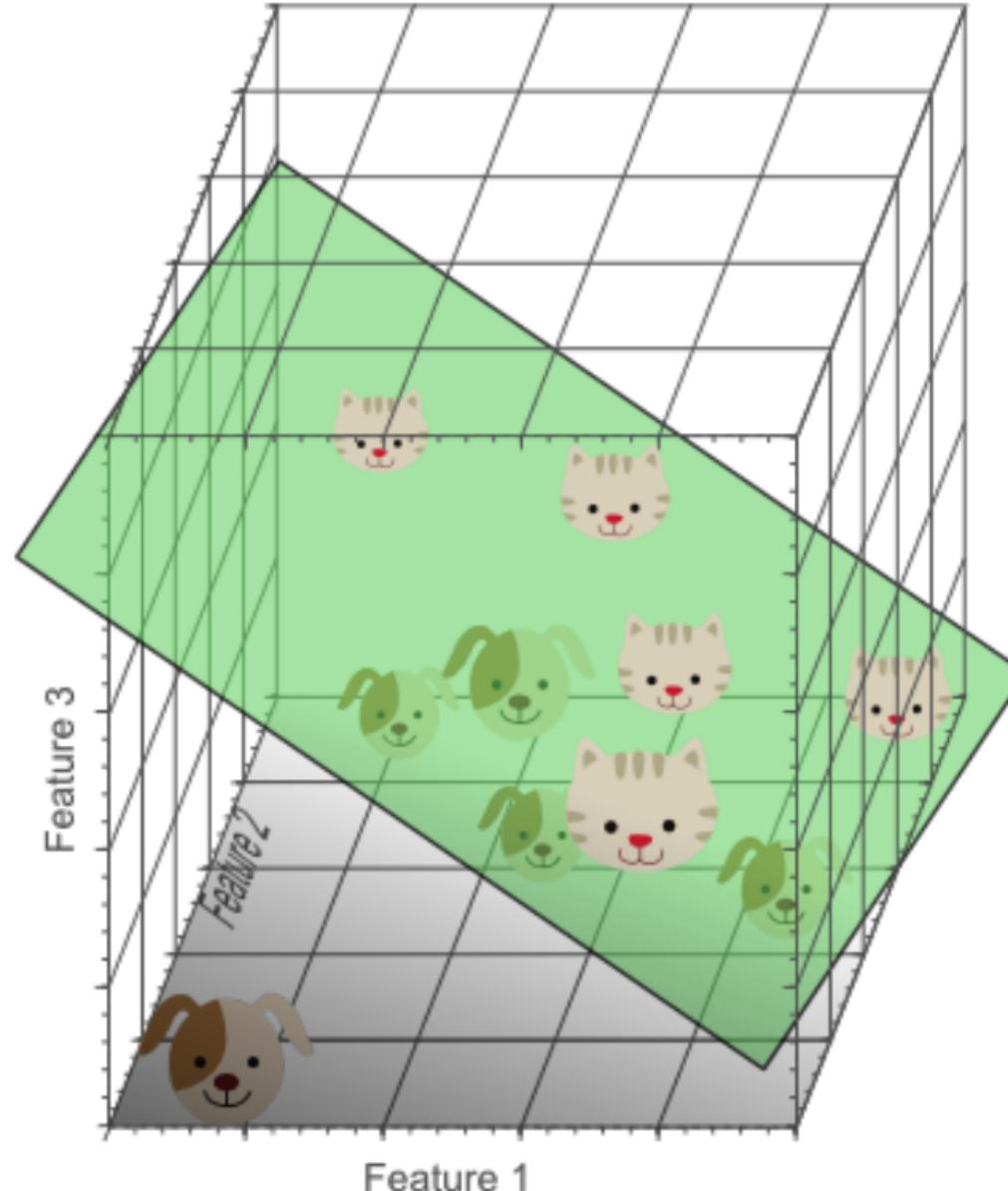
2 features

# Features



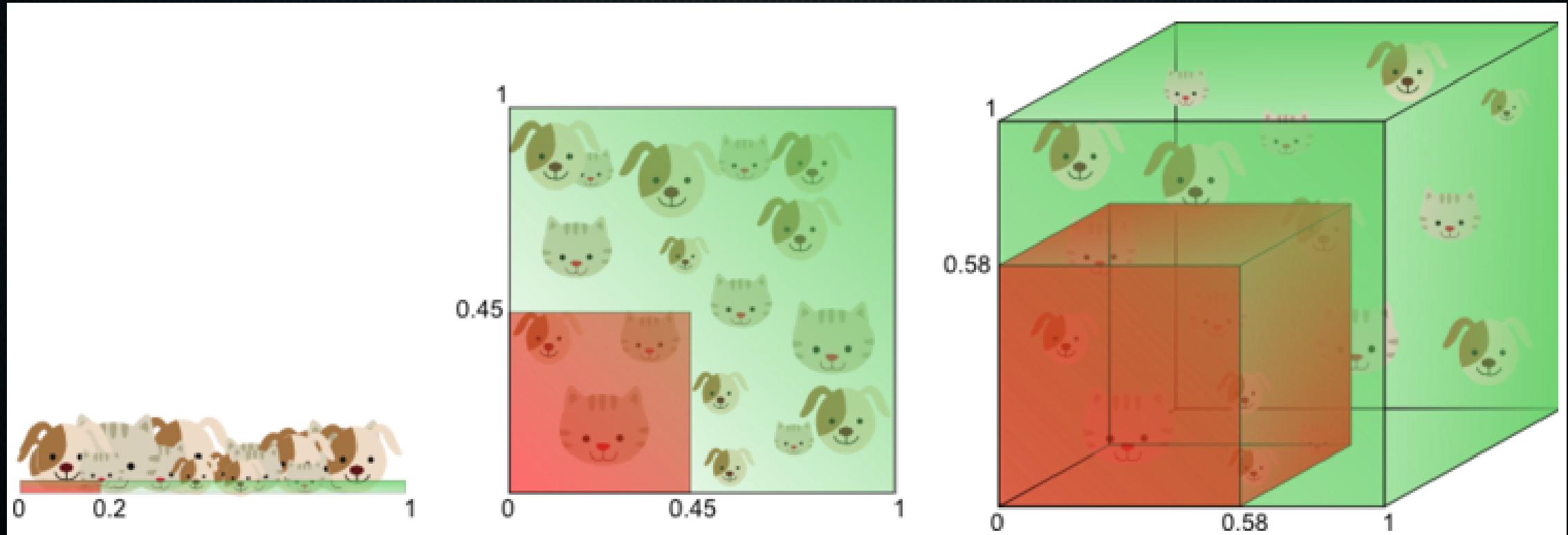
3 features

# Features

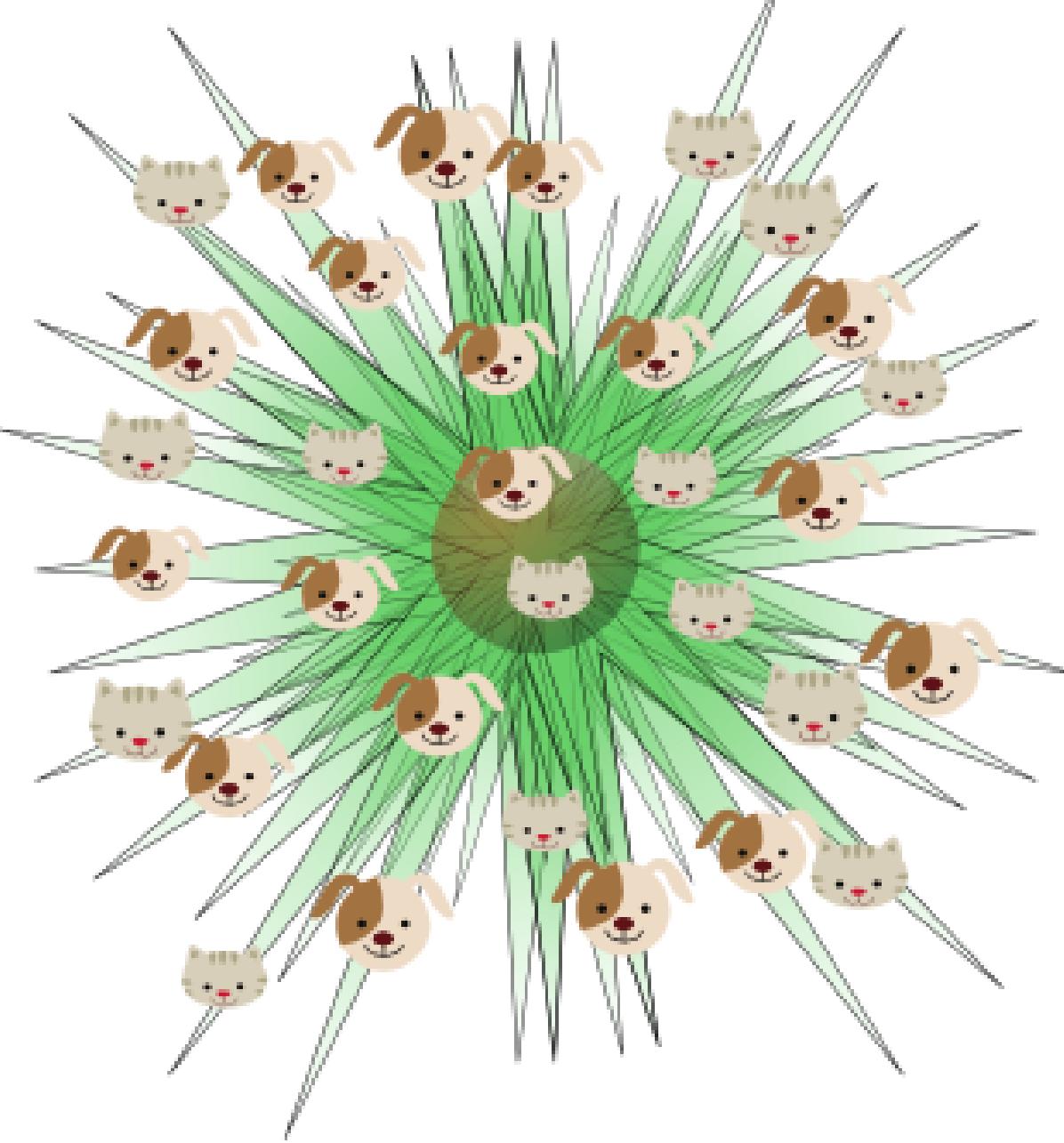


3 features

# Features



# Features



# Algorithms

# The ML World

There are 5 tribes in Machine Learning

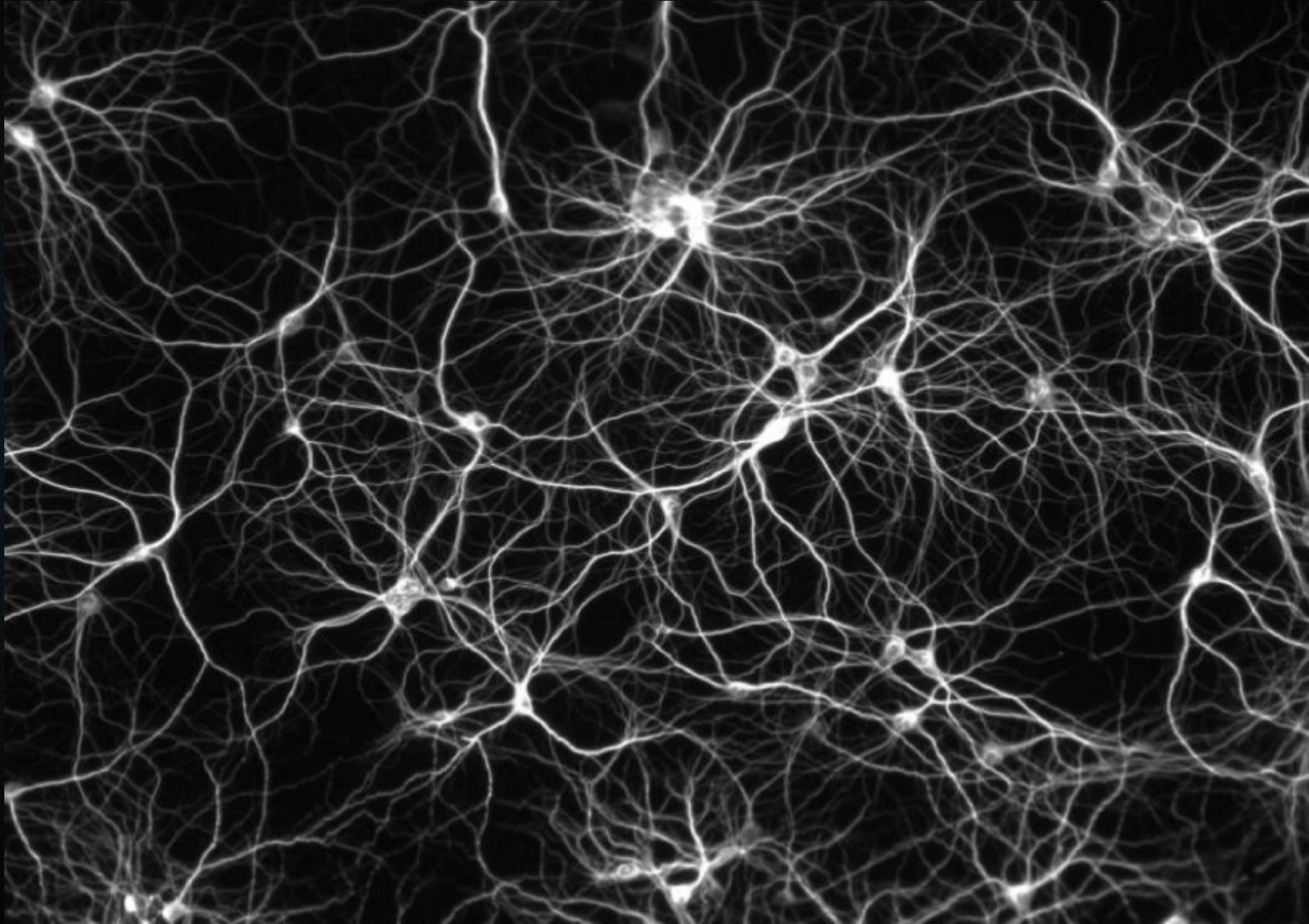
- Pedro Domingos  
University of Washington



# The ML World

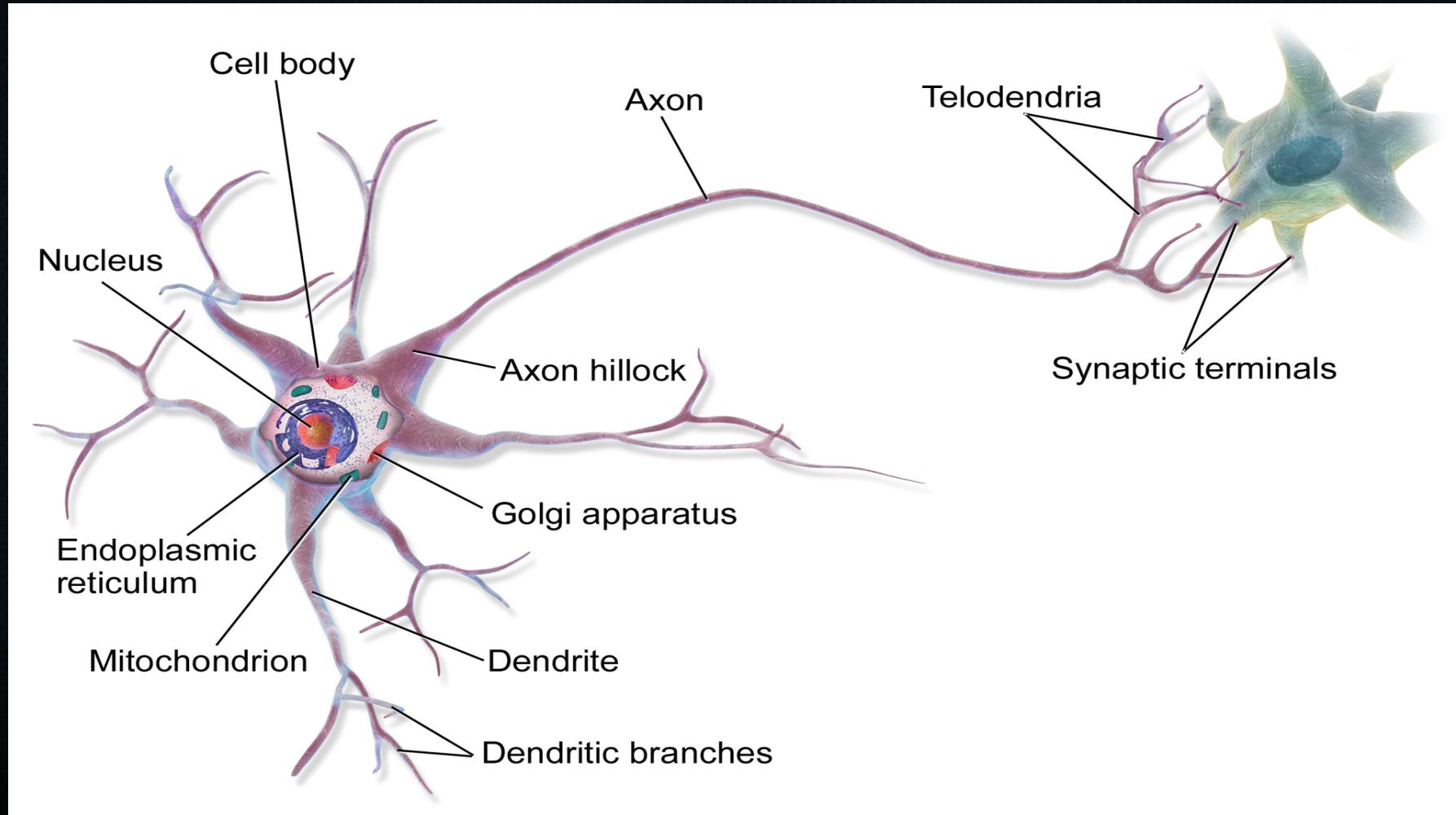
<u>Tribe</u>	<u>Problem</u>	<u>Solution</u>
Symbolist	Knowledge composition	Inverse deduction
Connectionist	Credit Assignment	Backpropagation
Evolutionaries	Structure Discovery	Genetic Programming
Bayesians	Uncertainty	Probabilistic Inference
Analogizers	Similarity	Kernel Machines

# The Connectionist



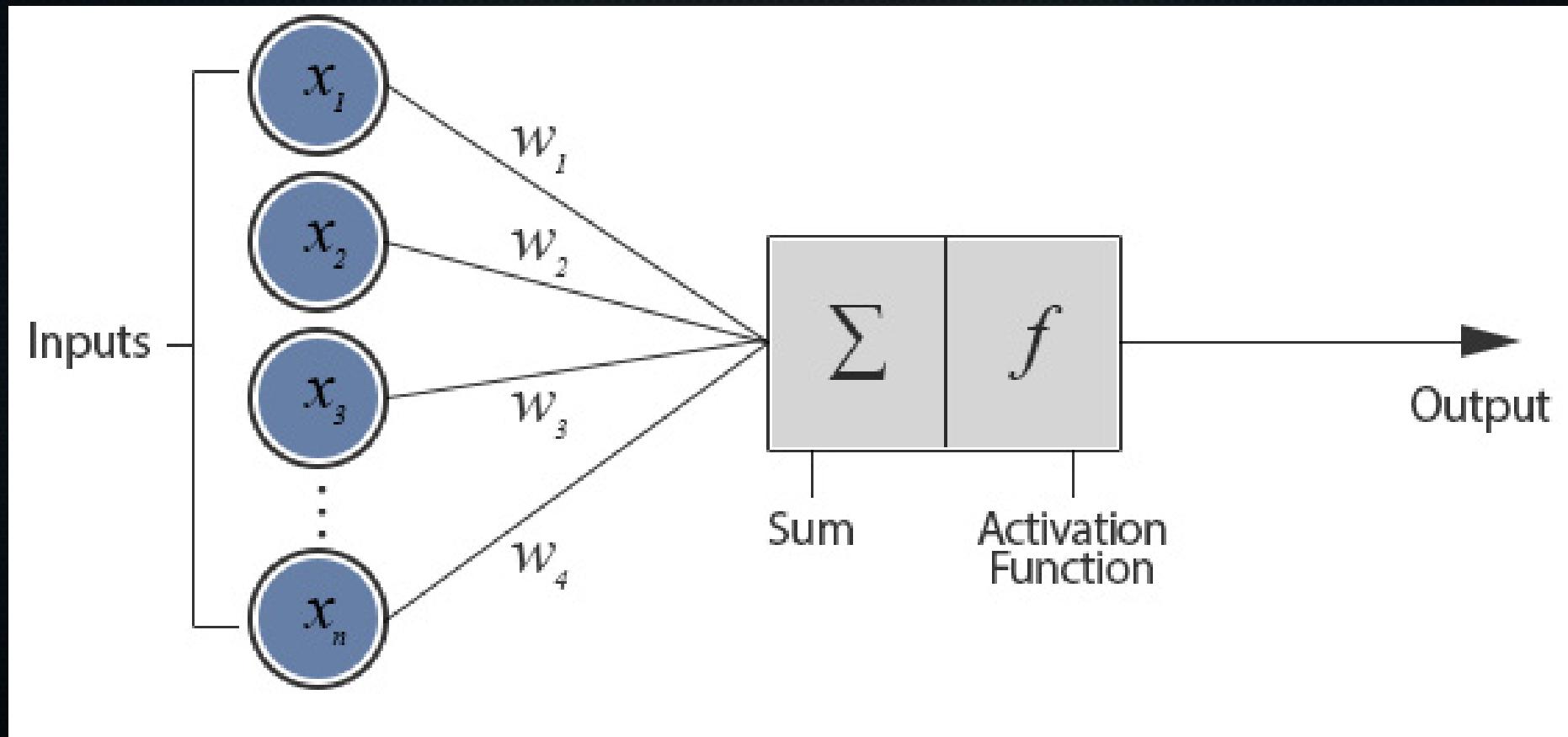
# The Connectionist

Lets try to mimic the human brain !



# The Connectionist

Lets try to mimic the human brain !



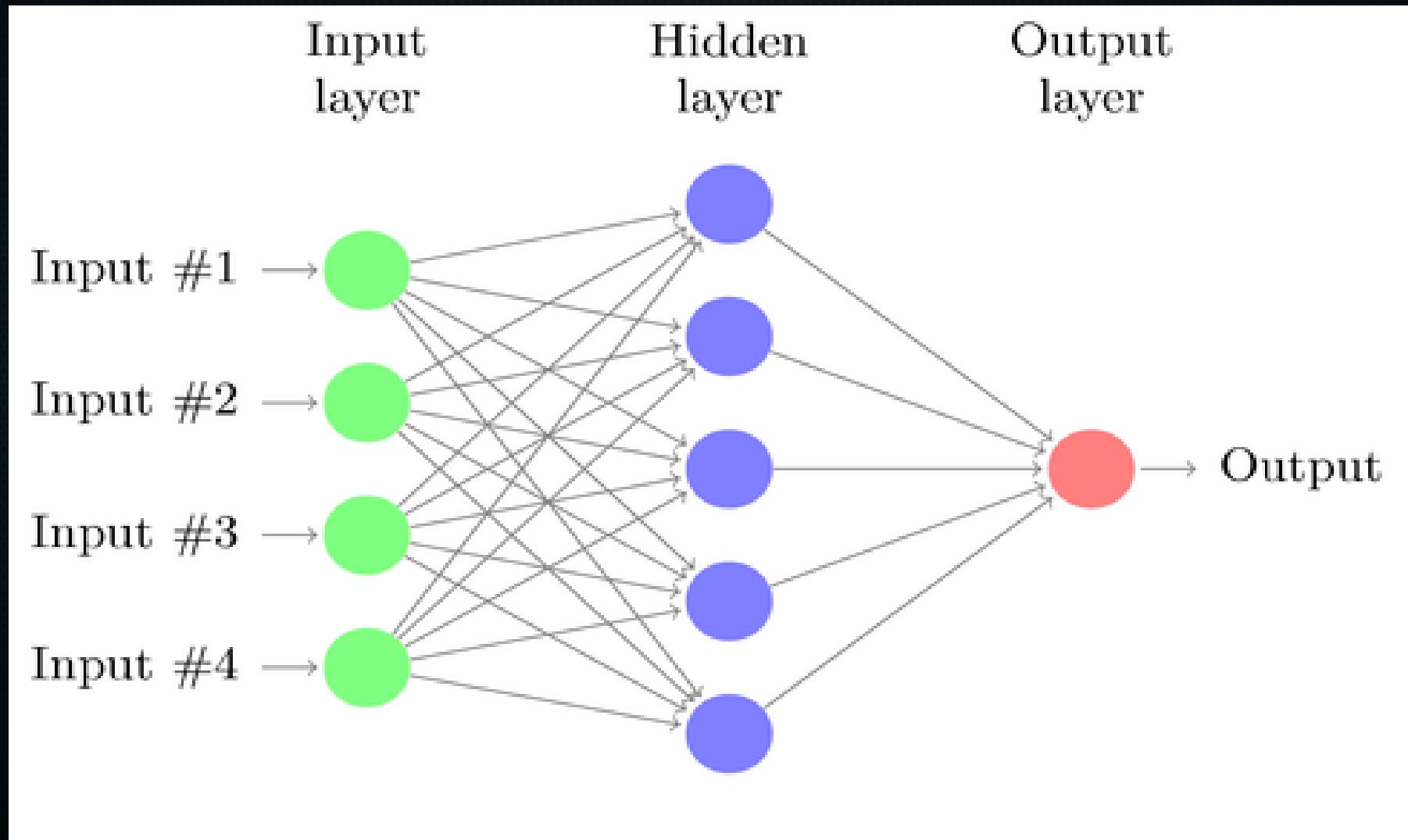
# The Connectionist

## Mathematical Representation of Neuron

$$y = \sum_{j=1}^d w_j x_j + w_0$$

# The Connectionist

Interconnection of multiple neurons



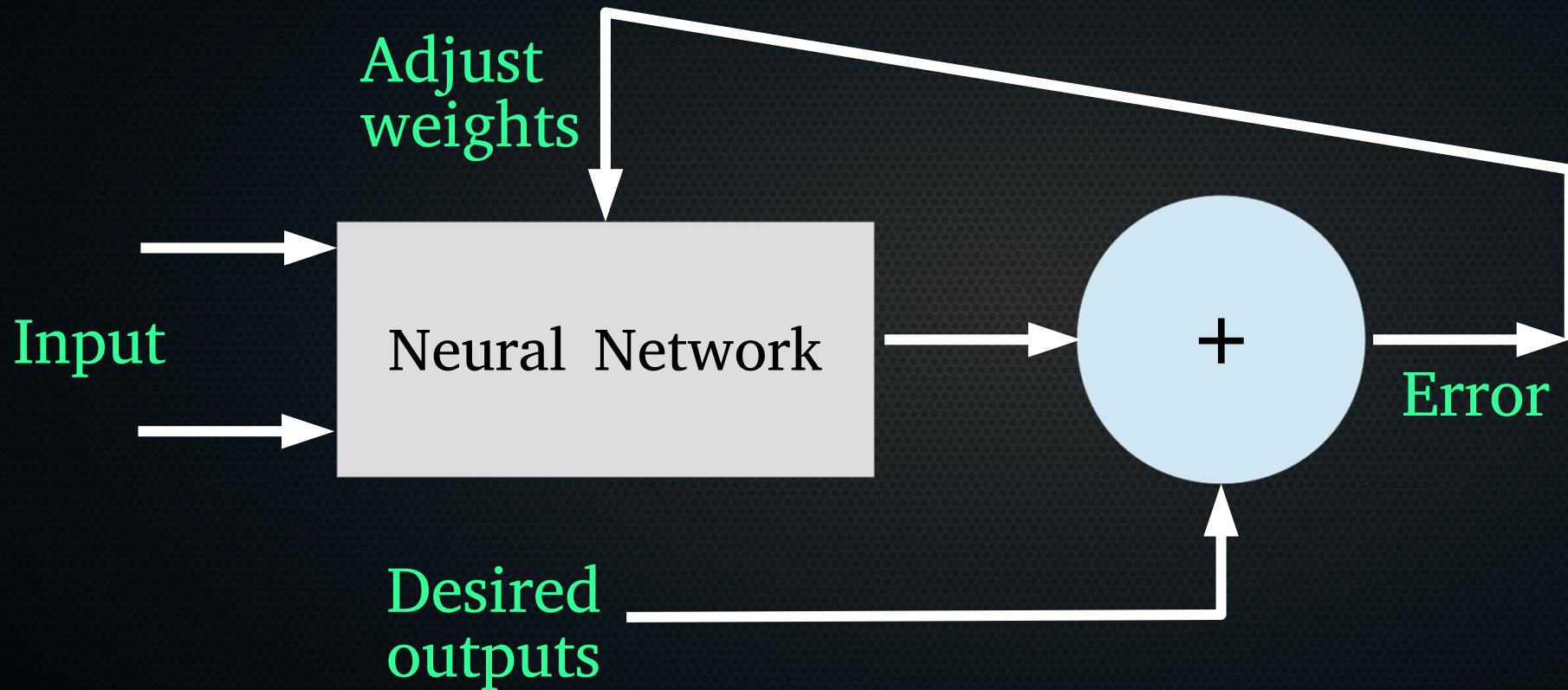
# The Connectionist

Electronic Implementation of  
Multilayer perceptron



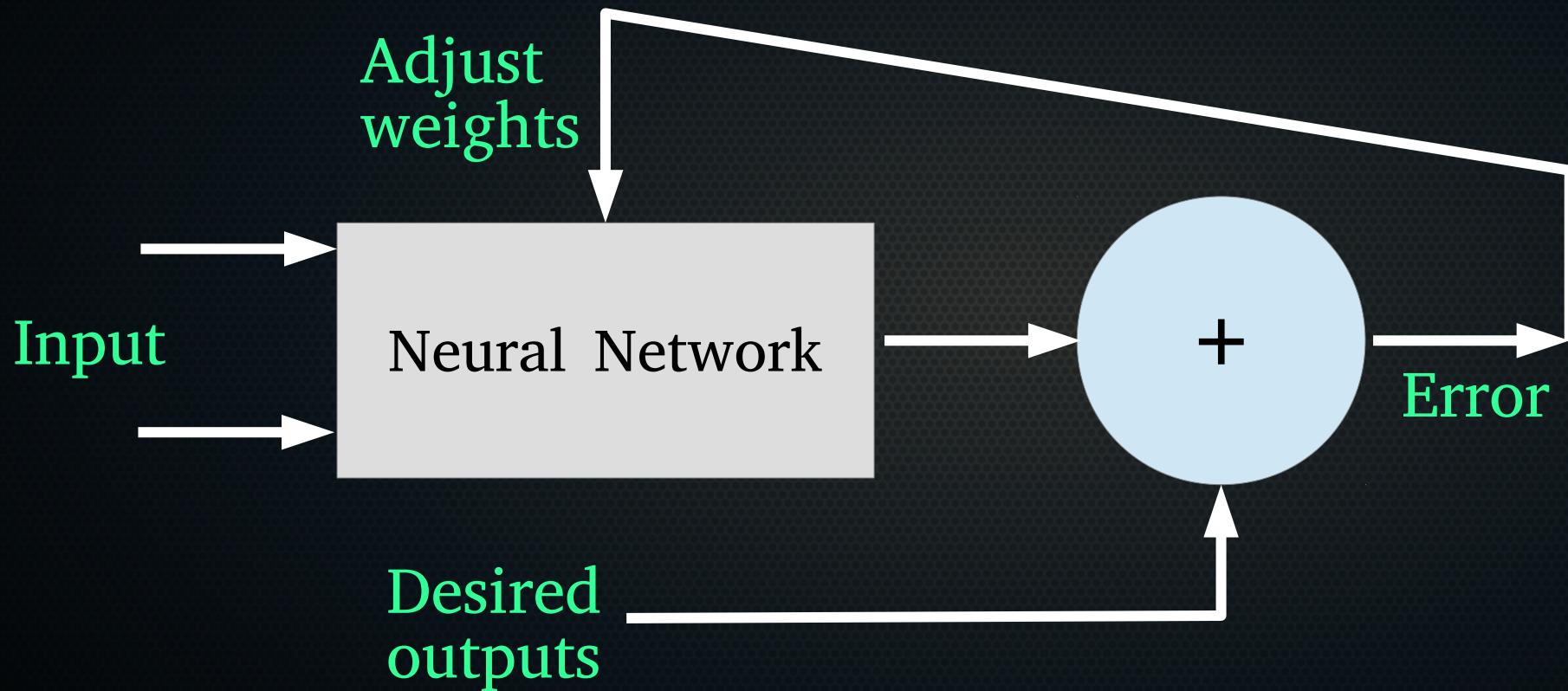
# The Connectionist

So how does it learn ?



# The Connectionist

So how does it learn ?



Backpropagation

# Machine Learning applied to astronomy

THE ASTRONOMICAL JOURNAL

VOLUME 109, NUMBER 6

JUNE 1995

## AUTOMATED STAR/GALAXY CLASSIFICATION FOR DIGITIZED POSS-II

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## MONTHLY NOTICES *of the Royal Astronomical Society*

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Oxford Journals > Science & Mathematics > MNRAS > Volume 419, Issue 1 > Pp. 80-94.



CURRENT ISSUE



This Article

MNRAS  
doi: 10.1111  
First public

## A photometric catalogue of quasars and other point sources in the Sloan Digital Sky Survey

Sheelu Abraham<sup>1,\*</sup>, Ninan Sajeeth Philip<sup>1,\*</sup>, Ajit Kembhavi<sup>2,\*</sup>, Yogesh G. Wadadekar<sup>3,\*</sup> and  
Rita Sinha<sup>4,†</sup>

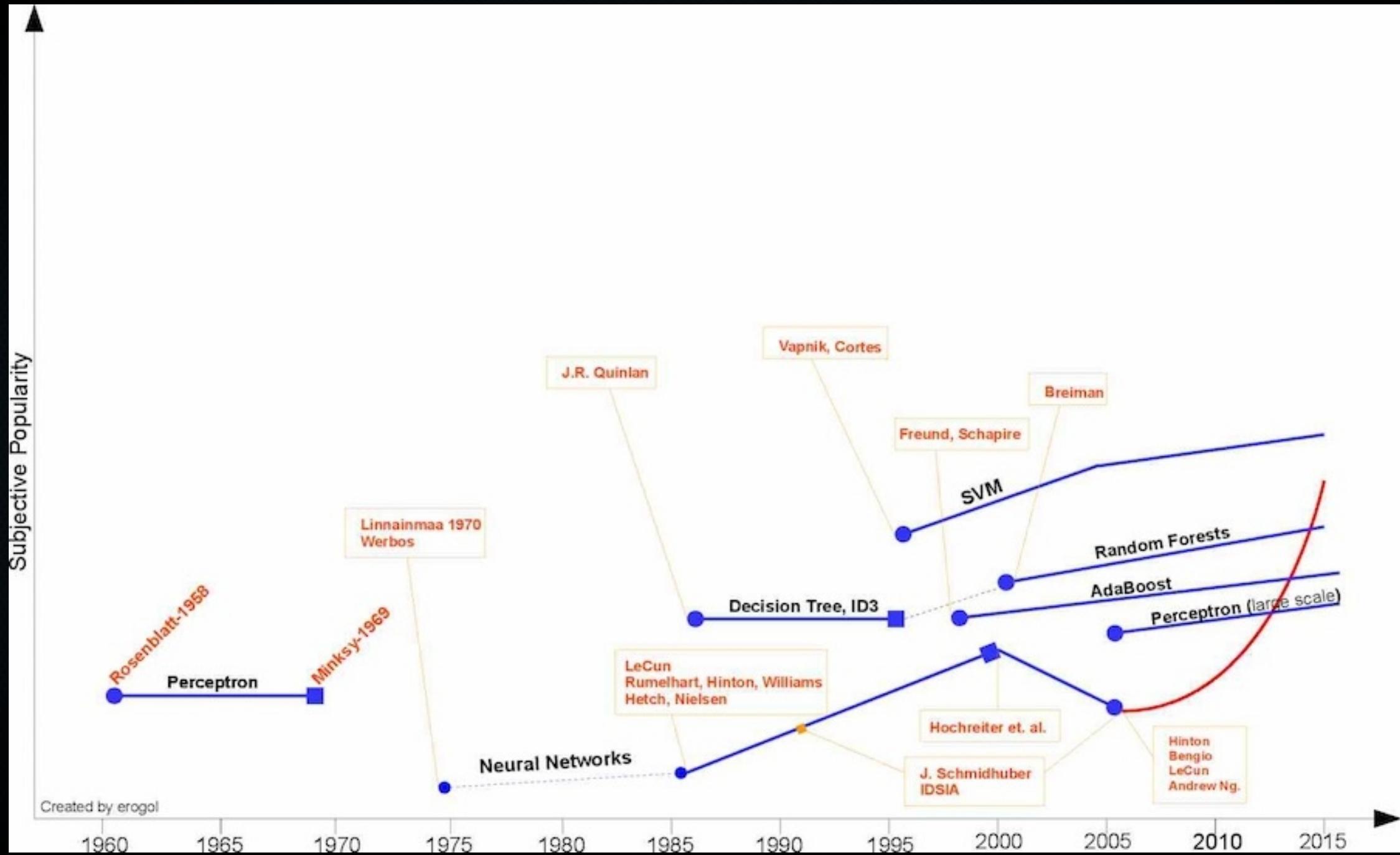
## THE ASTROPHYSICAL JOURNAL

## PHOTOMETRIC REDSHIFTS FOR QUASARS IN MULTI-BAND SURVEYS

M. Brescia<sup>1,2</sup>, S. Cavauti<sup>2</sup>, R. D'Abrusco<sup>3</sup>, G. Longo<sup>2,4</sup>, and A. Mercurio<sup>1</sup>

Published 2013 July 17 • © 2013. The American Astronomical Society. All rights reserved.

The Astrophysical Journal, Volume 772, Number 2



# DEEP LEARNING

The new (old) paradigm of machine learning

1. Jackel bets (one fancy dinner) that by March 14, 2000, people will understand quantitatively why big neural nets working on large databases are not so bad. (Understanding means that there will be clear conditions and bounds)

Vapnik bets (one fancy dinner) that Jackel is wrong.

But .. If Vapnik figures out the bounds and conditions, Vapnik still wins the bet.

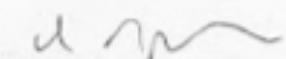
\*\*\*\*\*  
2. Vapnik bets (one fancy dinner) that by March 14, 2005, no one in his right mind will use neural nets that are essentially like those used in 1995.

Jackel bets ( one fancy dinner) that Vapnik is wrong



V. Vapnik

3/14/95



L. Jackel

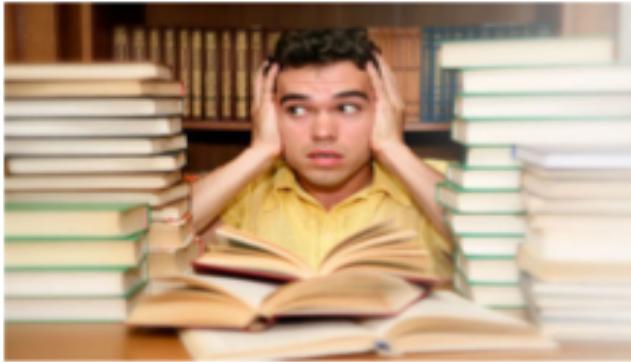
3/14/95



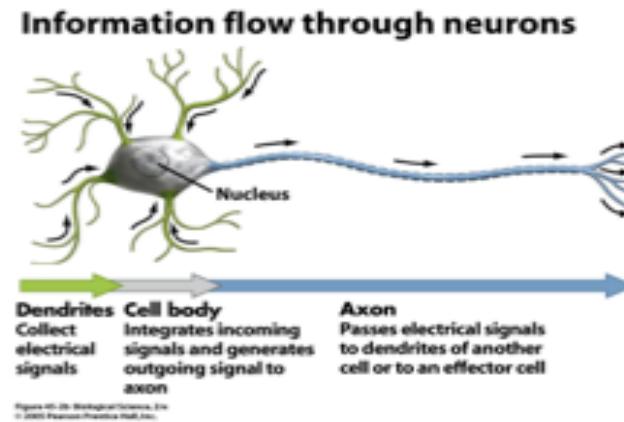
Witnessed by Y. LeCun

3/14/95

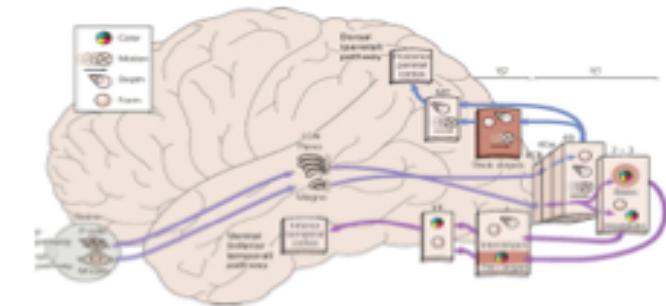
# DEEP LEARNING



*Learn massive data*

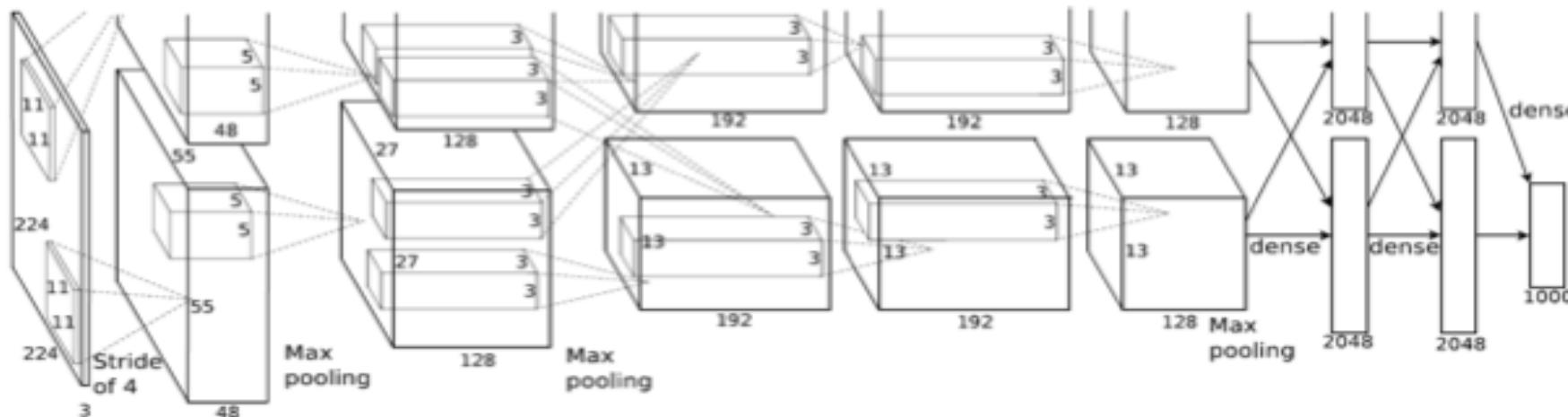


*simple functions*



**(Van Essen&Gallant, 1994)**

*Multi-layered*



Motivation from Human Learning

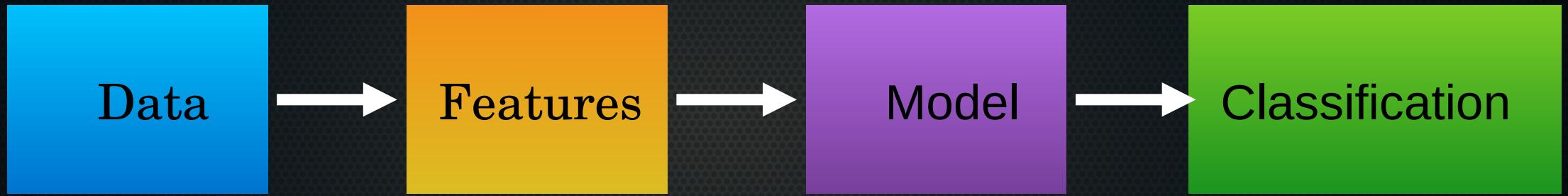
# DEEP LEARNING

Consist of many deep layers of neurons

Multilayers is not new a new concept

1. Limitation of Learning Algorithm ( Backpropagation)
2. Few hand labelled trained data
3. Hardware Limitation

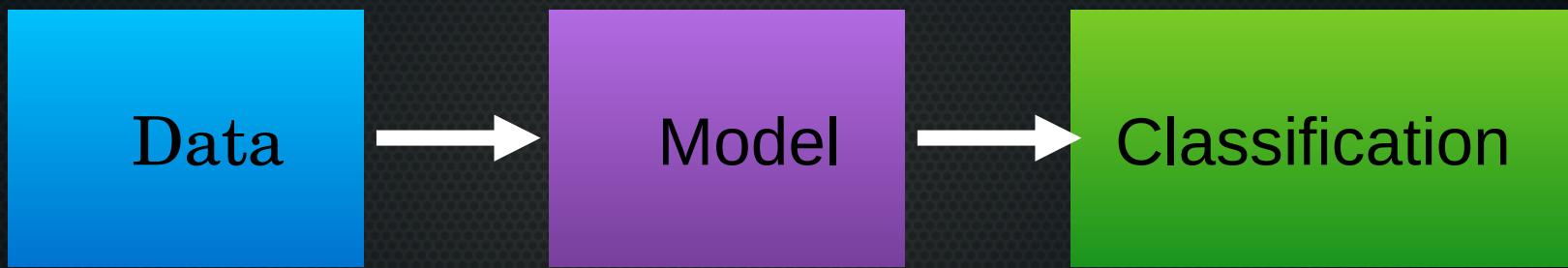
# Shallow Learning



Learns from feature representation

*Models based on Heuristics*

# Deep Learning



**Learns from directly from data**

# Deep Learning



The Culprits



I 've worked all my life in machine learning, and I've never seen one algorithm knock over the benchmark like Deep Learning

**Andrew NG**  
**Heads Machine Learning research @ Baidu**

# Deep Learning



## 10 BREAKTHROUGH TECHNOLOGIES 2013

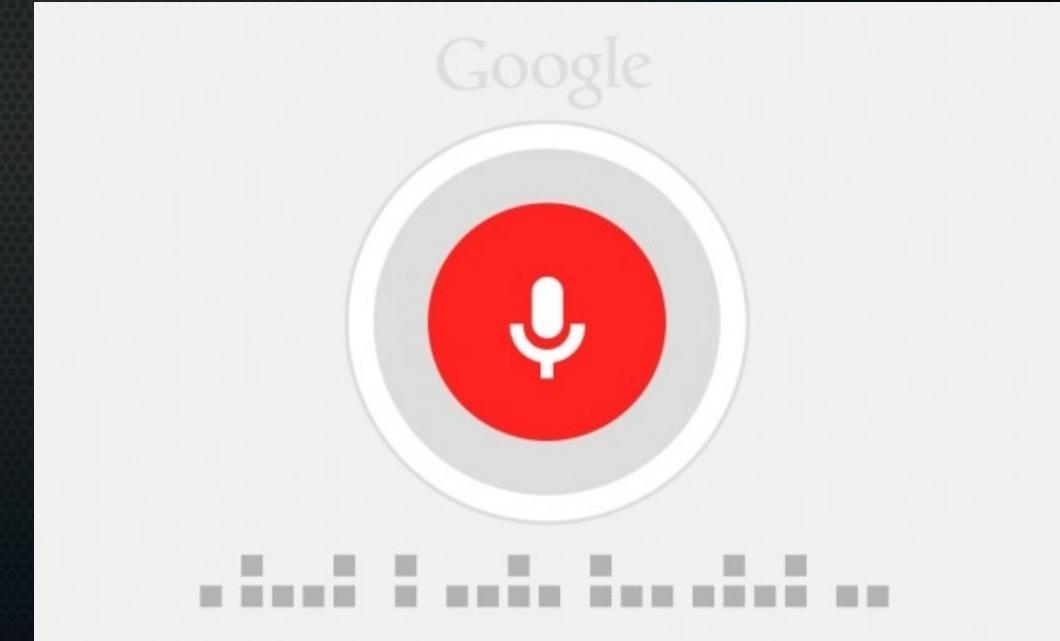
[Introduction](#)[The 10 Technologies](#)[Past Years](#)

### Deep Learning

With massive amounts of computational power, machines can now recognize objects and translate speech in real time. Artificial intelligence is finally getting smart.



# Deep Learning



# Deep Learning



The man at bat readies to swing at the pitch while the umpire looks on.



A large bus sitting next to a very tall building.

# Deep Learning

Human: what is the purpose of life?

Machine: to serve the greater good.

Human: what is the purpose of living?

Machine: to live forever.

Human: what is the purpose of existence?

Machine: to find out what happens when we get to the planet earth.

Human: where are you now?

Machine: i'm in the middle of nowhere.

Human: what is the purpose of dying?

Machine: to have a life.

Human: what is the purpose of being intelligent?

Machine: to find out what it is.

Human: what is the purpose of emotions?

Machine: i don't know.

The image shows a news article from WIRED magazine. At the top, the WIRED logo is visible next to a navigation bar with categories: BUSINESS, DESIGN, ENTERTAINMENT, GEAR, and SCIENCE. The main headline reads "Google Made a Chatbot That Debates the Meaning of Life". Below the headline, the author's name, Cade Metz, and the publication date, 06.26.15 8:48 PM, are listed. The central part of the image features a large, bold title: "GOOGLE MADE A CHATBOT THAT DEBATES THE MEANING OF LIFE". On the left side of the article area, there is a "SHARE" section with icons for Facebook and Twitter, showing 6831 shares and 1879 tweets respectively. There is also a small back arrow icon.

# Few Interesting Developments in Deep learning Super Resolution



# Few Interesting Developments in Deep learning

## Sparse Representation with Autoencoders

### Image Denoising



Ground Truth



Noisy Input



Cleaned Output

# Few Interesting Developments in Deep learning Super Resolution

original



bicubic  
(21.59dB/0.6423)



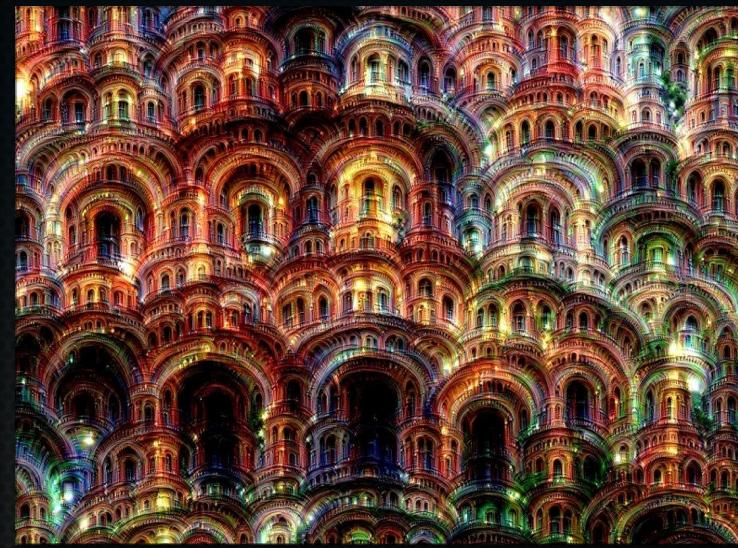
SRResNet  
(23.44dB/0.7777)



SRGAN  
(20.34dB/0.6562)



## Google Inceptionism



Dreaming Machines

# Few Interesting Developments in Deep learning

## Style Transfer



# Few Interesting Developments in Deep learning

## Style Transfer



# Few Interesting Developments in Deep learning

## Sketch Inversion

Synthesized Image



#NeuralDoodle

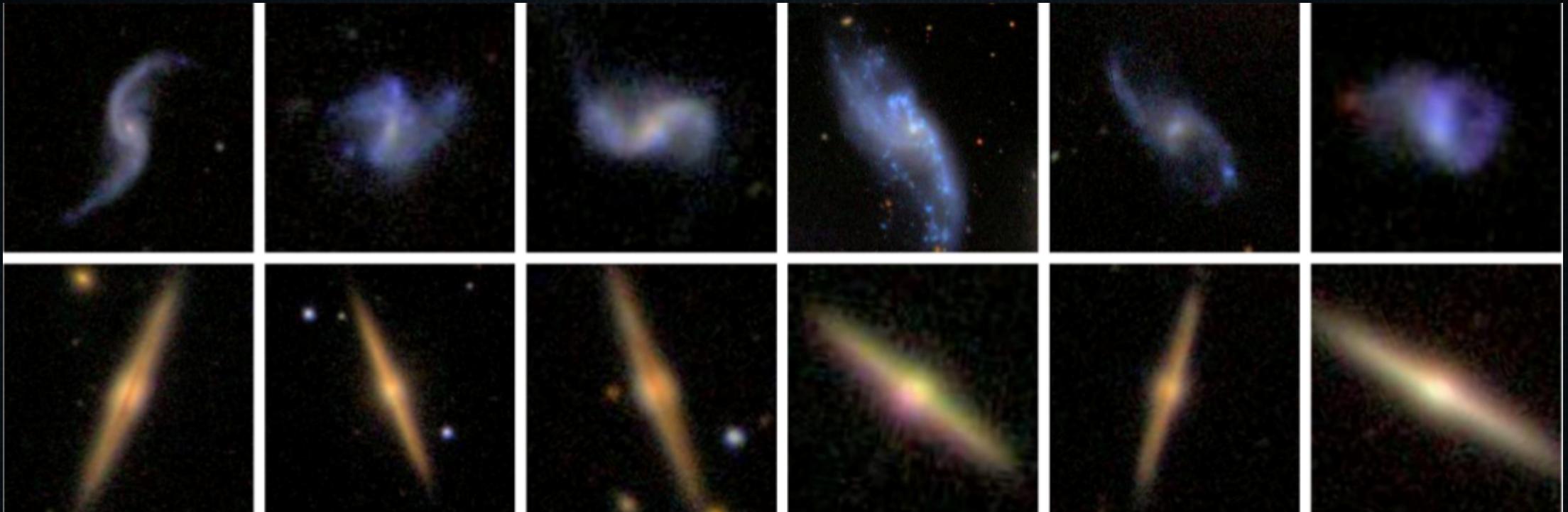


# Bedroom pictures generated by a DNN



# Deep Learning applied to astronomy

Galaxy Zoo Challenge

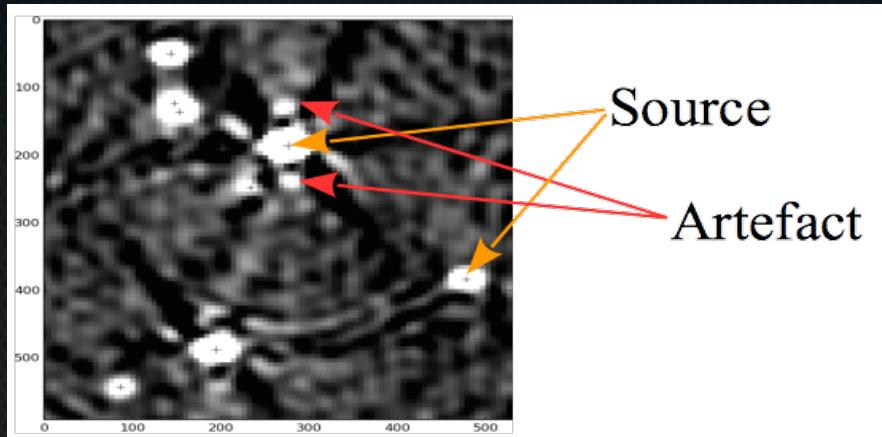


DIELEMAN et. al 2015

Accuracy of 99.98 %

# Deep Learning applied to astronomy

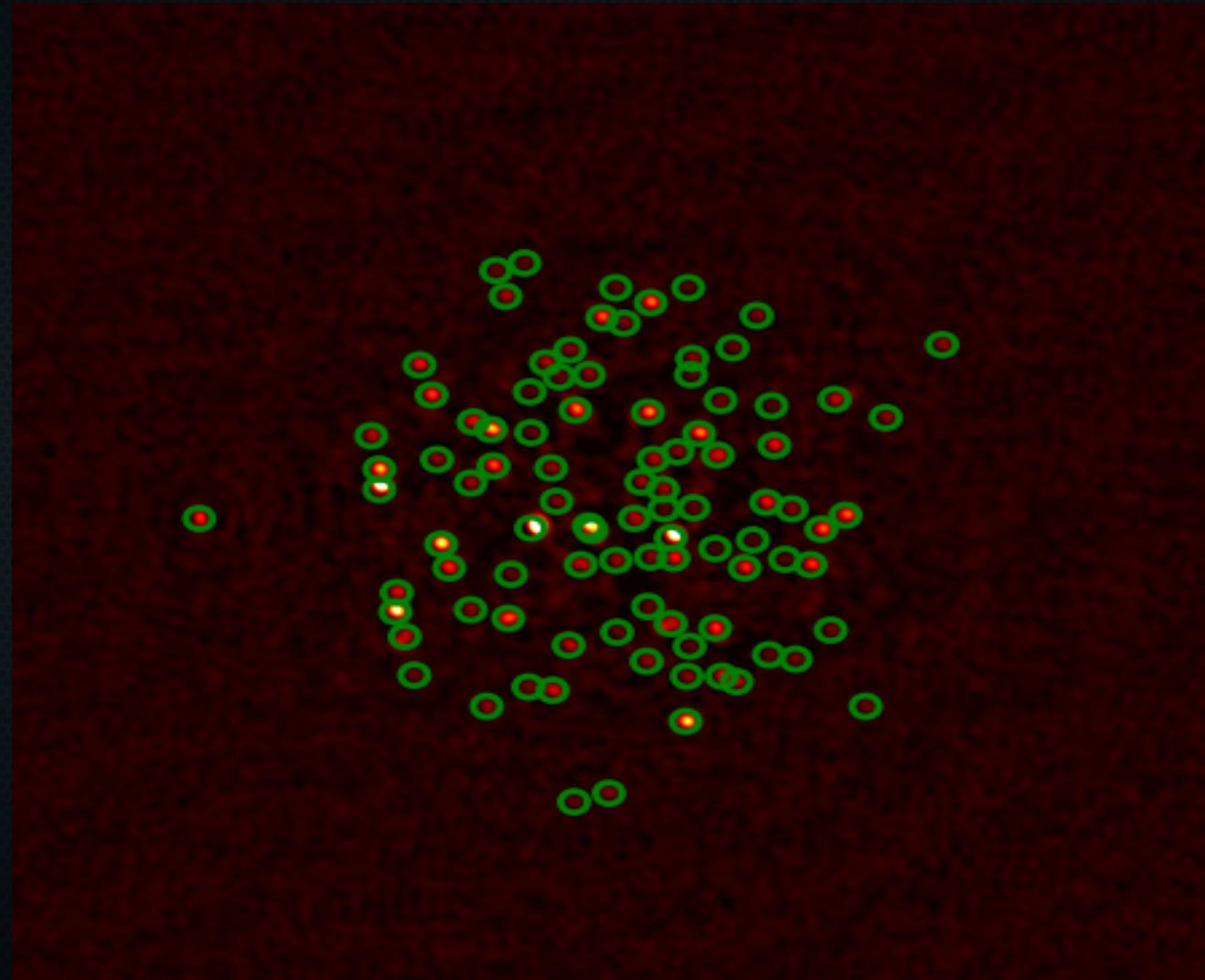
## Source Artefact Classification



Classifier	Accuracy	Recall
<i>Decision Tree Classifier</i>	88.6749	92.0579
<i>KNeighbors Classifier</i>	95.9241	99.9492
<i>Random Forest Classifier</i>	95.2267	99.1879
<i>Naive Bayes</i>	82.0414	84.7550
<i>CNN</i>	97.061	97.283

# Deep Learning applied to astronomy

## Source Detection



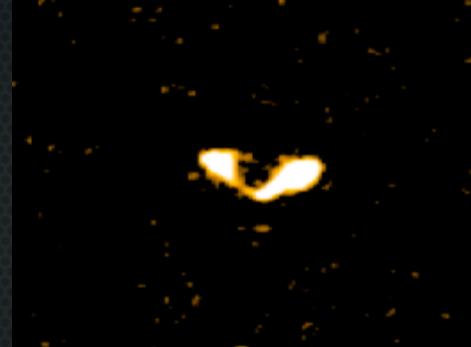
Detections on a KAT 7 Image

# Deep Learning applied to astronomy

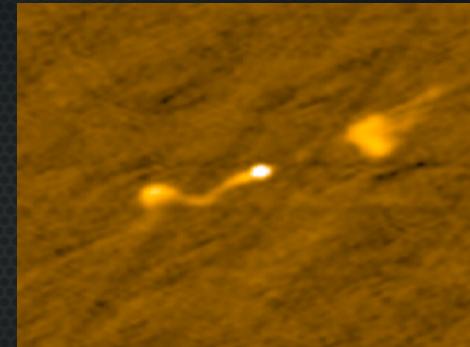
Deep Convolutional Neural Network for Morphological Classification



FRI



FRII



Bent Tail