

# Artificial Intelligence and the Future of Medicine/Mankind

Howard Schneider  
Sheppard Clinic North, Toronto, Canada

OMA Section on Primary Care Mental Health  
Toronto, March 2020

# CONFLICTS OF INTEREST

- ▶ None

# COMMERCIAL NAMES

- ▶ I will try to minimize use of commercial names, where feasible (many AI-related products are company specific)

DR HOWARD SCHNEIDER, MD, MDPAC(C), CCFP

## **WHY SHOULD I GIVE THIS TALK?**

### **Practicing physician**

- ▶ Background –General Practice/ Family Practice
- ▶ A decade –Psychiatry Consultations in ER (Laval)
- ▶ Two decades –Community Mental HealthCare(GTA)

DR HOWARD SCHNEIDER, MD, MDPAC(C), CCFP

## **WHY SHOULD I GIVE THIS TALK?**

**Interest – How does mind work?**

**Flip side – How to create an AGI?**

**(Artificial General Intelligence, ‘HLAI’, ‘Strong AI’)**

- ▶ Research – Cognitive Architectures
- ▶ (I design the innards of the machines to produce AI/AGI)

# LEARNING OBJECTIVES

- ▶ **1. Real understanding of what AI is:**
- ▶ 1a. Deep Learning and Reinforcement Learning
- ▶ 1b. Field of Artificial Intelligence (AI)
- ▶ 1c. Neuro-Symbolic Gap
- ▶ **2. How will AI in next decade (or two) affect my patients' lives?**
- ▶ **3. How will AI affect my practice of medicine including psychotherapy?**
- ▶ 3a. How is AI affecting medicine at present?
- ▶ 3b. How will AI affect medicine in the next decade?
- ▶ **4. How will AI affect the future of mankind?**
- ▶ **5. Discussion**

WILL DO BEST TO KEEP ON SCHEDULE....

(90 MINUTES TALK, 30 MINUTES QUESTIONS)



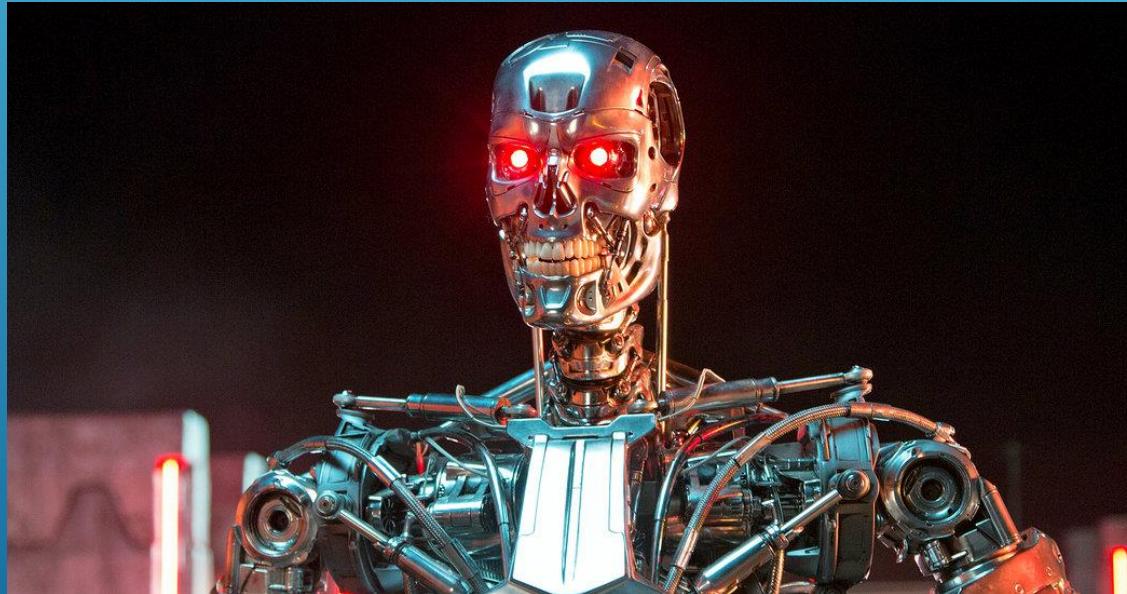
NOT REQUIRED.... BUT.....  
CONSIDER MAKING NOTES IF THIS HELPS  
YOU LEARN....



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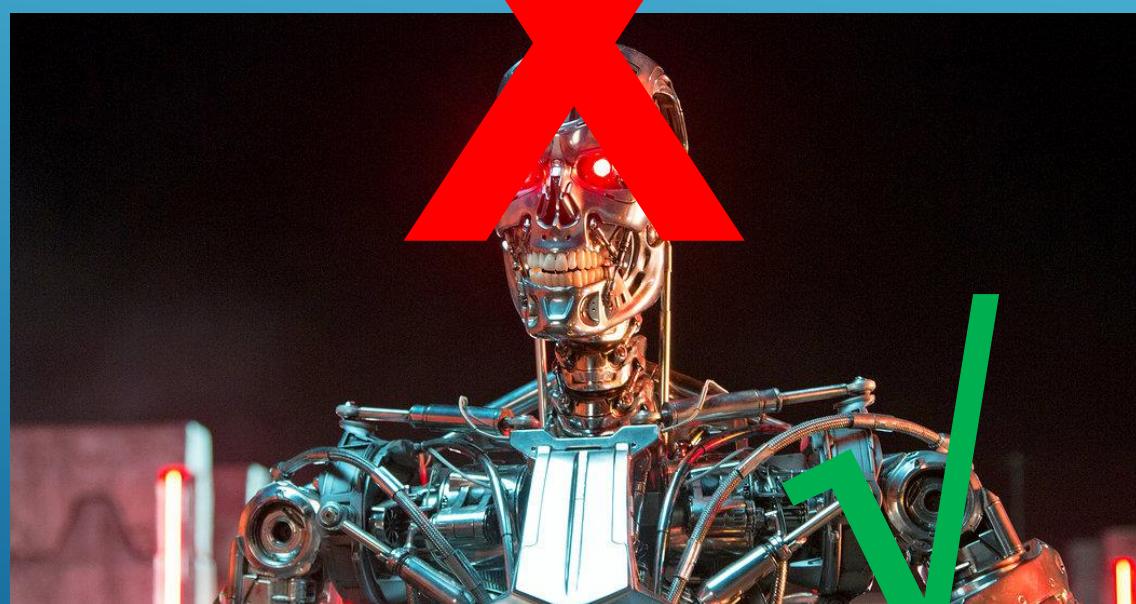
FORGET ABOUT CURRENT HYPE YOU SEE  
ABOUT AI (ARTIFICIAL INTELLIGENCE) ALL  
AROUND YOU IN THE MEDIA....



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FORGET ABOUT CURRENT HYPE YOU SEE  
ABOUT AI (ARTIFICIAL INTELLIGENCE) ALL  
AROUND YOU IN THE MEDIA....



WILL **NOT** HAPPEN WITH  
CURRENT TECHNOLOGY

# AT PRESENT: FORGET ABOUT CURRENT HYPE YOU SEE IN MEDICINE ABOUT AI



Dr Howard Schneider - Artificial Intelligence \*\*INTENDED FOR LIVE PRESENTATION, NOT FOR SELF-READING\*\*

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NORMAL COMPUTER ENGINEERING  
CAN STILL GIVE LOTS OF  
IMPROVEMENTS....

NOT  
REALLY AI



MANY IMPROVEMENTS IN EMR  
(FOR EXAMPLE) POSSIBLE WITH  
GOOD COMPUTER  
ENGINEERING PRACTICES (THE  
AI PART MAY BE MINISCULE)

# AT PRESENT: FORGET ABOUT CURRENT HYPE YOU SEE IN MEDICINE ABOUT AI



RUNNING HOSPITALS OR YOUR PRACTICE BY BIG DATA IS NOT TRUE MEDICINE – IT IS SIMPLY VERY POWERFUL STATISTICS – WE WILL COME BACK AND TALK ABOUT THIS LATER

# LEARNING OBJECTIVES

- ▶ 1. Real understanding of what AI is:
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- ▶ 5. Discussion

# THESE DAYS, PEOPLE USE THE TERM “AI” TO REFER TO **DEEP LEARNING**

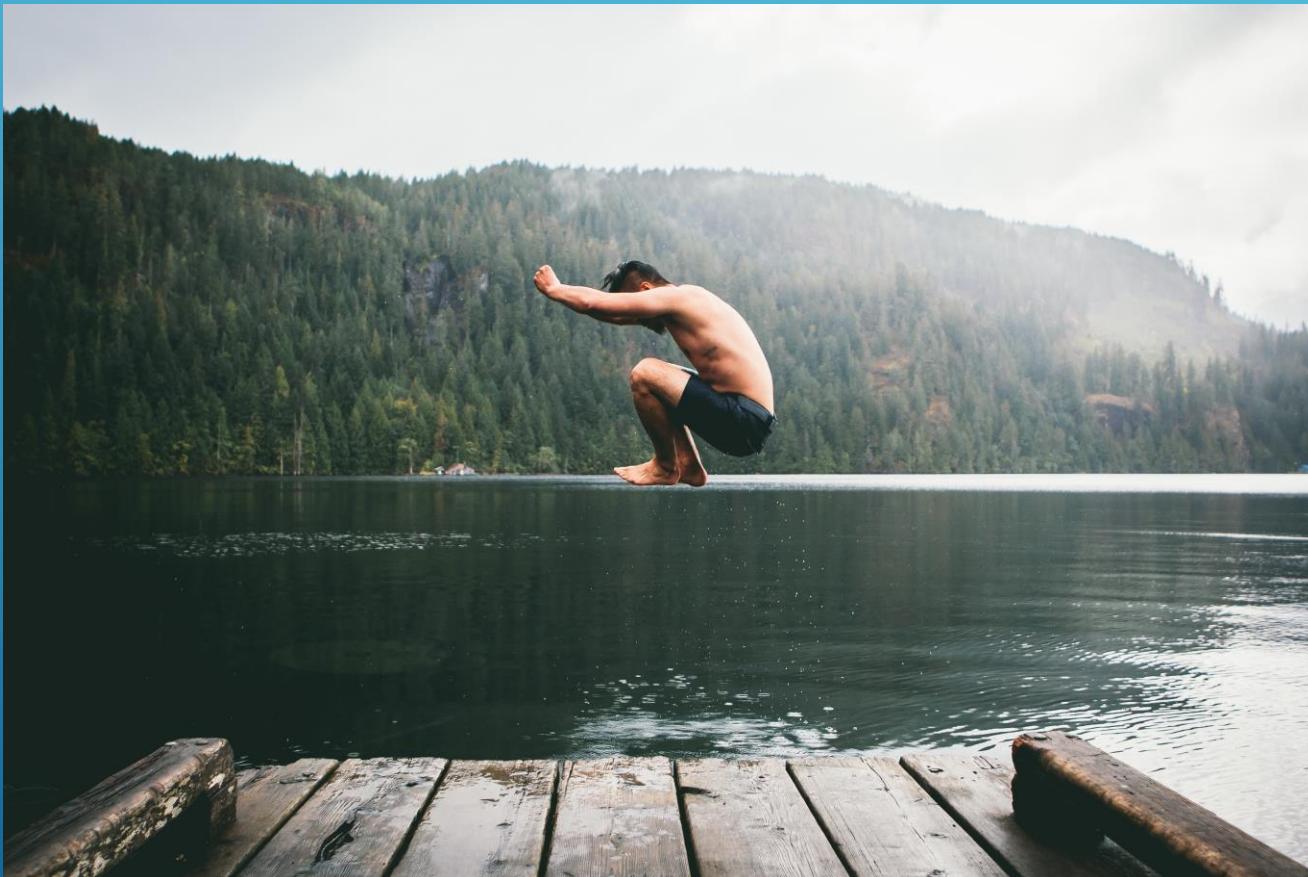
Of course, AI is much more than ‘Deep Learning’ – we’ll talk about that later.



← **LONG ROAD TO COVER  
EVEN THE INTRODUCTORY  
MATERIAL CONCERNING  
ARTIFICIAL INTELLIGENCE**

1. Definition of AI
2. History of AI
3. Mathematical Primer
4. Computer Science Theoretical Concepts
5. Computational Devices
6. Programming Languages
7. .... .... ....

**LET'S JUST JUMP  
IN....**

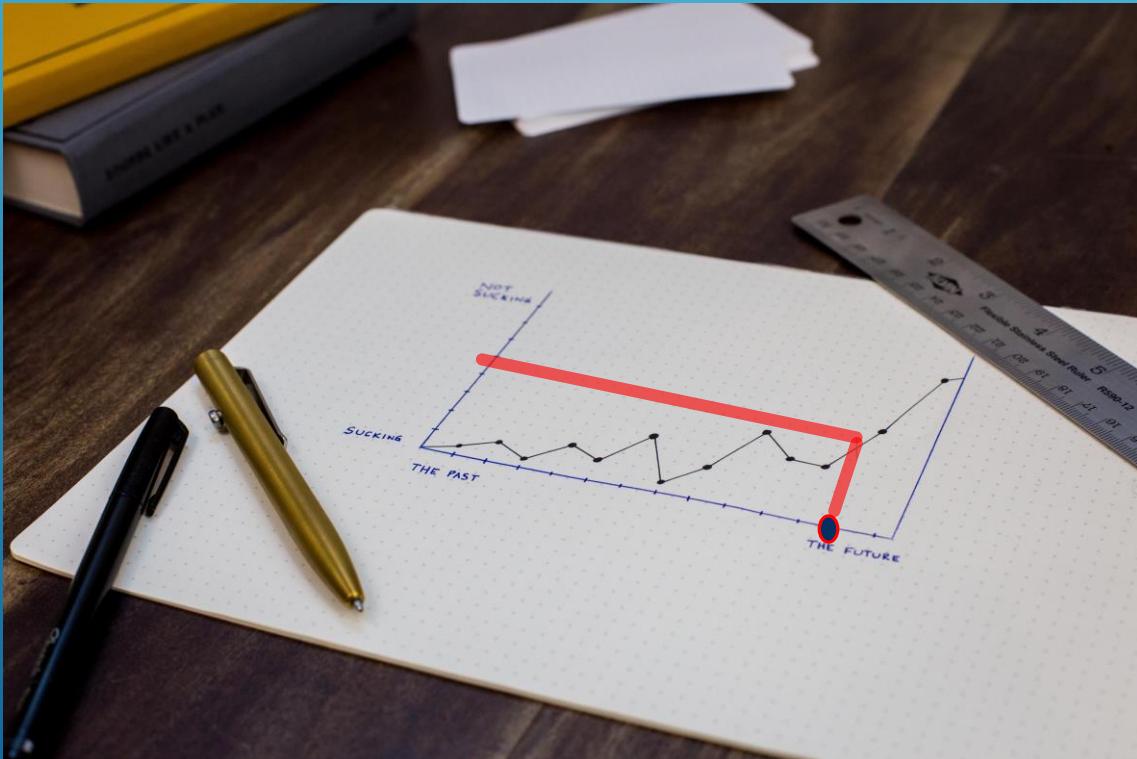


# OK.... WHAT IS DEEP LEARNING?

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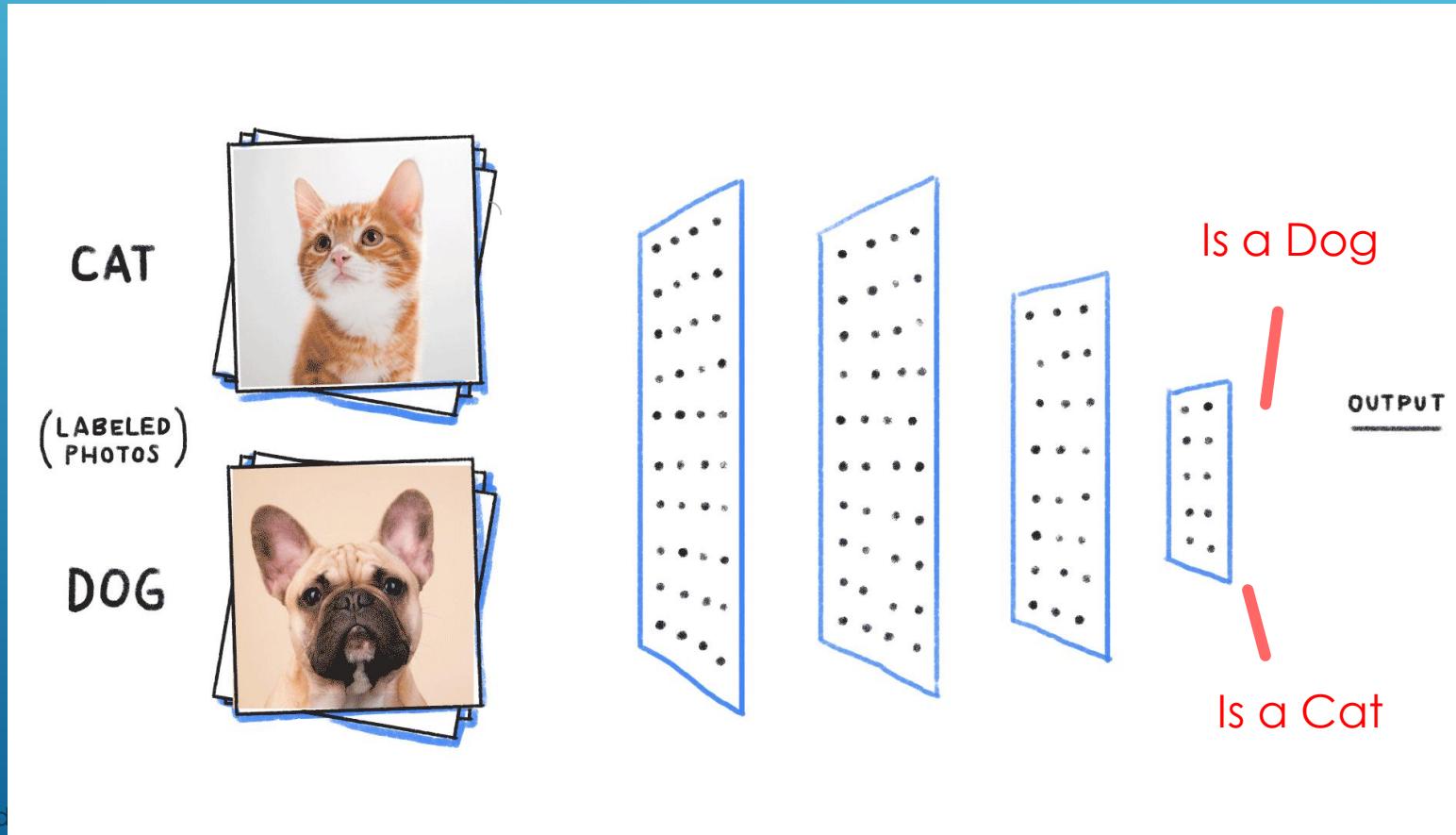
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# THIS IS YOU – EG, PREMED CHEMISTRY – DOING SIMPLE “ARTIFICIAL INTELLIGENCE”, IE, DEEP LEARNING

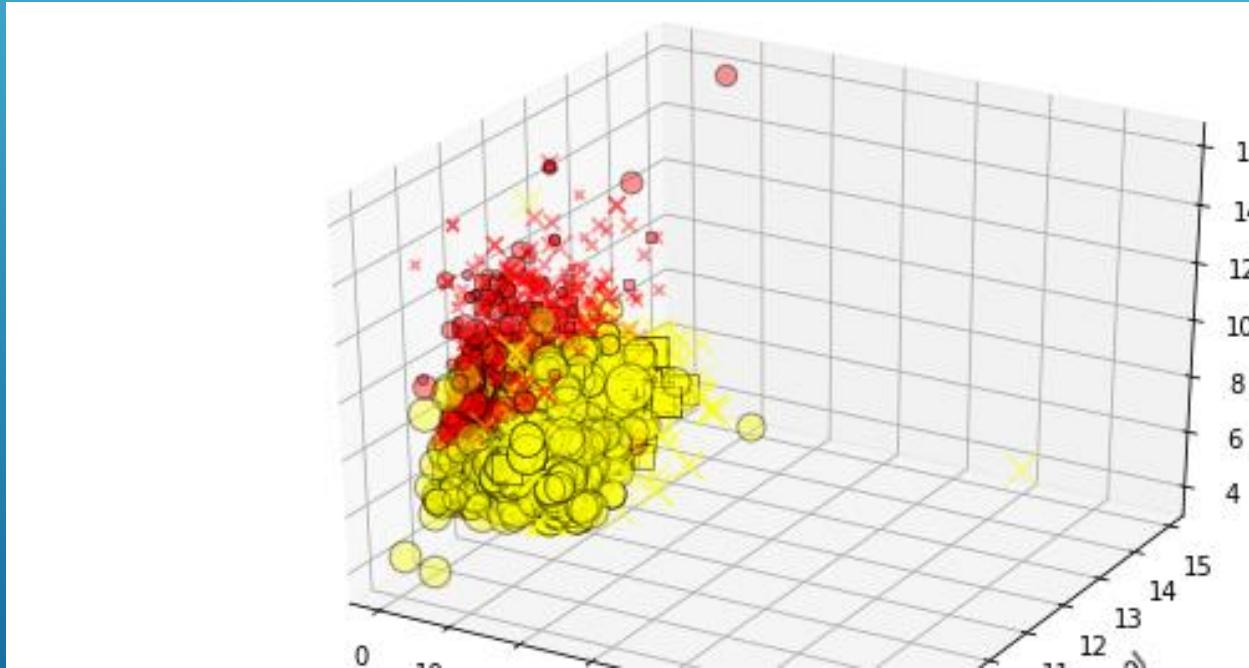


New X value never seen before, you can predict the Y value

# NOW IMAGINE MAKING A GRAPH SHOWING DIFFERENCES TO CLASSIFY ANY DOG FROM ANY CAT

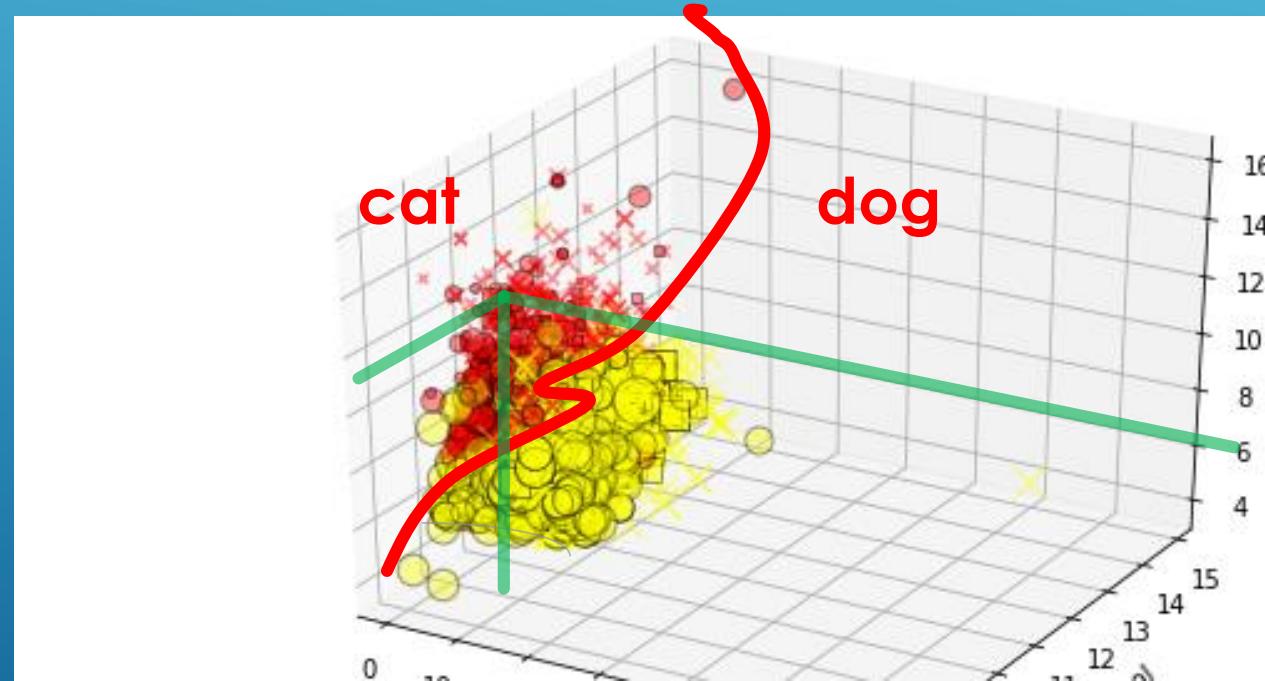


- CONSIDER DIFFERENT FEATURES OF DIFFERENT DOGS AND CATS
- PLOT THEM
- BELOW IS 3-D BUT MAYBE REALLY NEED 1000-D (OR 64,000 DIMENSIONS!!)



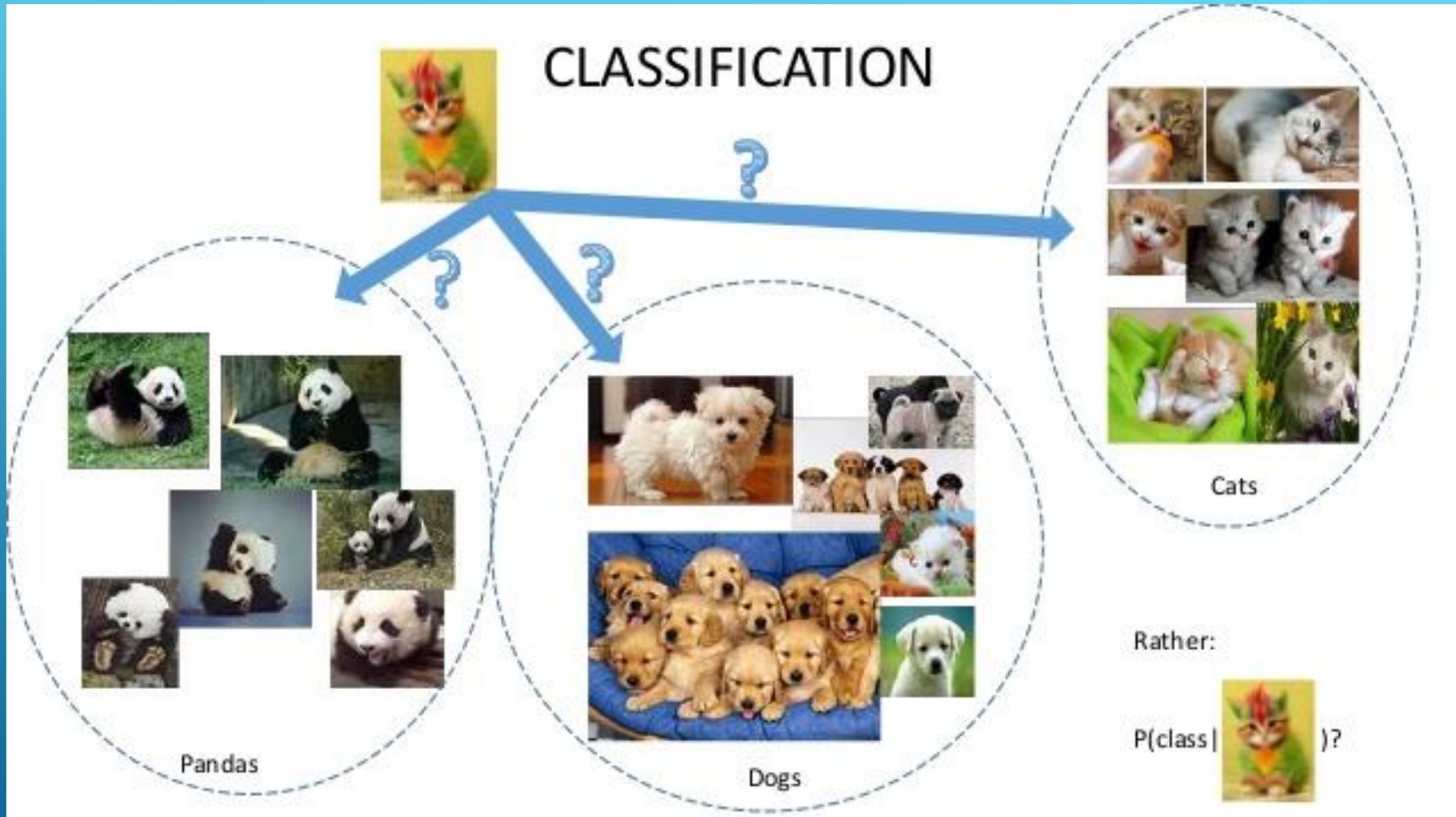
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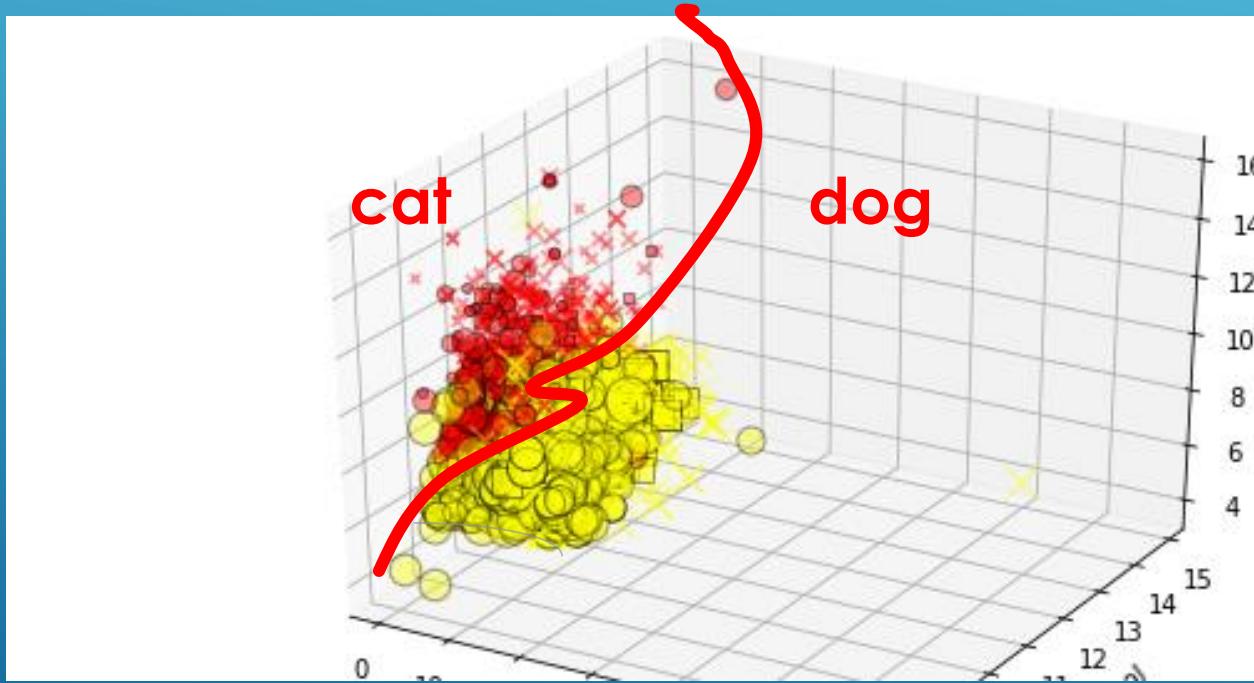


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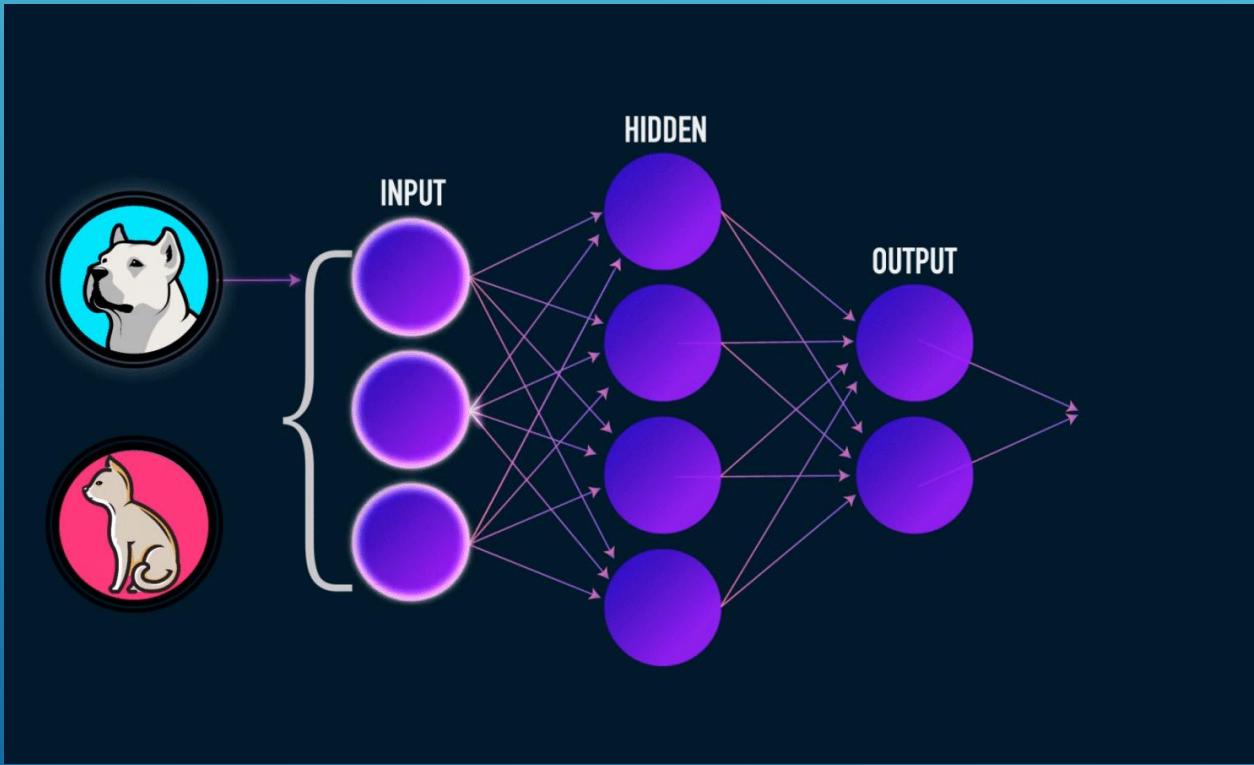
# CLASSIFICATION



OK....HOW DO WE AUTOMATICALLY  
BUILD SUCH A 3-D OR 1000-DIMENSION  
GRAPH?

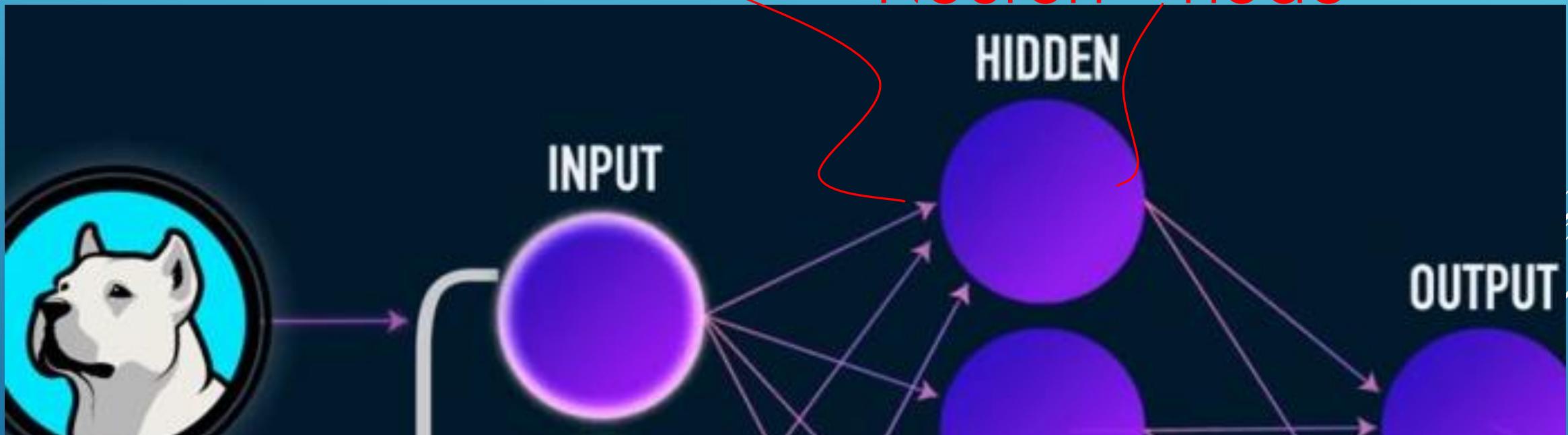


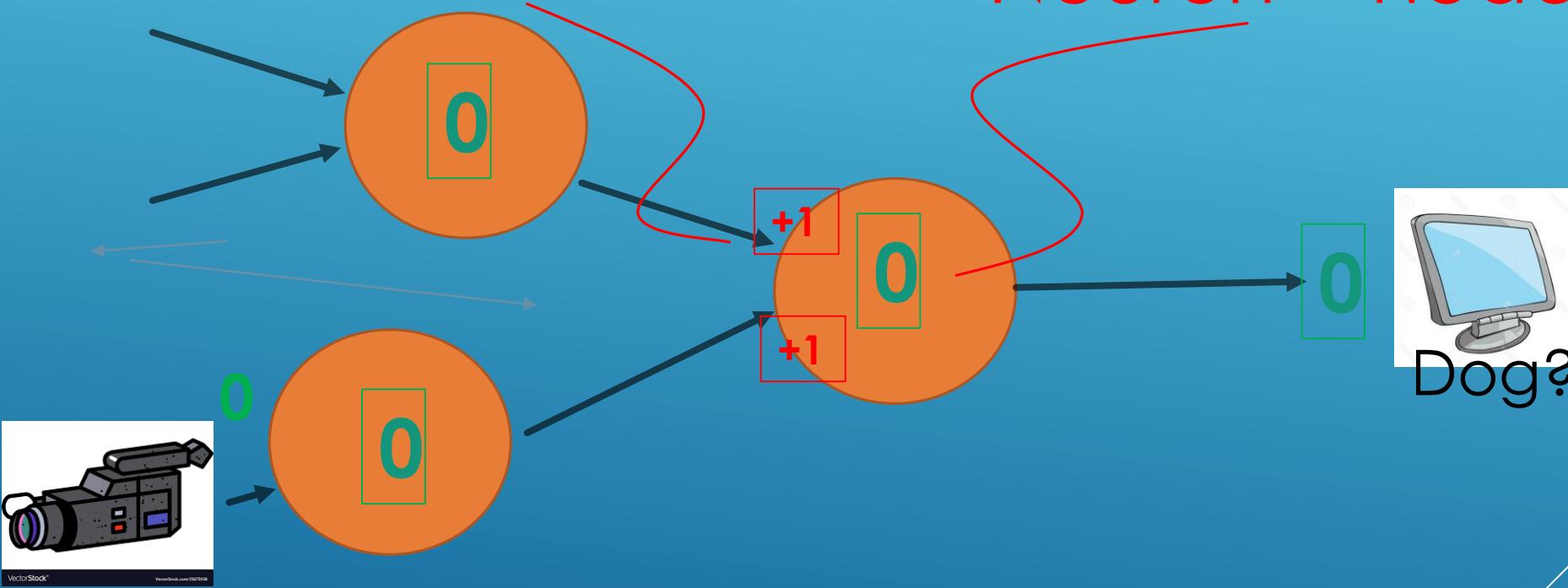
# NEURAL NETWORK TO 'AUTOMATICALLY' LEARN TO TELL A DOG FROM A CAT



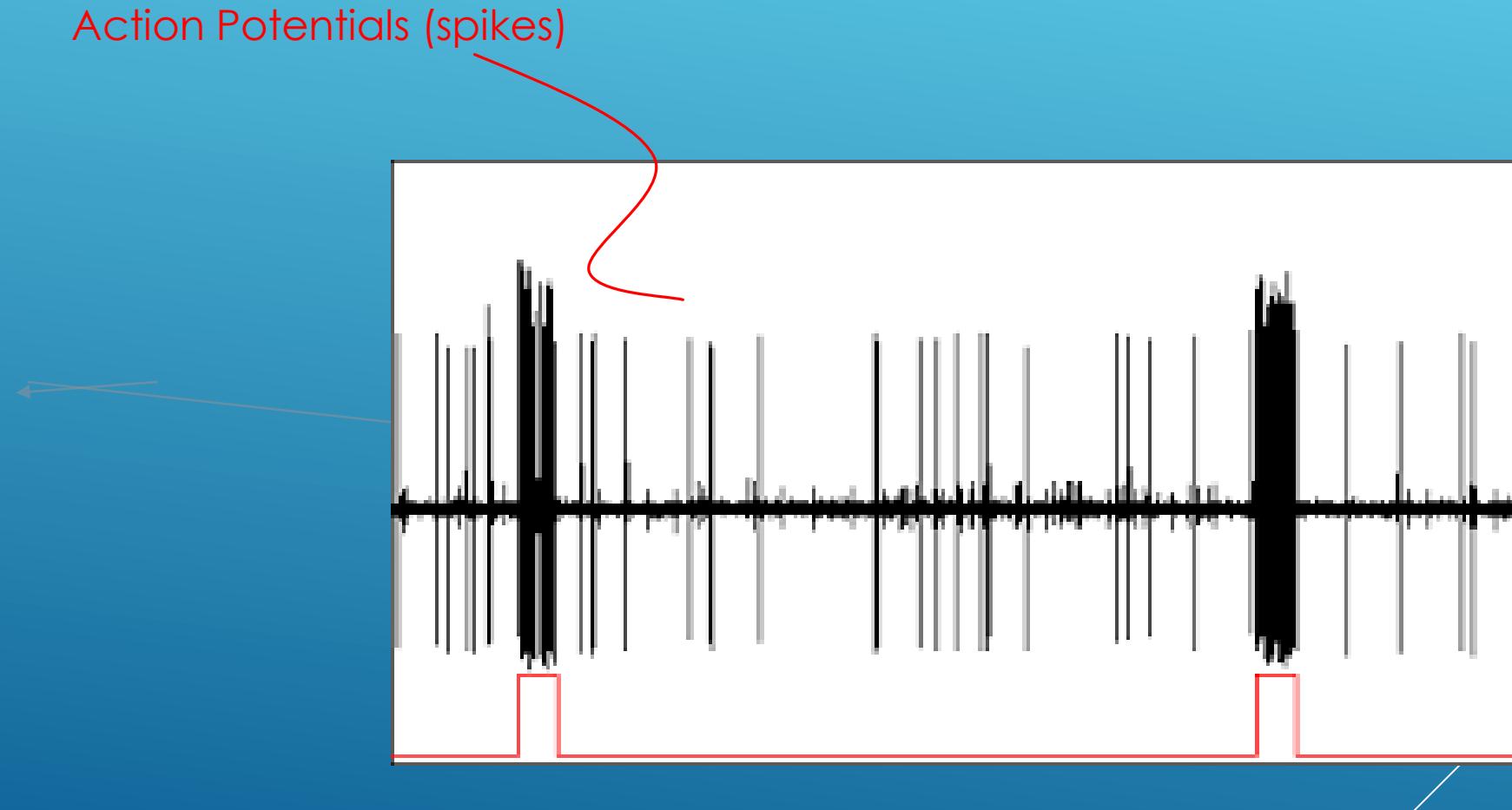
Synapse = weight

Neuron = node





# Real Neural Networks

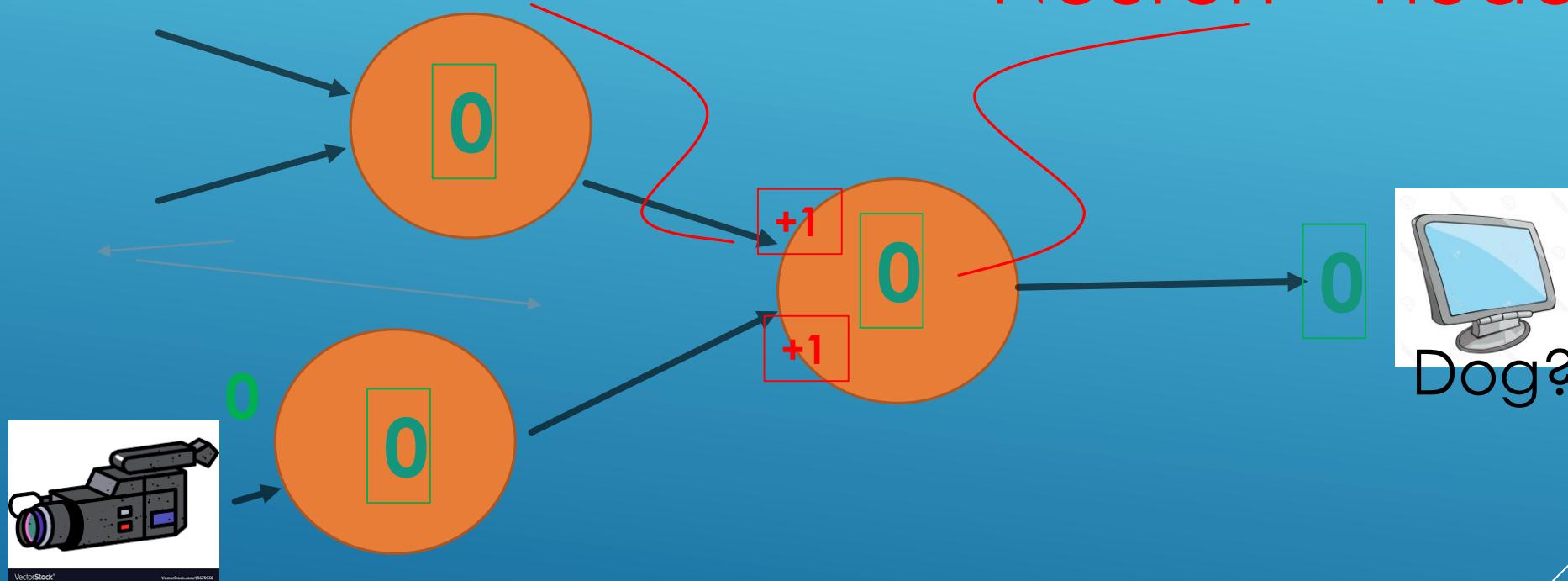


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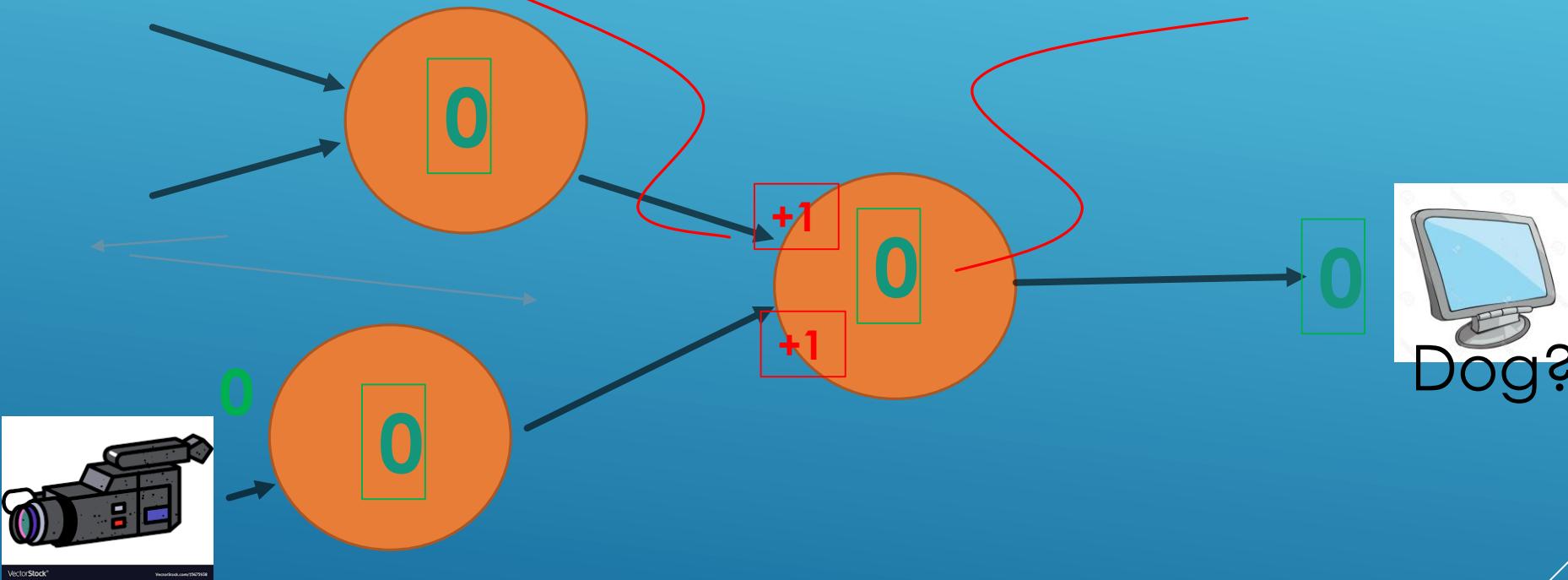
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# “Artificial Neural Network” (ANN)

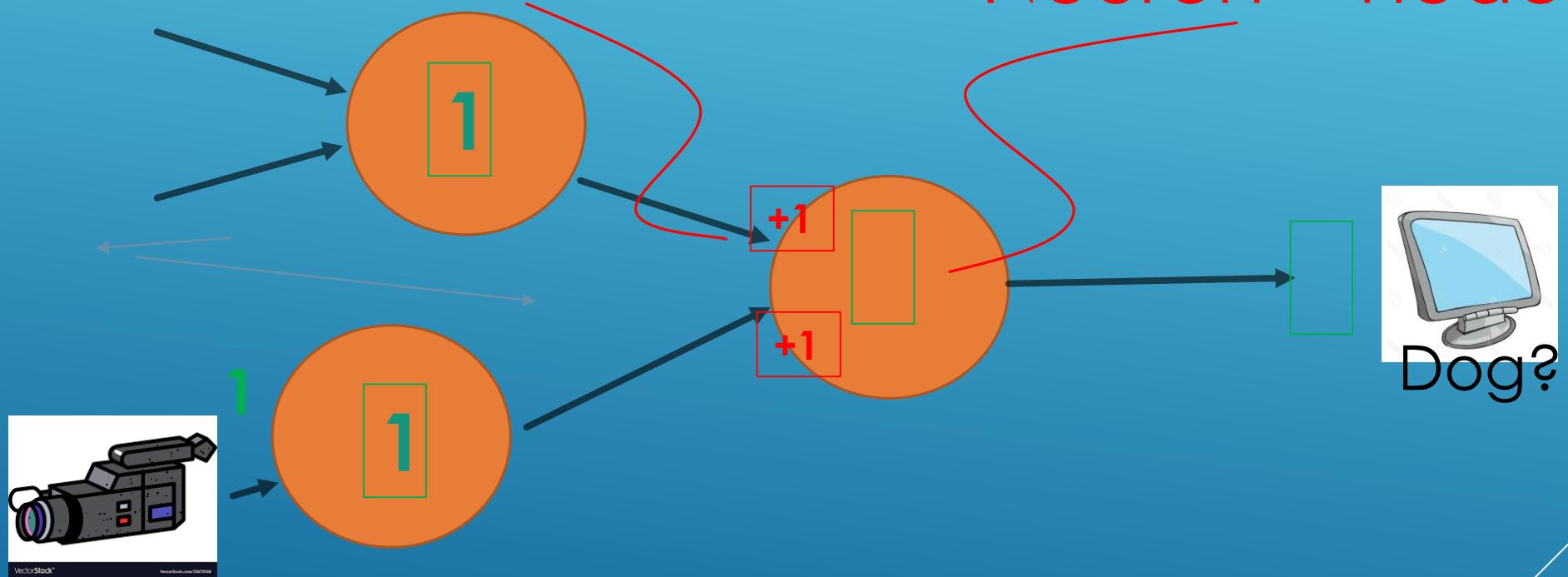
Synapse = weight



Neuron = node

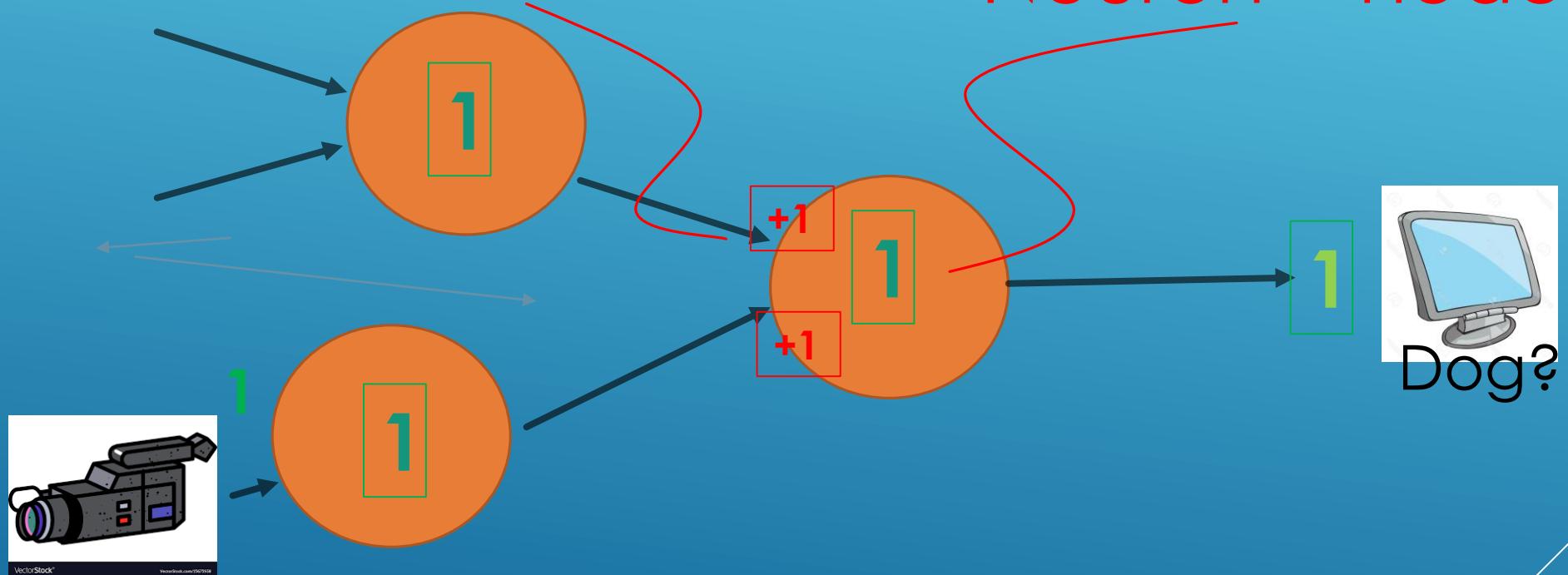


Synapse = weight



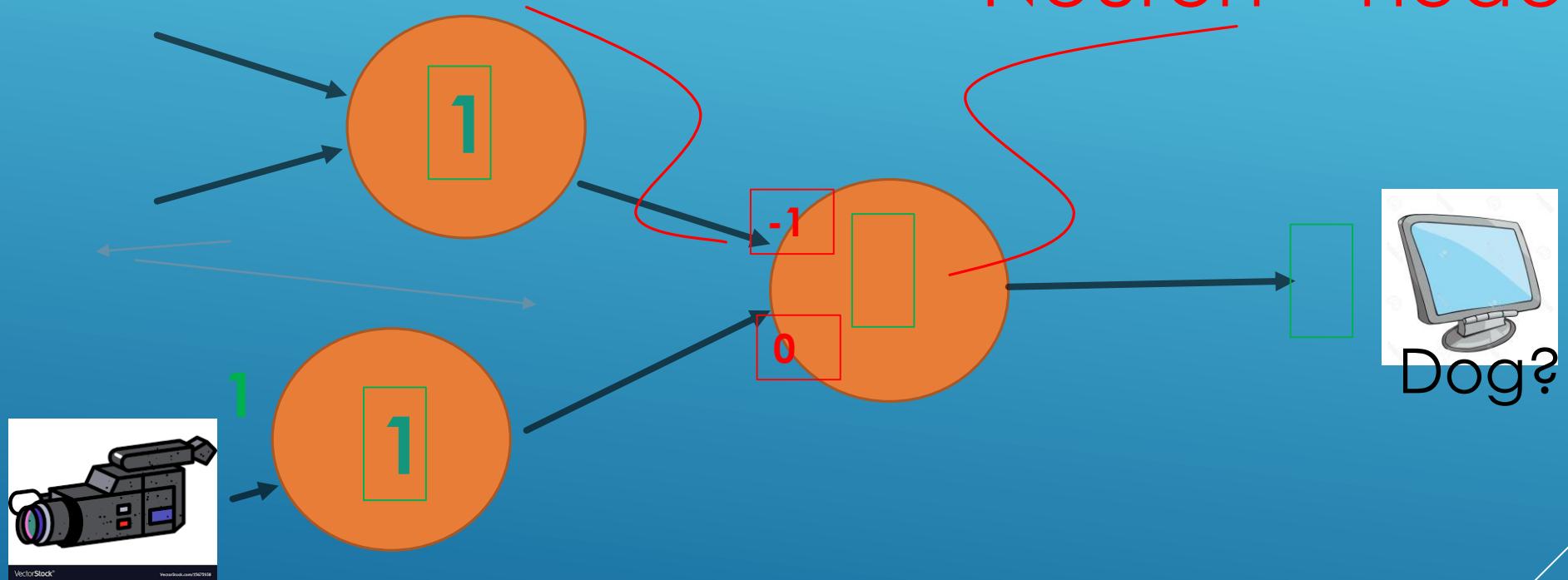
Neuron = node

Synapse = weight



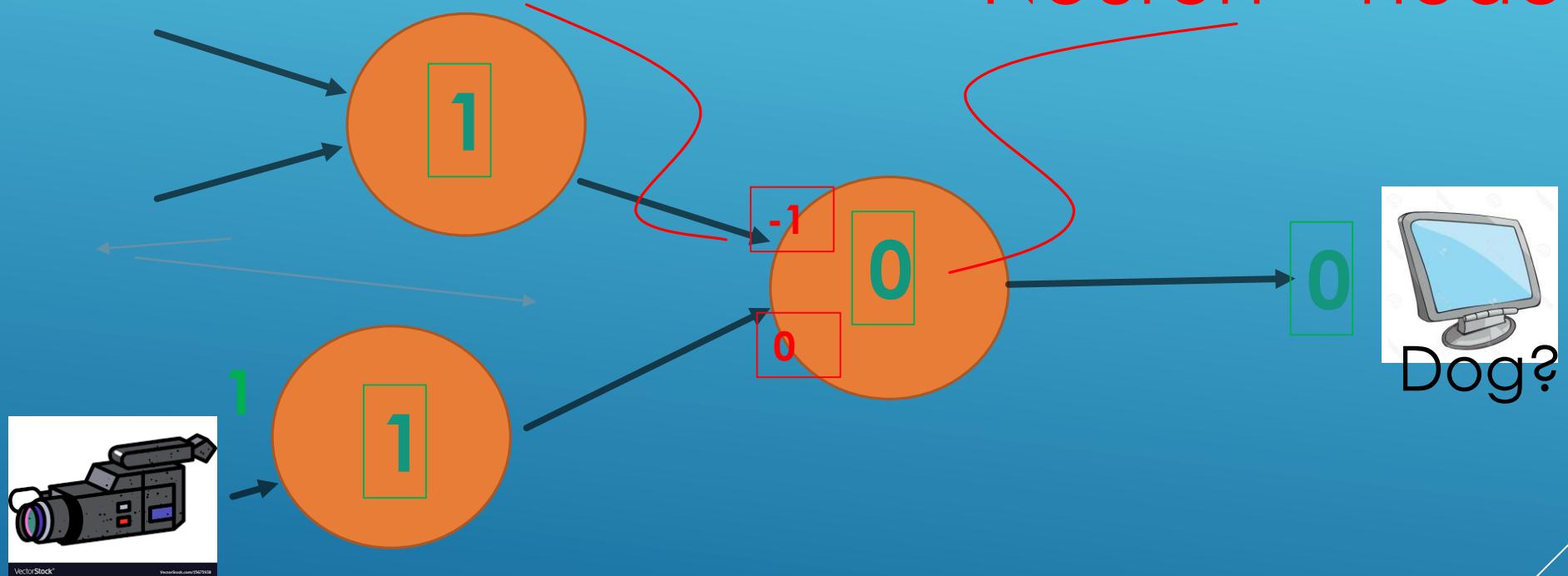
Neuron = node

Synapse = weight



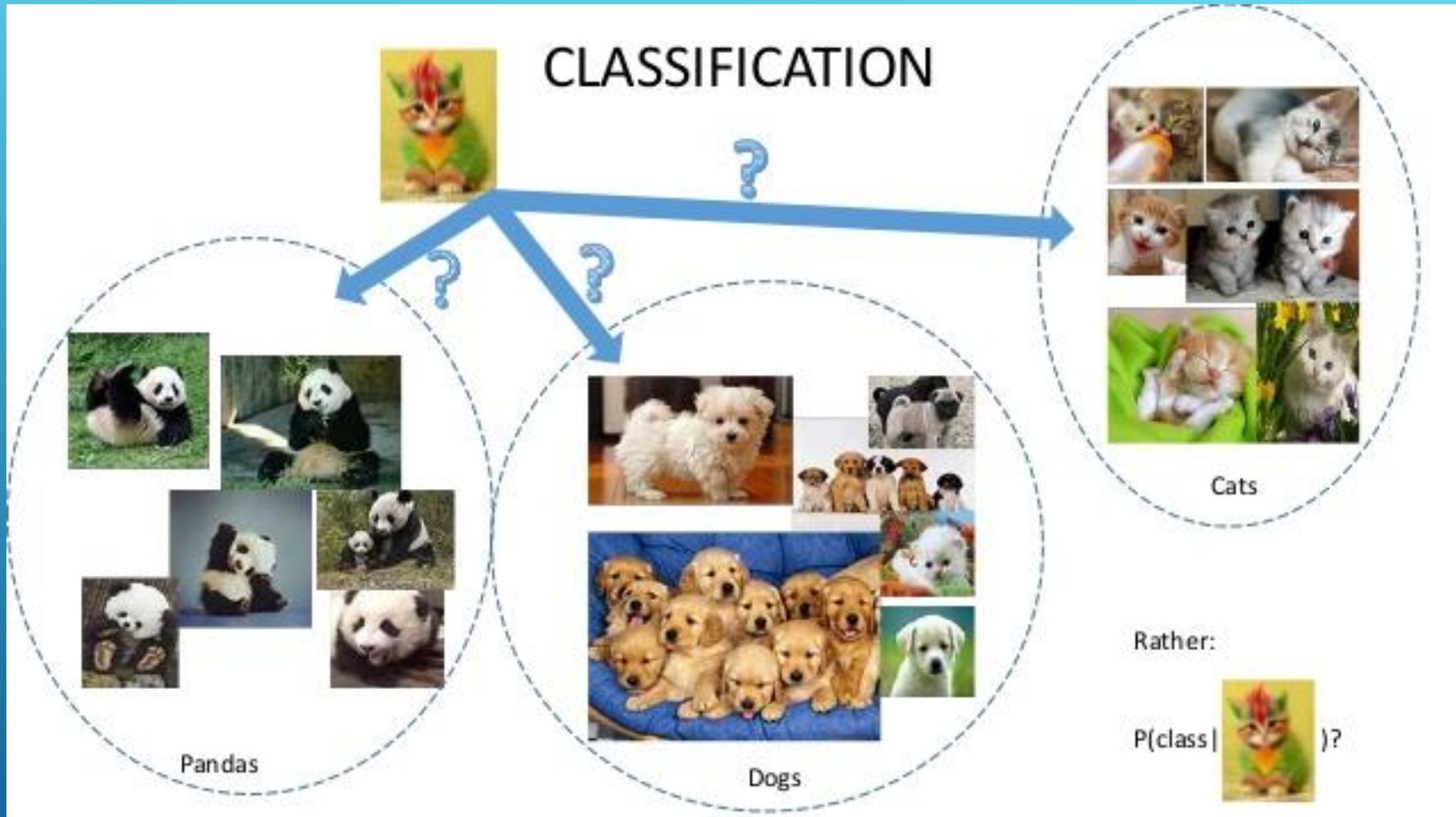
Neuron = node

Synapse = weight

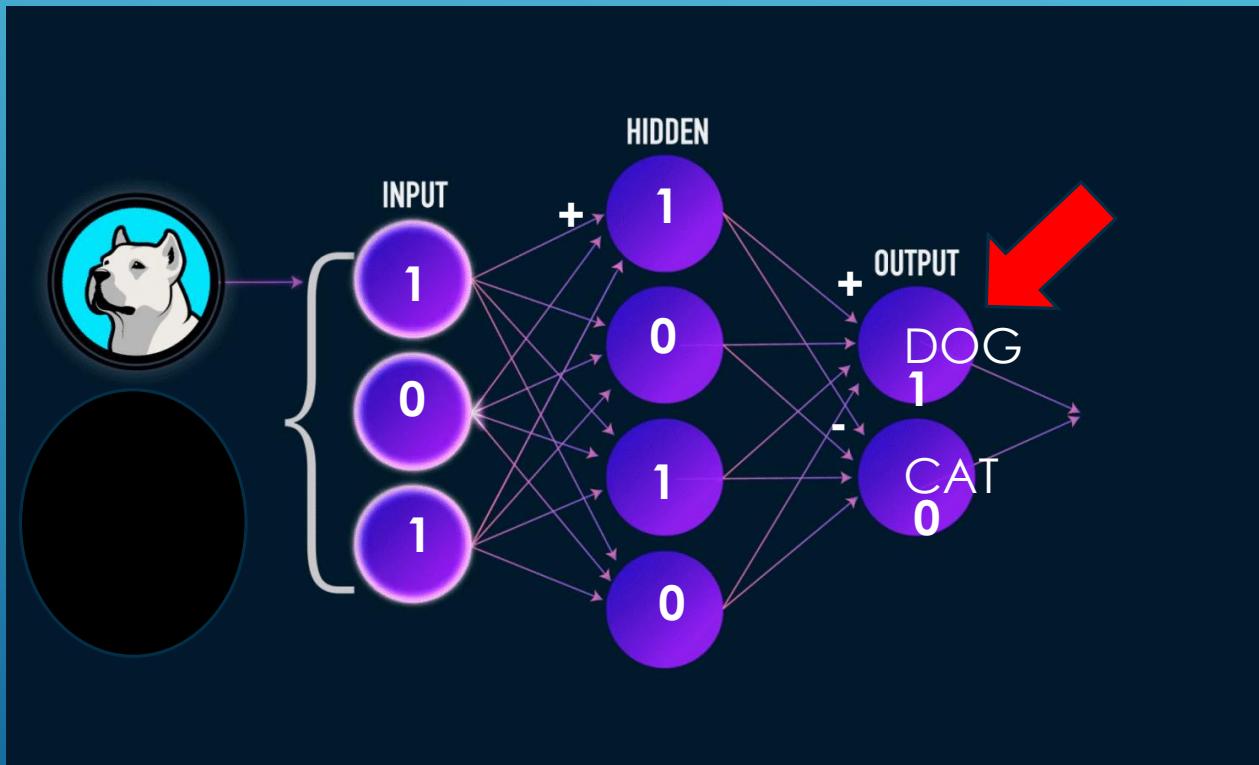


Neuron = node

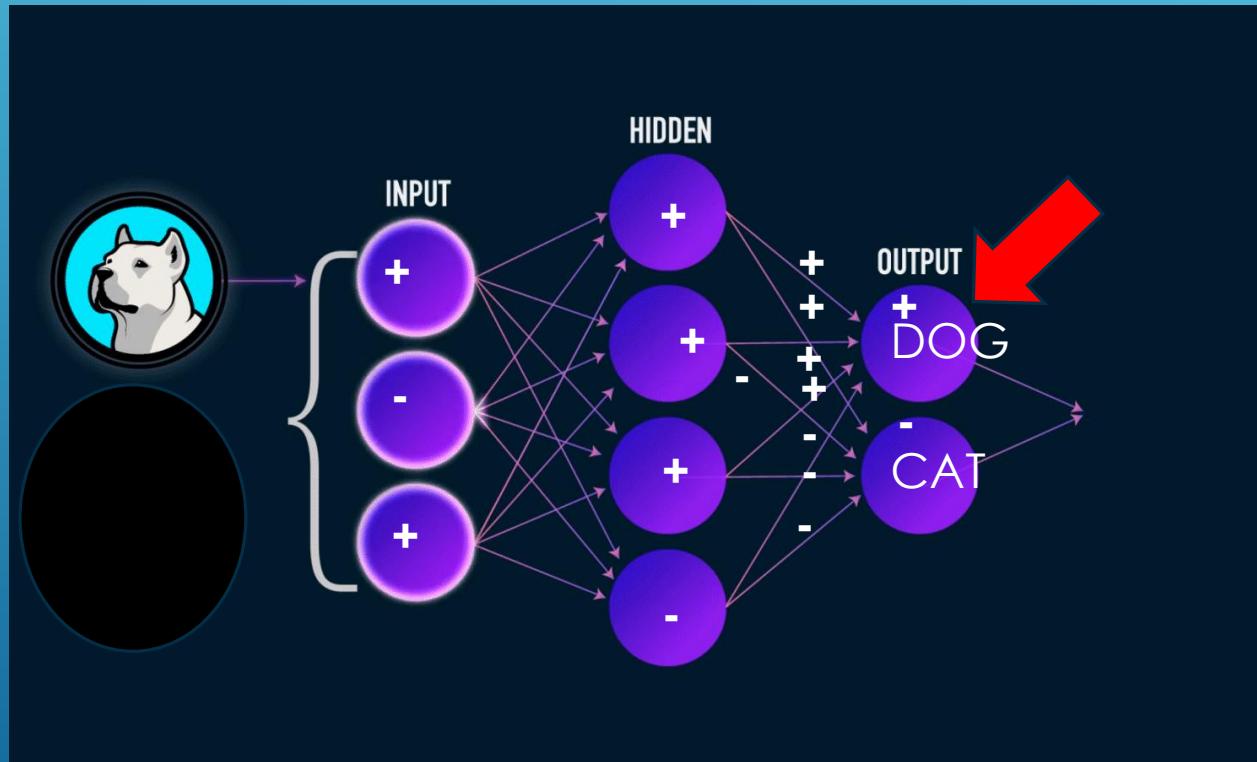
# CLASSIFICATION



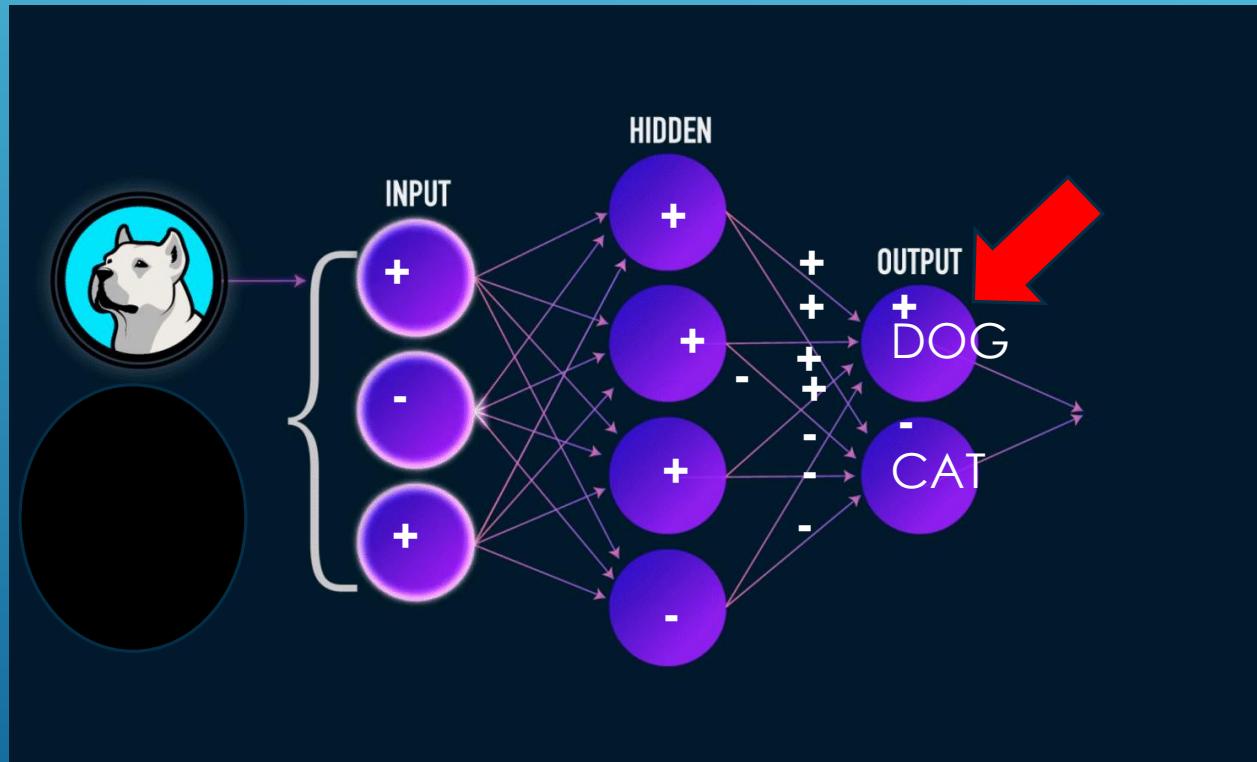
“ANN” == ARTIFICIAL NEURAL NETWORK  
("DEEP LEARNING") == ANN WITH LOTS OF LAYERS



FOR THE PIXEL INPUTS OF THE DOG, STRONGER SYNAPSES GOING TO THE NEURONS FROM INPUT TO HIDDEN TO “DOG” OUTPUT

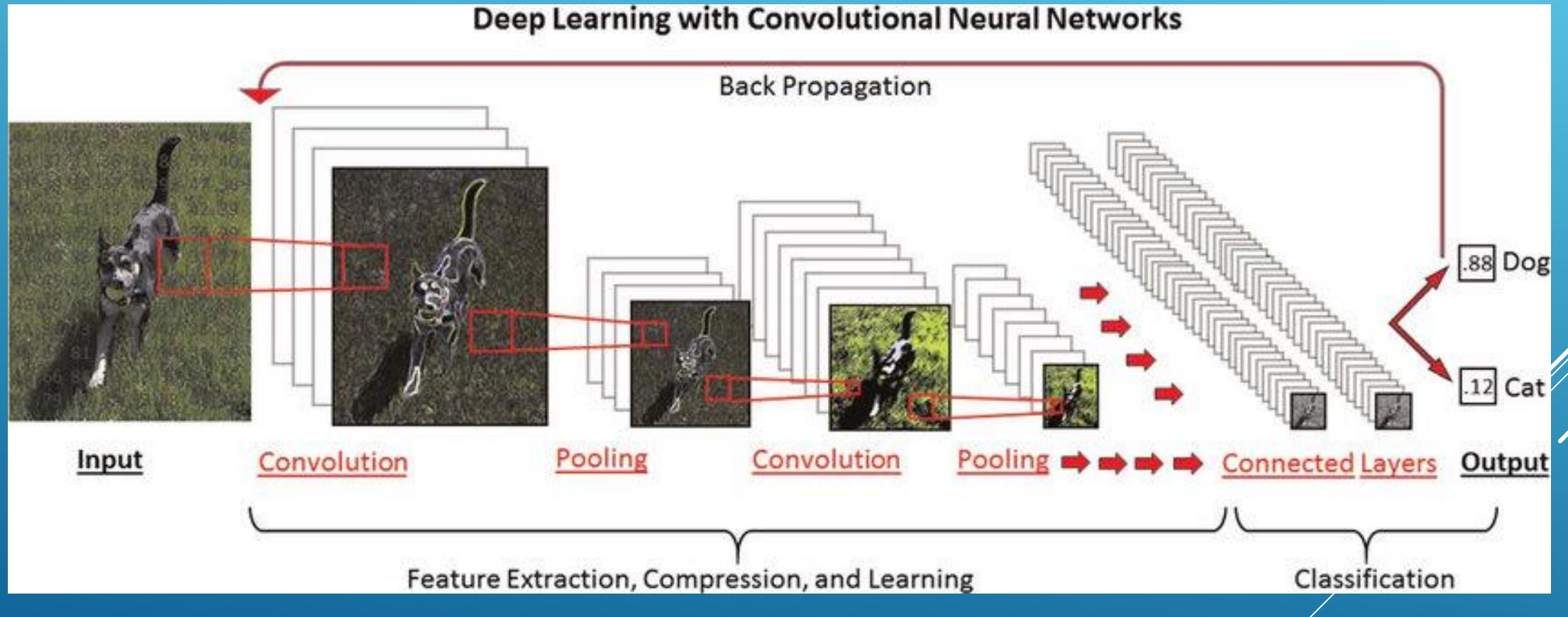


# HOW DID THE NEURAL NETWORK (“DEEP LEARNING NETWORK” IF MORE LAYERS) GET WIRED UP LIKE THIS TO GIVE US THIS ANSWER?

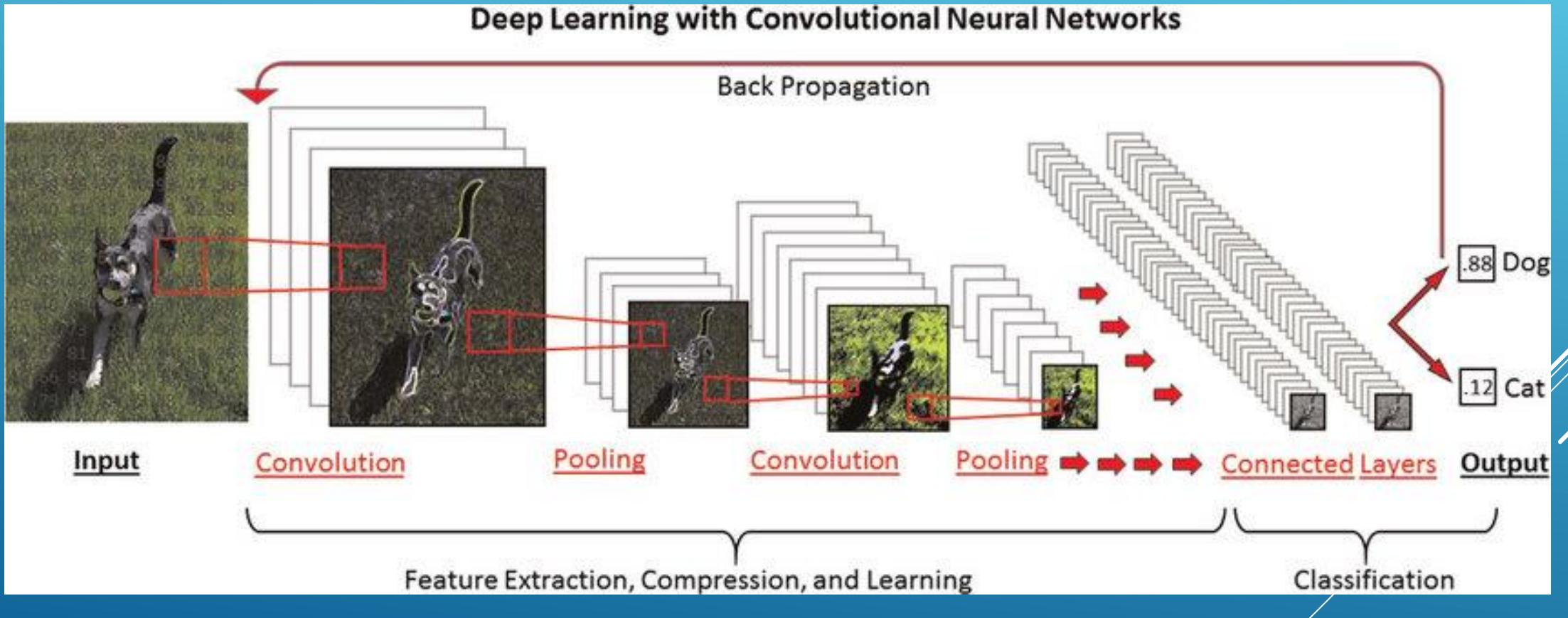


# REALLY LOOKS MORE LIKE THIS

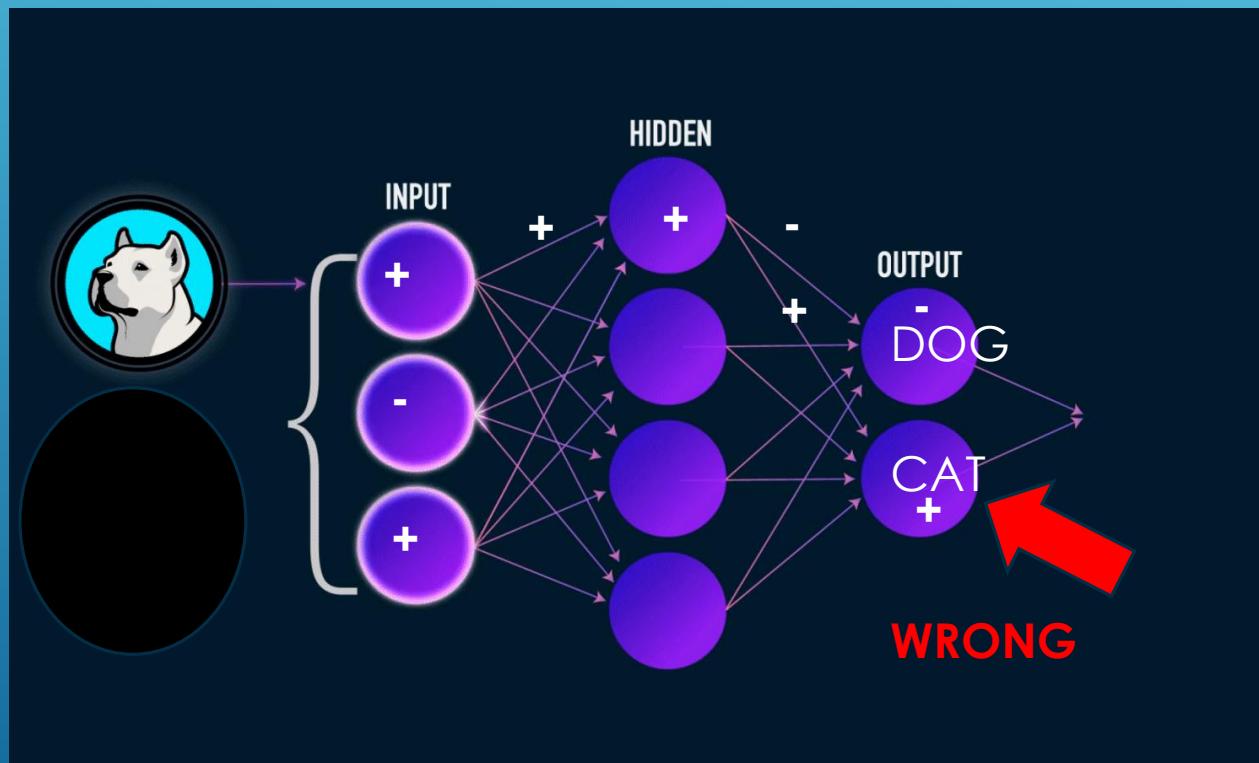
("DEEP LEARNING" == LOTS OF HIDDEN LAYERS OF NEURONS)



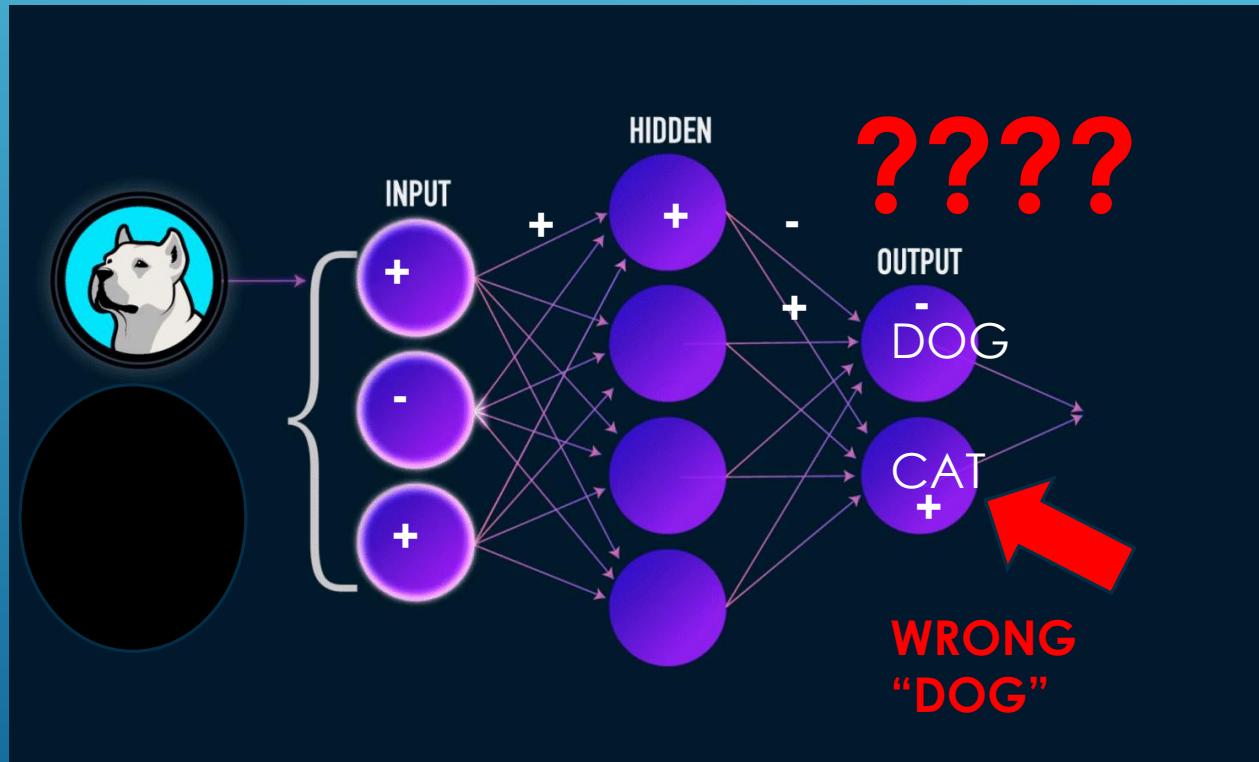
# DON'T HAVE TO BUILD THIS UP BY HAND (MASSIVE EFFORT, POOR RESULTS)



# START OFF WITH RANDOM WEIGHTS ON THE SYNAPSES....

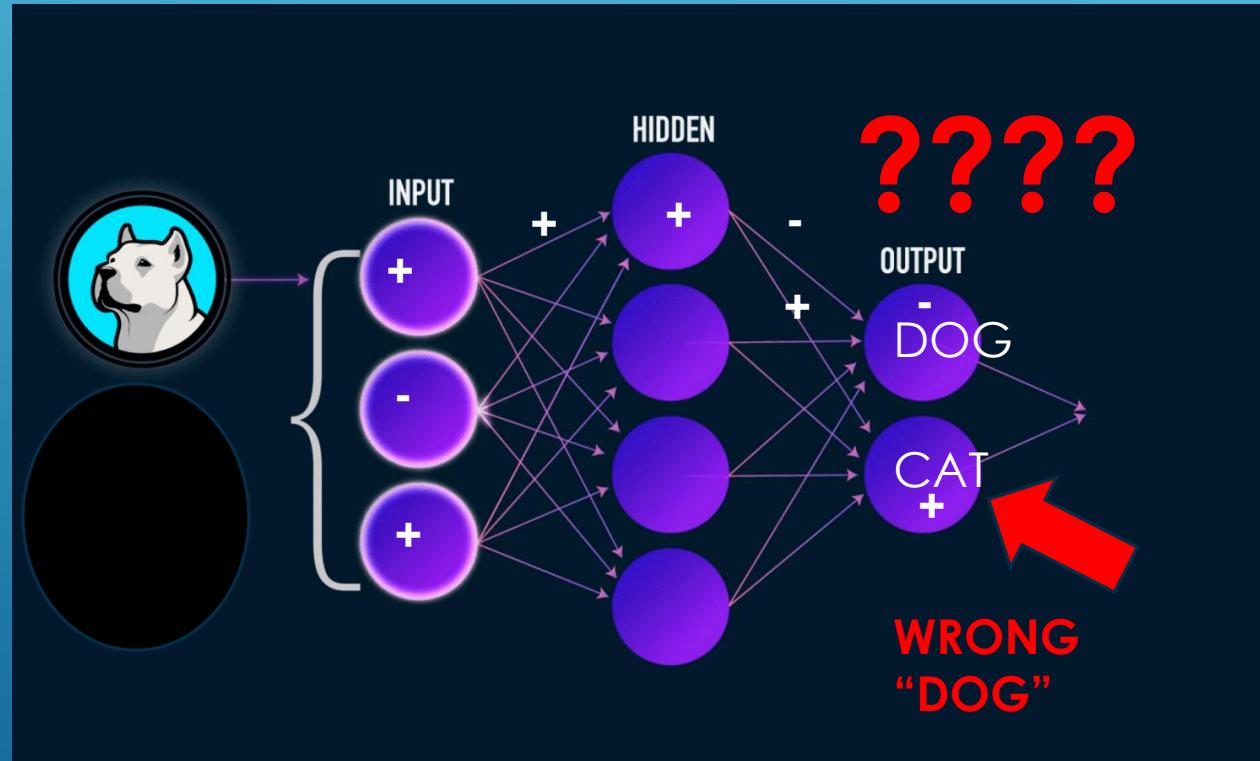


# HOW TO FIX THIS AUTOMATICALLY? (WELL....SEMI-AUTOMATICALLY SINCE NEED HUMAN TO HAVE ALREADY FIGURED OUT THIS IS A DOG)

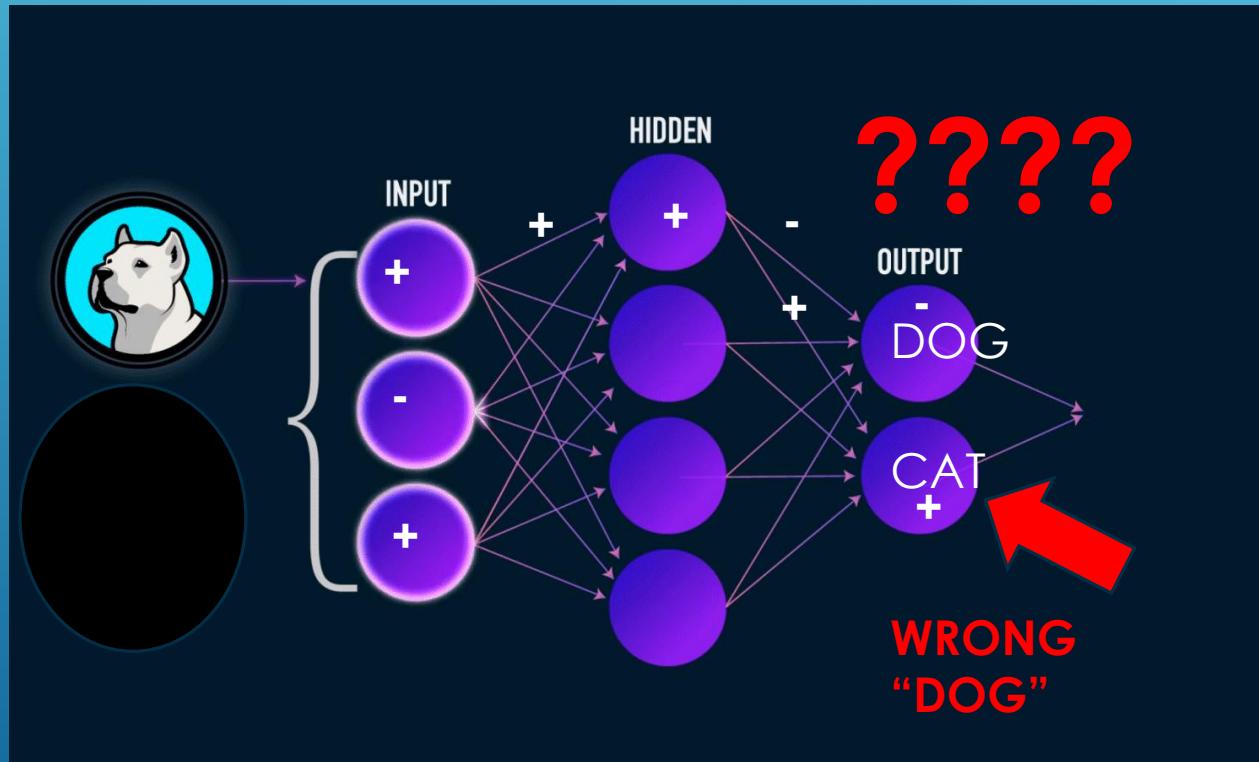


# Supervised Learning ("SL")

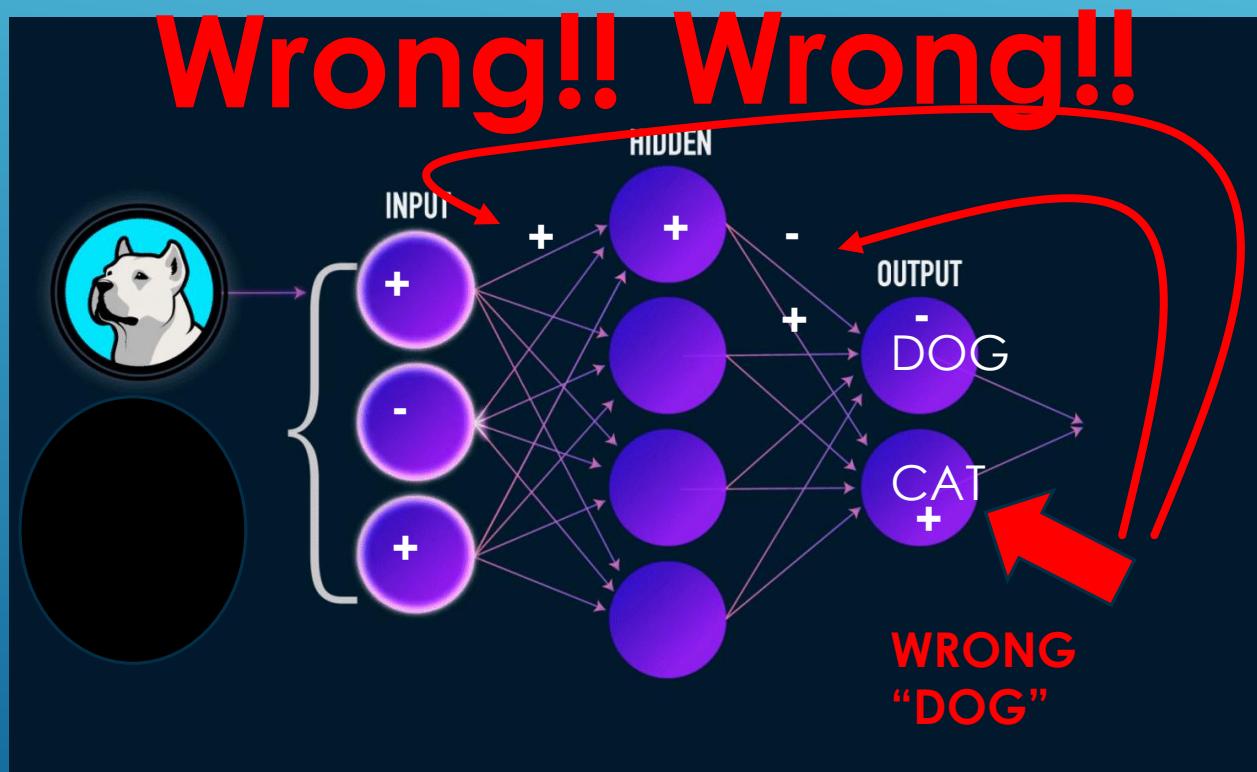
HOW TO FIX THIS AUTOMATICALLY?  
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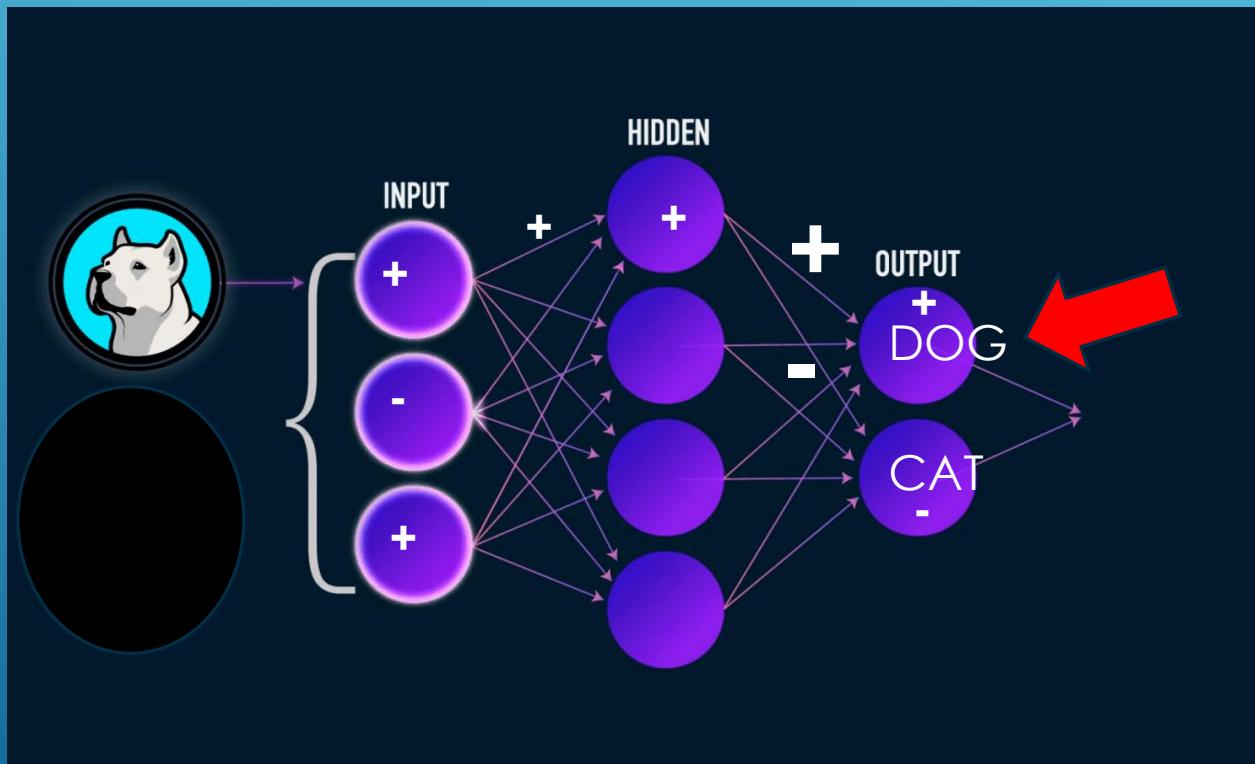
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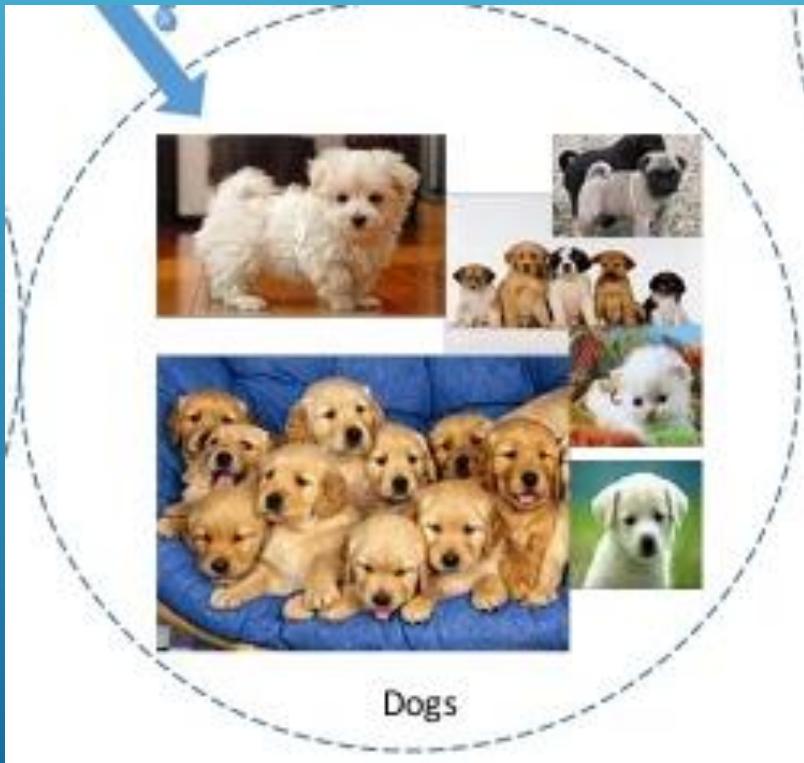
# FIX AUTOMATICALLY WITH FEEDBACK



AFTER ENOUGH TRAINING CYCLES, THE NEURAL NETWORK CAN CLASSIFY AN IMAGE AS A DOG VERSUS CAT

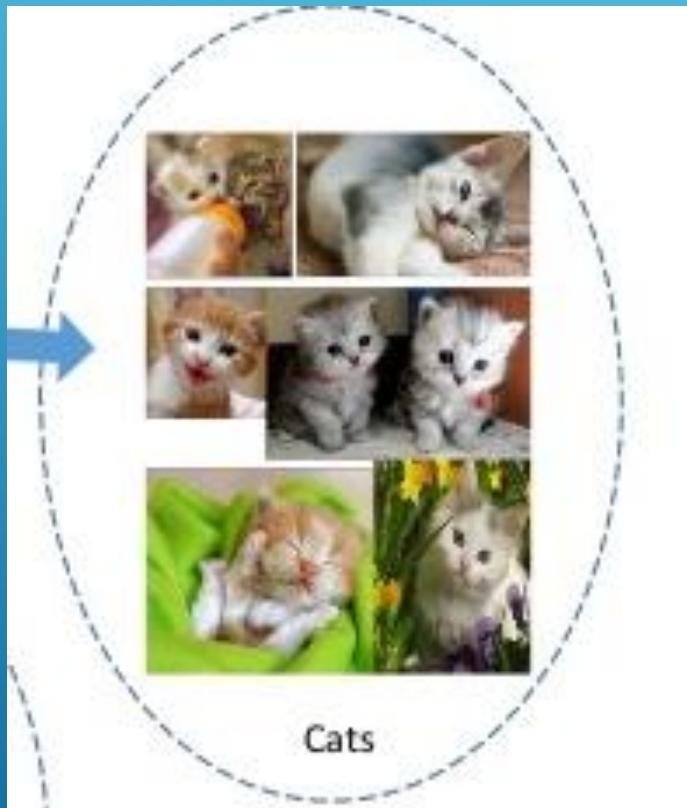


# WE TRAIN OUR NETWORK ON A VARIETY OF DIFFERENT DOGS



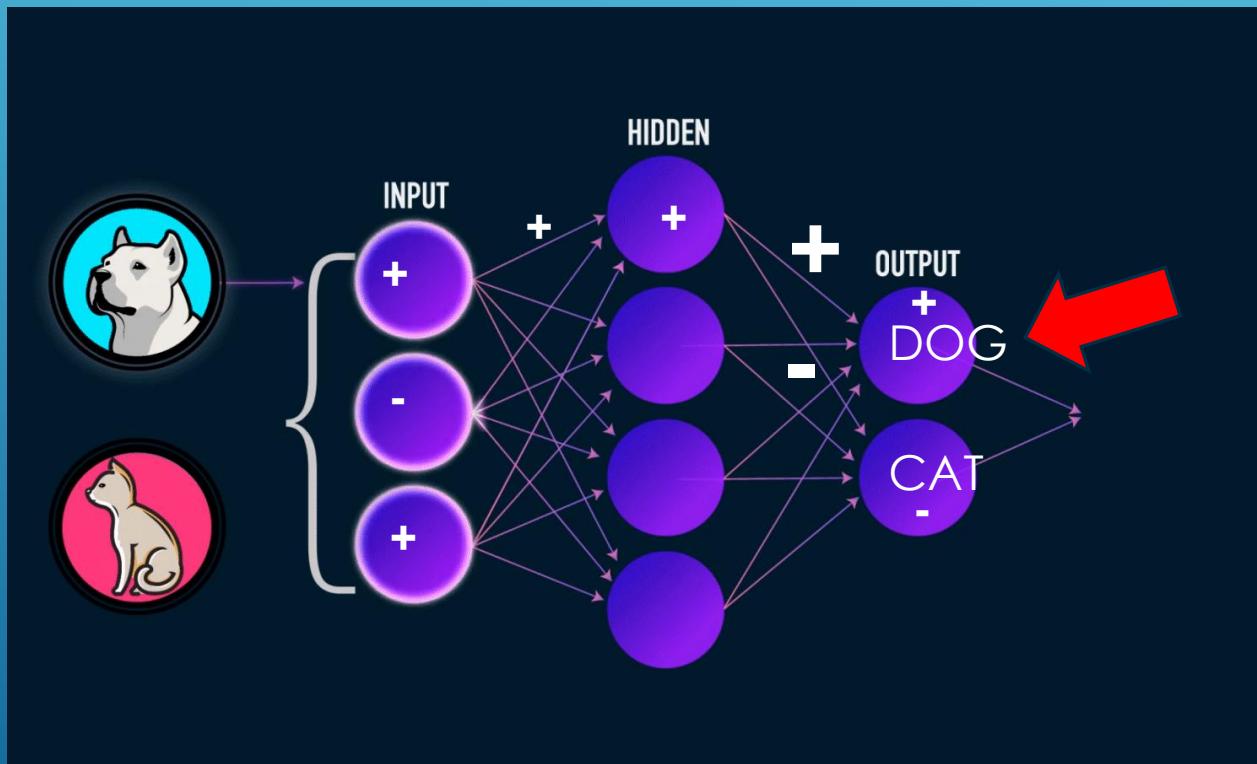
Pass in a file with pictures of many different types of dogs, and all these pictures are labeled “dog” so the neural network will know that the correct answer is to classify as a dog

# WE TRAIN OUR NETWORK ON A VARIETY OF DIFFERENT CATS

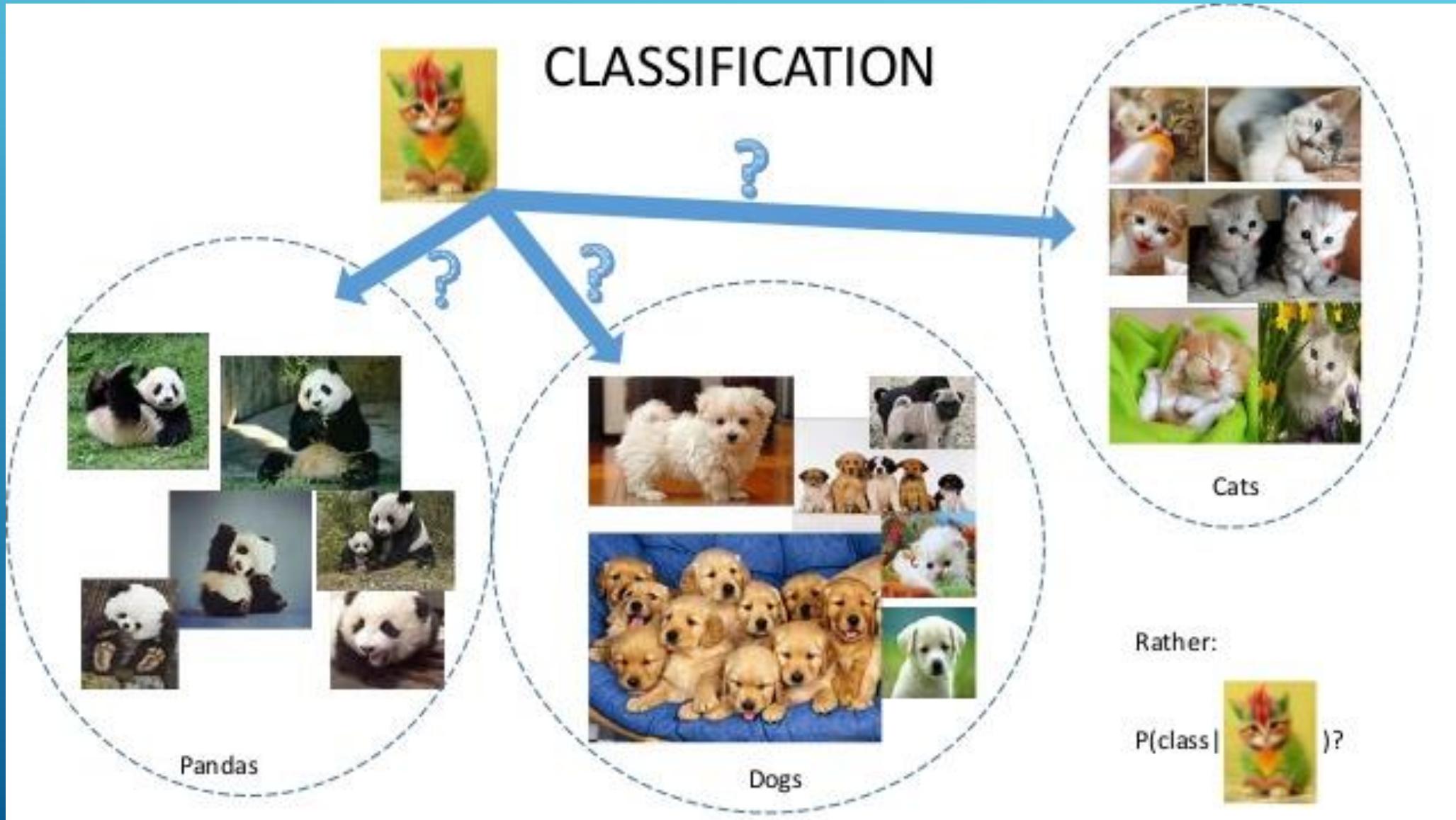


Pass in a file with pictures of many different types of cats, and all these pictures are labeled “cat” so the neural network will know that the correct answer is to classify as a cat

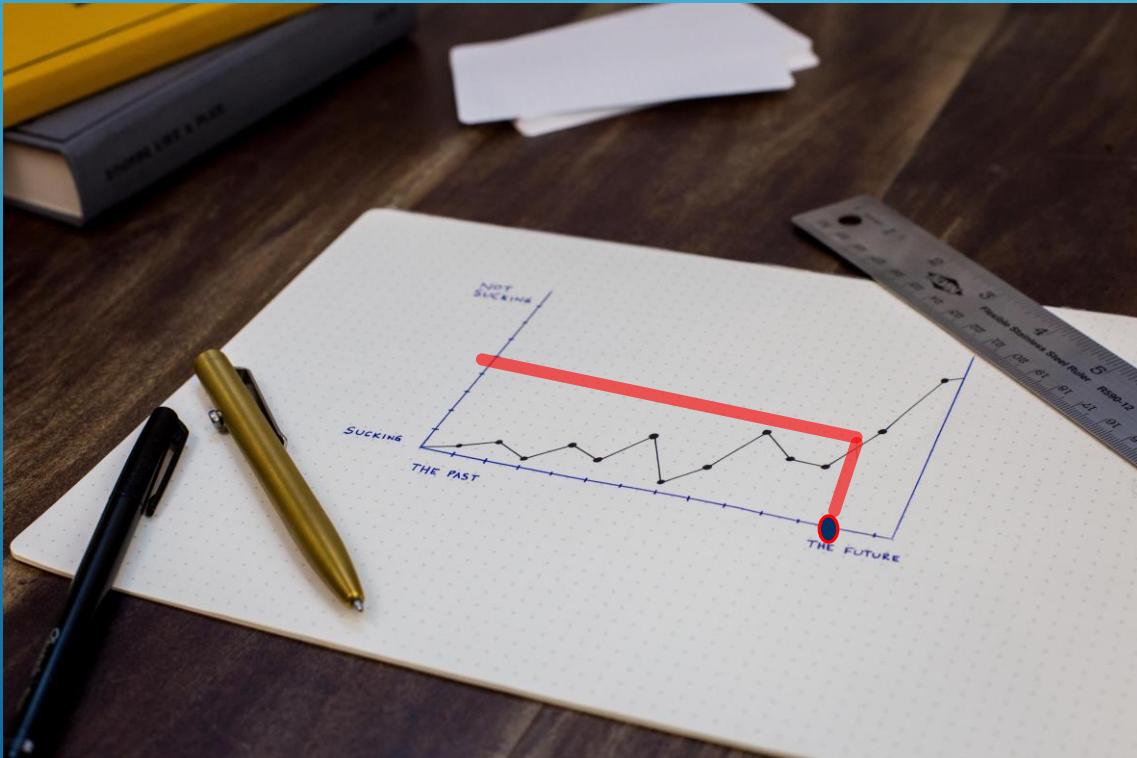
AFTER ENOUGH TRAINING CYCLES, ON DIFFERENT TYPES OF DOGS AND CATS, THE NEURAL NETWORK CAN CLASSIFY DIFFERENT IMAGES AS A DOG VERSUS CAT



# NEURAL NETWORK CAN CLASSIFY CAT IT HAS NEVER SEEN BEFORE IN TRAINING

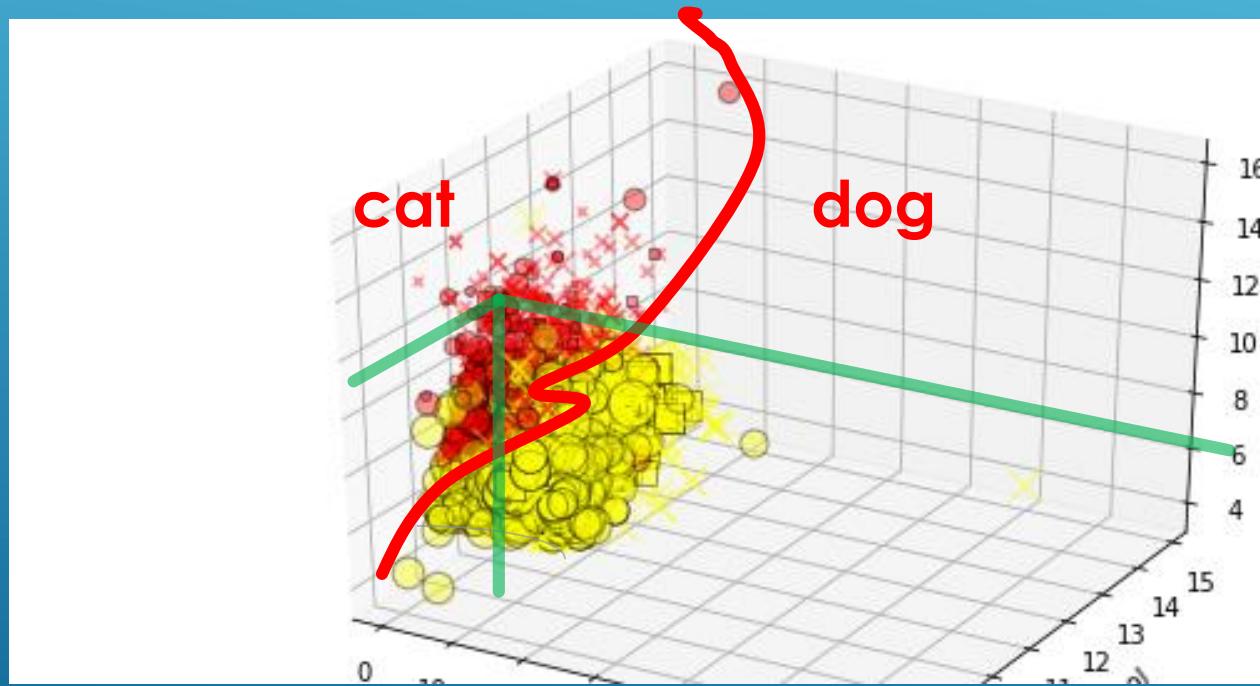


# YOU WERE ABLE TO CLASSIFY A DATA POINT YOU NEVER SAW BEFORE ALSO ON YOUR GRAPH



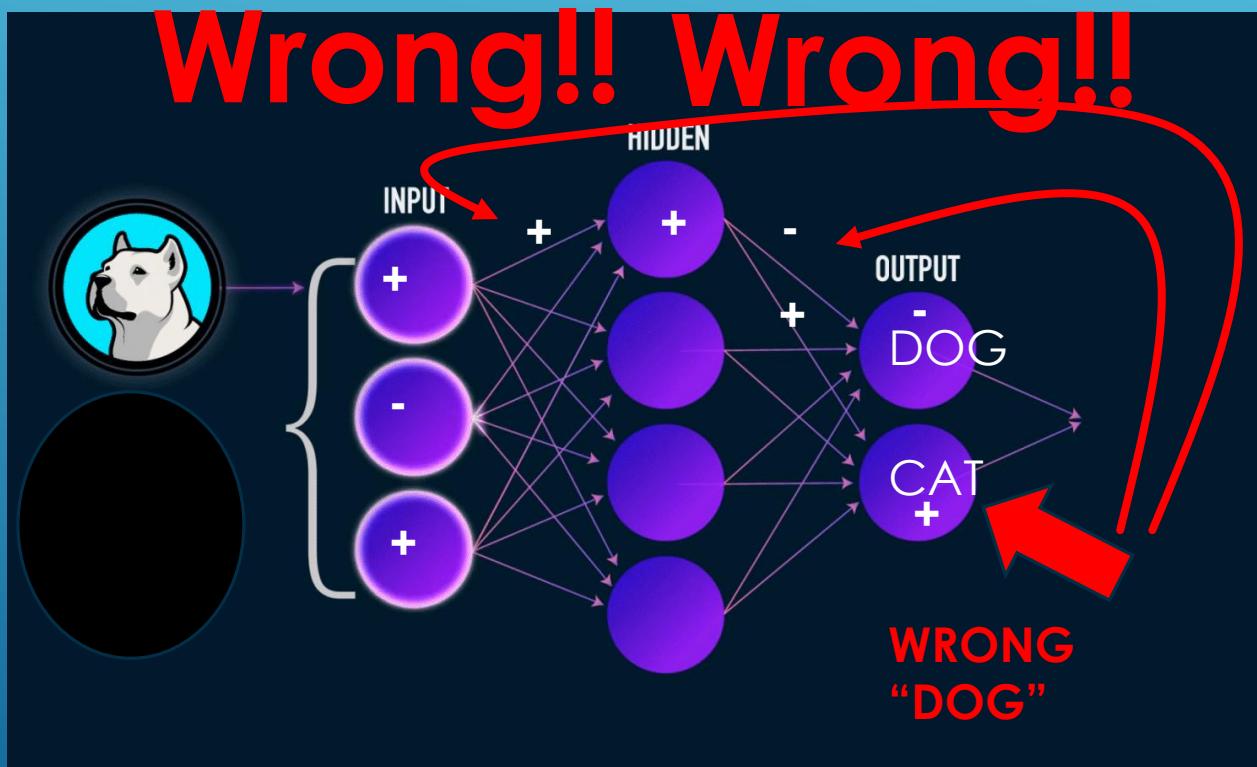
New X value never seen before, you can predict the Y value

-ANIMAL WE HAVE NEVER SEEN BEFORE, WE CAN FIGURE OUT IF A DOG OR A CAT

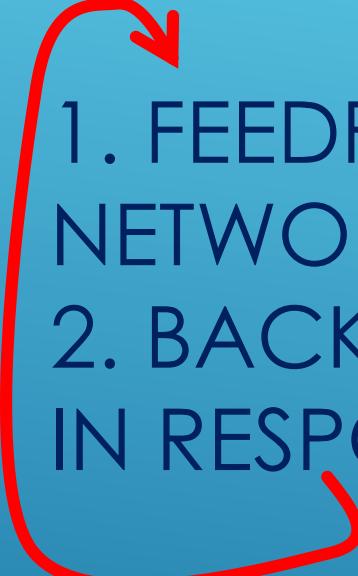


# “BACKPROPAGATION”

METHOD OF USING FEEDBACK TO CHANGE THE WEIGHTS IN A WAY THAT WILL HELP NETWORK CLASSIFY WITH LESS ERROR



# BACKPROPAGATION

- 
1. FEEDFORWARD OPERATION – TRY OUT NEURAL NETWORK AND SEE ERROR IT PRODUCES IN OUTPUT
  2. BACKPROPAGATION OPERATION – ADJUST WEIGHTS IN RESPONSE TO ERROR

OVER AND OVER AGAIN (VERY FAST COMPUTER)



ONCE YOU ARE SATISFIED WITH TRAINING, STOP AND YOU HAVE A NEURAL NETWORK THAT WORKS WELL

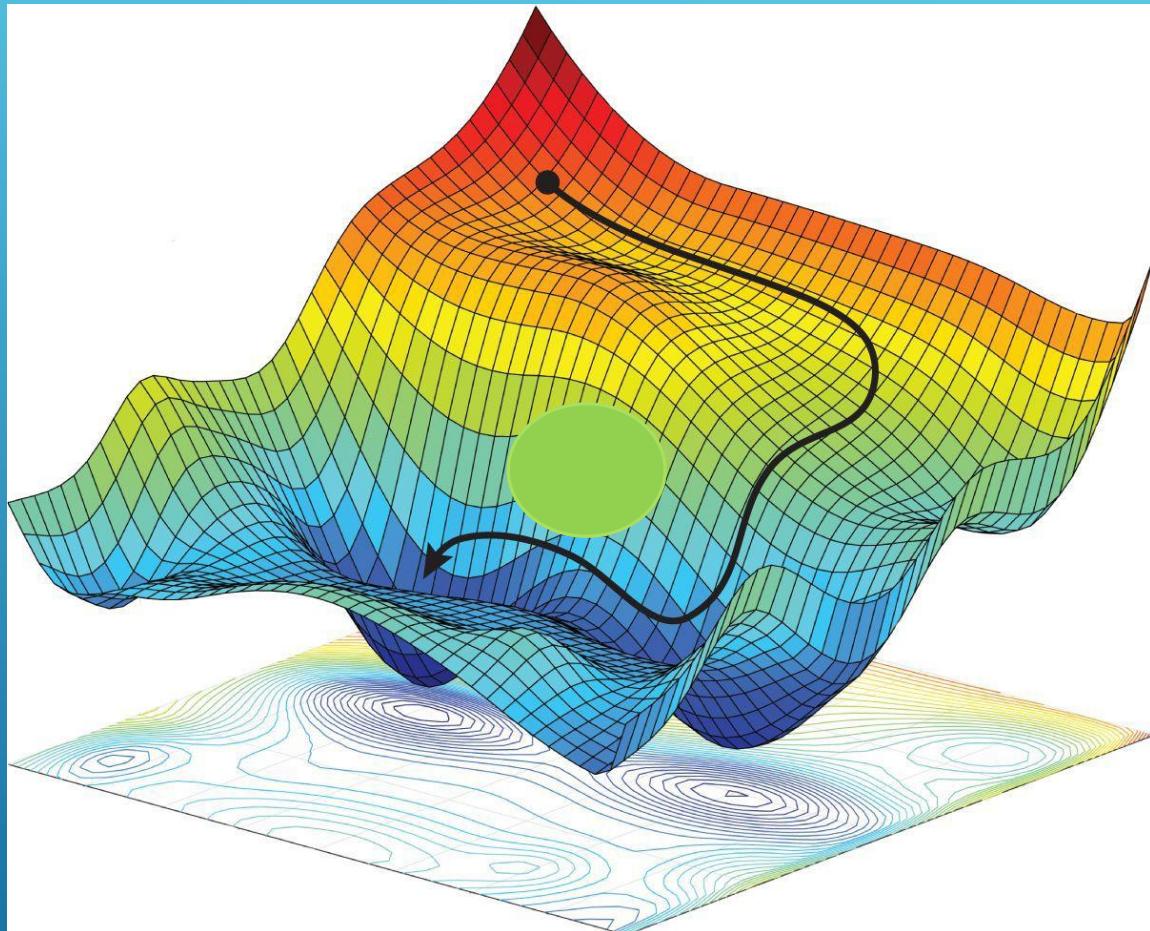
# STOCHASTIC GRADIENT DESCENT (SGD)

'Stochastic' – single random sample each iteration

'Gradient' – slope of a function (partial derivatives of set of parameters)

'Gradient Descent' – iterative optimization method

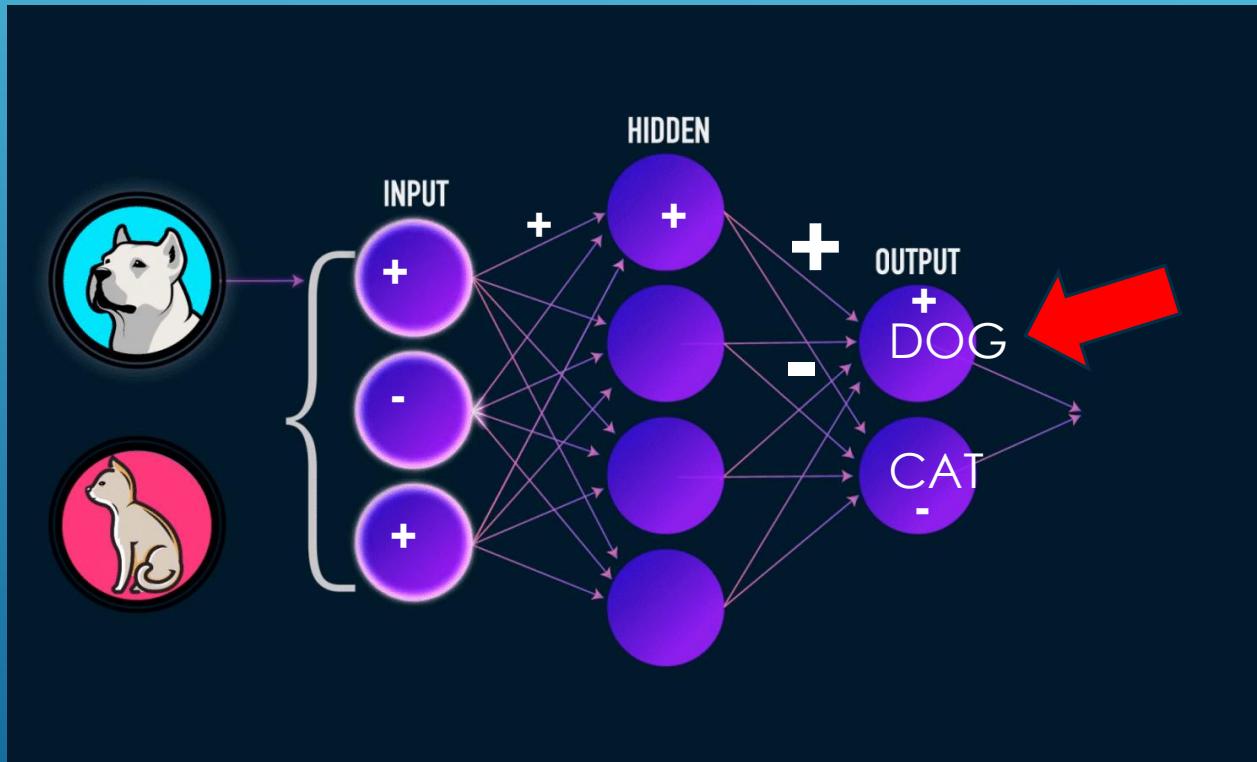
Can apply to 1000's of dimensions, not just 3-D shown in figure



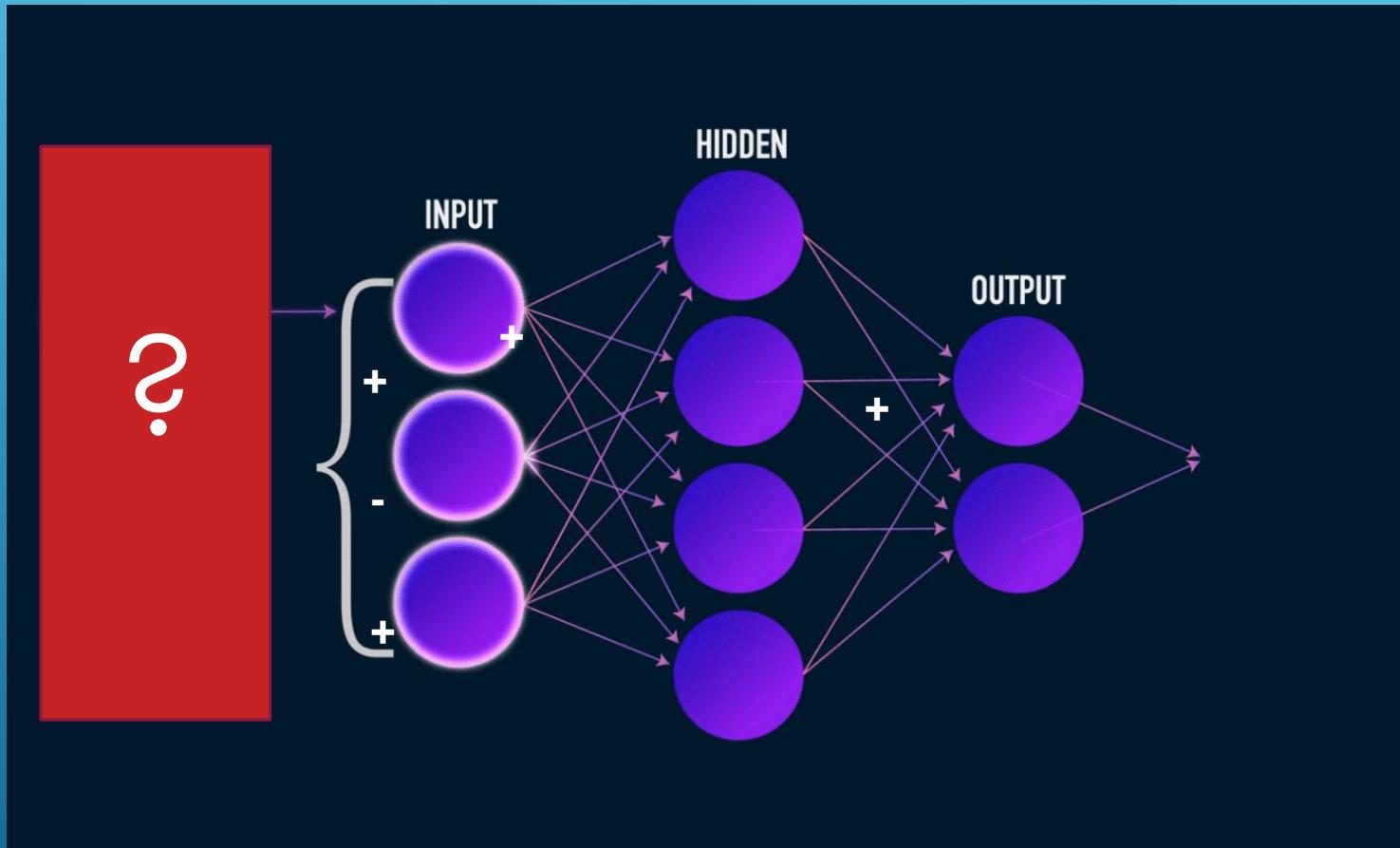
A wide-angle photograph of a tropical beach at sunset. The sky is filled with large, billowing clouds colored in shades of orange, yellow, and blue. The ocean waves are a vibrant turquoise color, crashing onto the light-colored sand. In the distance, a line of palm trees stands on a low hill. The overall atmosphere is peaceful and scenic.

Let's pause, and think about  
what technology we just  
showed.....

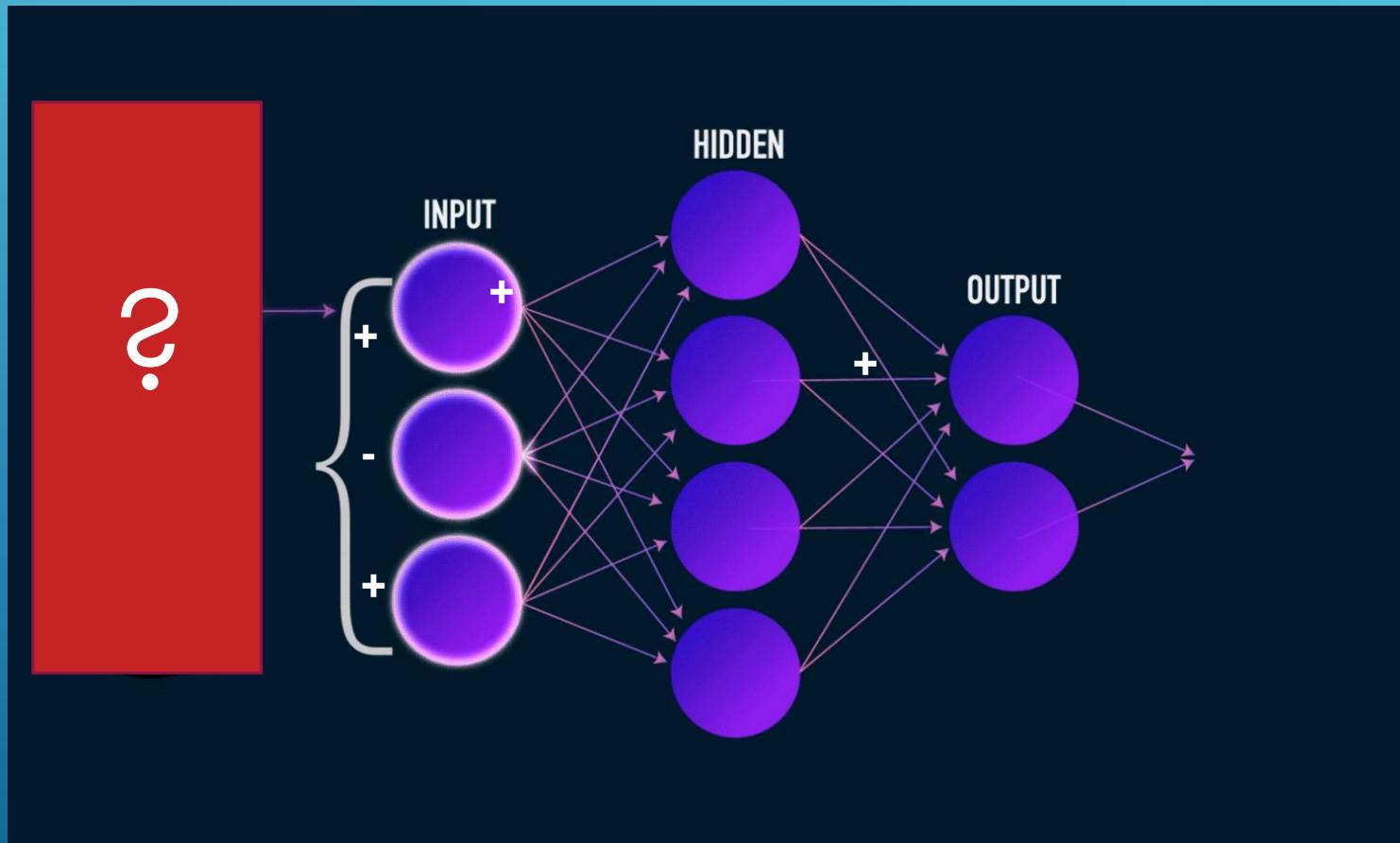
# OUR NEURAL NETWORK CAN RECOGNIZE DOGS FROM CATS.....



# OR IT CAN RECOGNIZE AND CLASSIFY JUST ABOUT ANY IMAGE.....



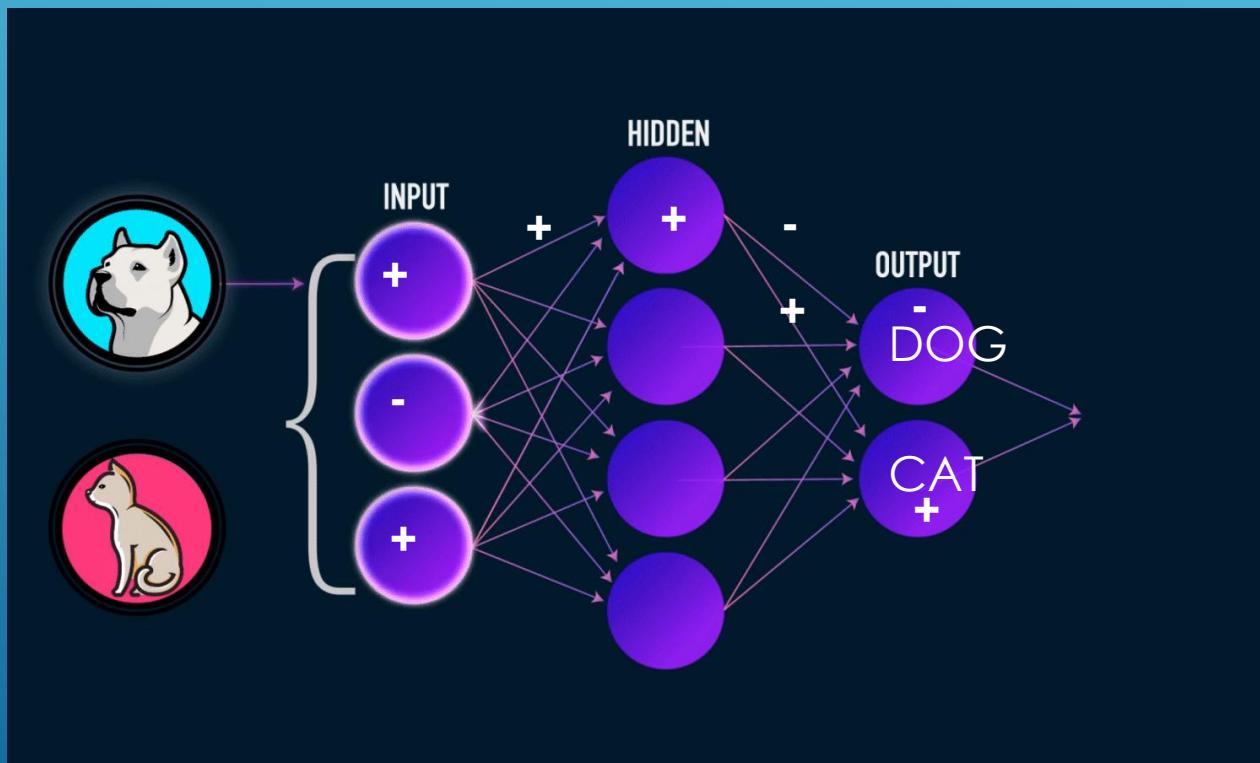
WITH SMALL CHANGES TO THE WAY WE ORGANIZE THE LAYERS, THE NEURAL NETWORK CAN CLASSIFY SOUNDS AND SPEECH AND MARKETING DATA AND.....



A photograph of a tropical beach at sunset. The sky is filled with warm, orange and yellow clouds. The ocean waves are crashing onto the light-colored sand, creating white foam. In the distance, there are some palm trees and buildings. The overall atmosphere is peaceful and beautiful.

How do we create a neural network to recognize pictures (or sounds) (or our marketing data) (or just about anything.....)?

# 1. TAKE A NEW NEURAL NETWORK (RANDOM WEIGHTS ON THE SYNAPSES.... )

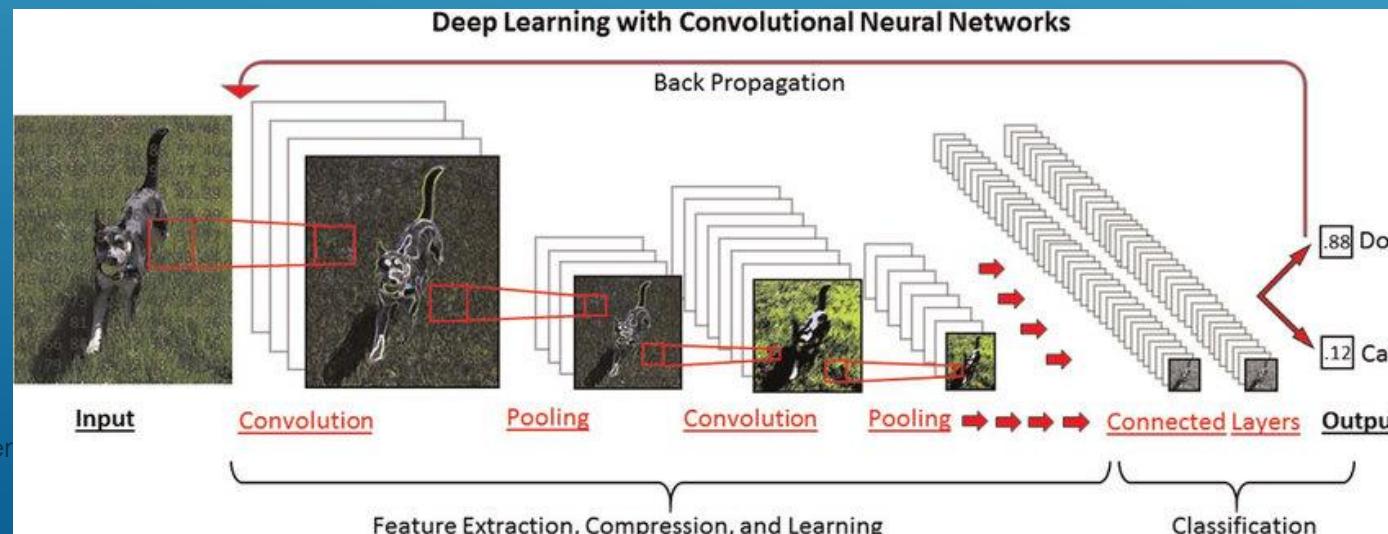


1980's

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- WE DON'T ACTUALLY BUILD NEURAL NETWORKS OUT OF TRANSISTORS OR NEURONS, BUT RUN SIMULATIONS ON A COMPUTER
- WE HAVE TENS OF THOUSANDS OF INPUTS (EG,  $256 \times 256 \times 3$  COLOR VIDEO CAMERA = 200,000 INPUT NODES WHICH THEN CONNECT TO MILLIONS AND MILLIONS OF NEURONS IN THE NETWORK)
- WEIGHTS OF MILLIONS AND MILLIONS OF SYNAPSES WILL HAVE TO BE CALCULATED DURING TRAINING

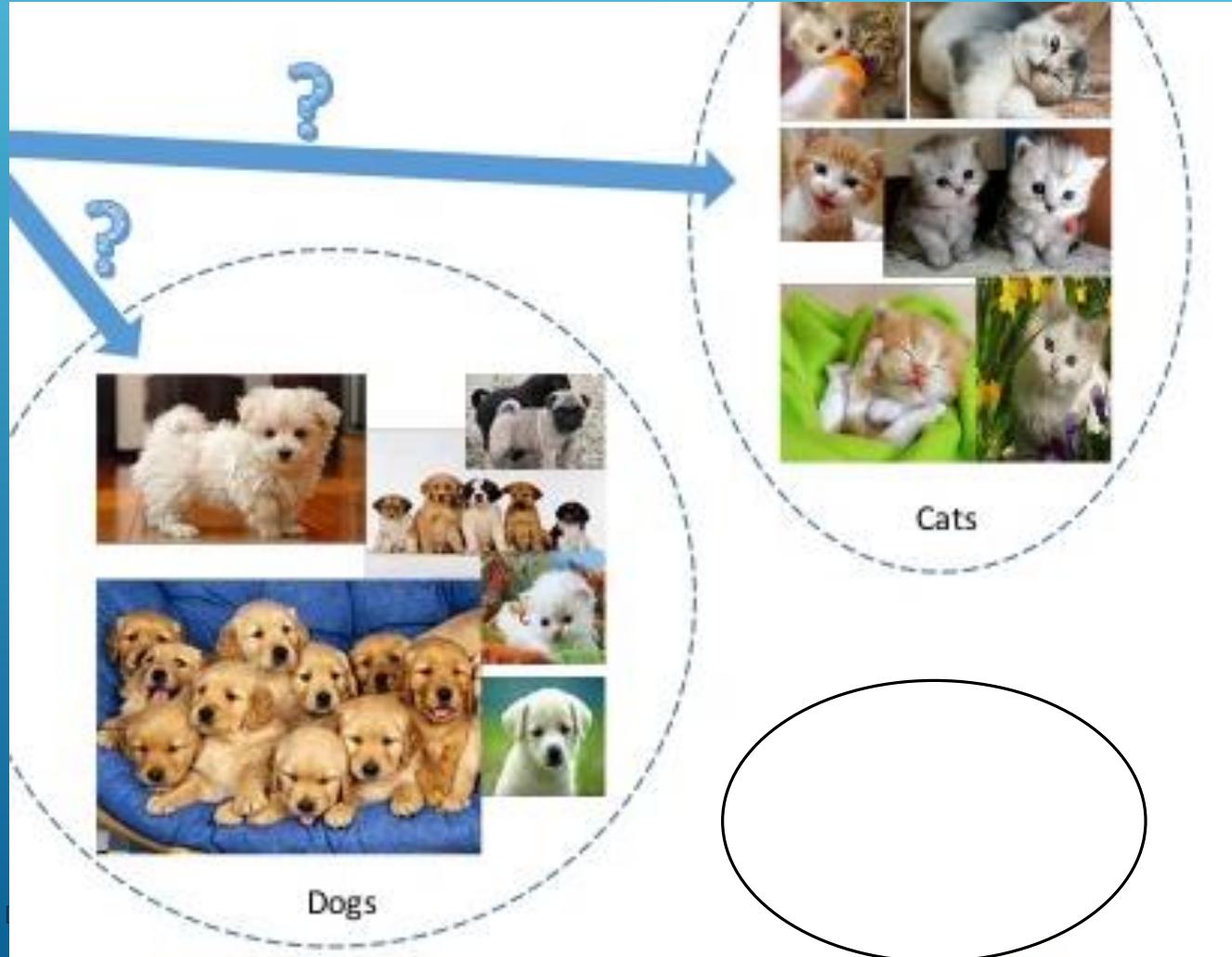


## 2. GET A COMPUTER FAST ENOUGH TO DO TRILLIONS AND TRILLIONS AND TRILLIONS OF OPERATIONS AND CALCULATIONS



'COMPUTE'  
2010'S

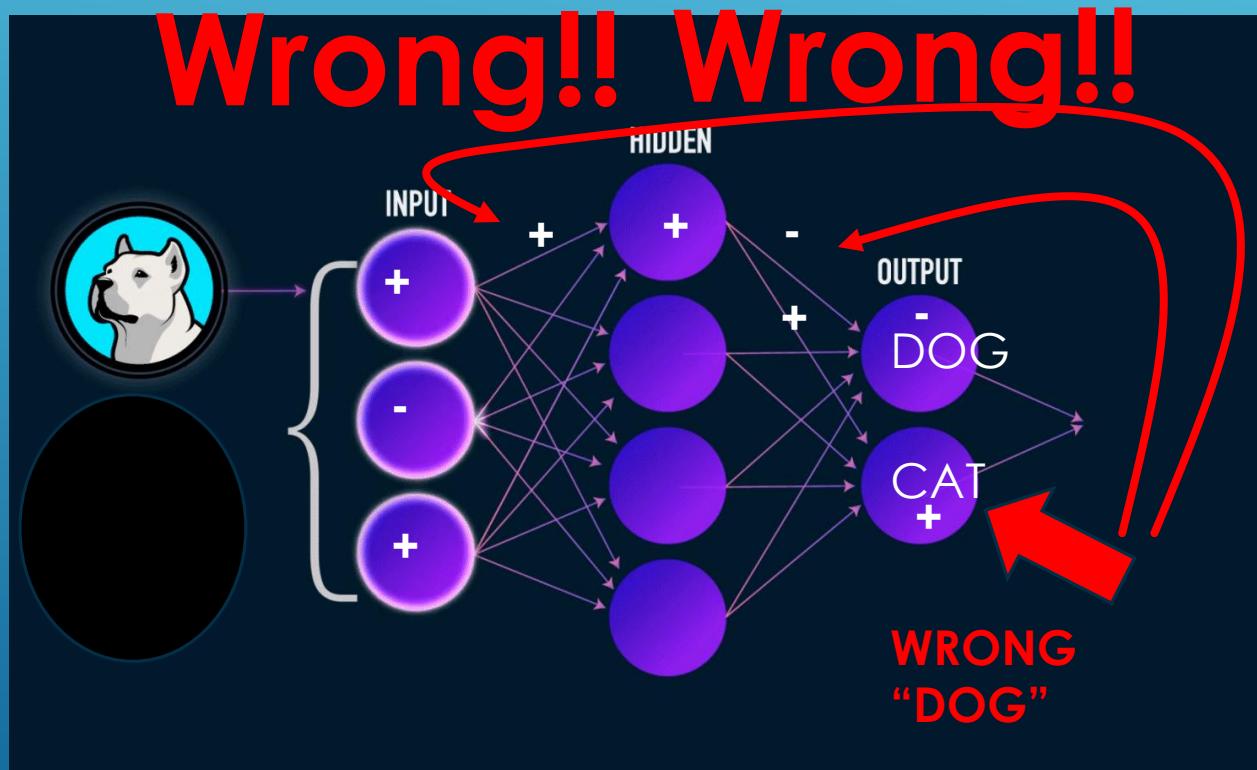
### 3. GET LOTS AND LOTS OF TRAINING DATA (ACTUALLY – THOUSANDS OR MILLIONS OF IMAGES!!)



'BIG DATA'  
2000'S

G\*\*

# 4. FEED DATA INTO THE NETWORK & SEE ERRORS 'BACKPROPAGATION' – USE FEEDBACK TO AUTOMATICALLY ADJUST SYNAPSES TO REDUCE ERRORS

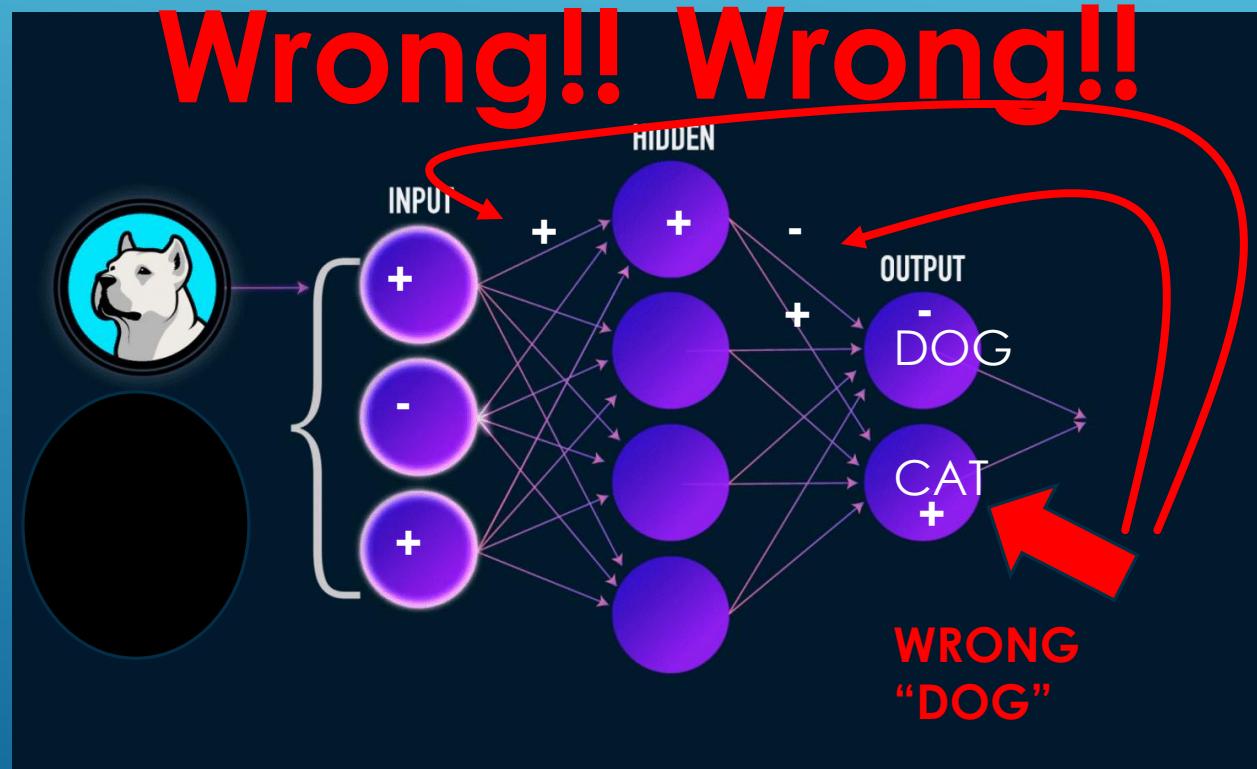


# 5. REPEAT #4

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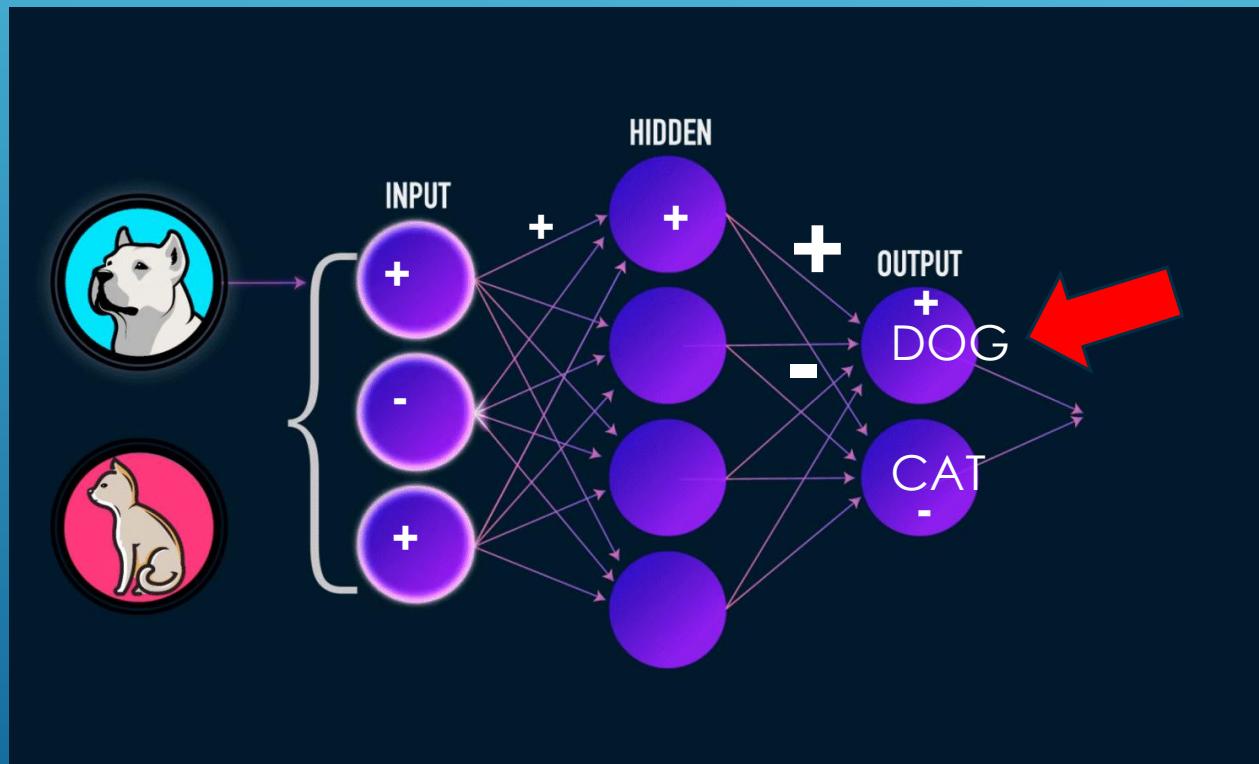
## 4. FEED DATA INTO THE NETWORK 'BACKPROPAGATION' – USE FEEDBACK TO AUTOMATICALLY ADJUST SYNAPSES



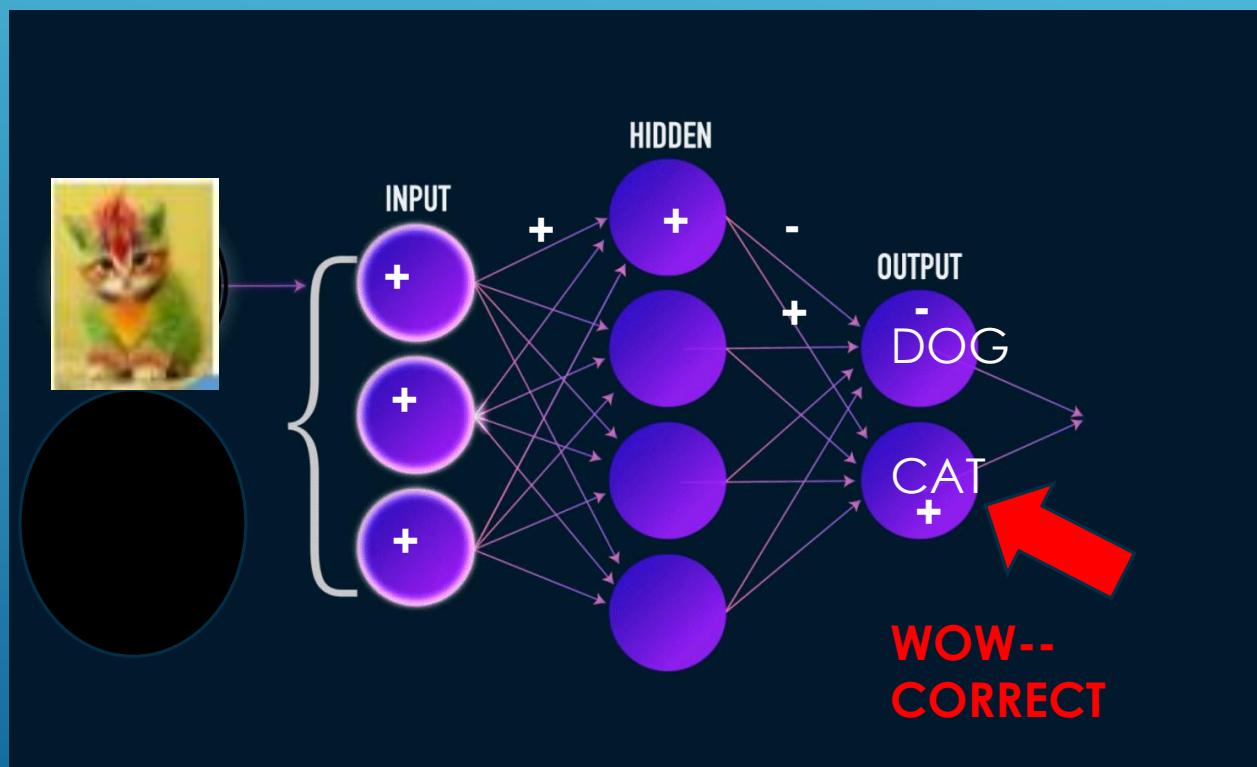
# 5. REPEAT #4

(OVER AND OVER AND OVER AGAIN....)

## 6. WHEN NEURAL NETWORK SEEKS ACCURATE ENOUGH TO RECOGNIZE VARIOUS DIFFERENT DOGS AND CATS – TRAINING IS COMPLETE



# 7. USE NEURAL NETWORK TO RECOGNIZE ALL SORTS OF CATS AND DOGS



CAN DO SAME THING AND MAKE NEURAL NETWORK TO  
RECOGNIZE FACES.... OR SOUNDS.... OR SPEECH.... OR  
SCIENTIFIC DATA.... OR MARKETING DATA.....

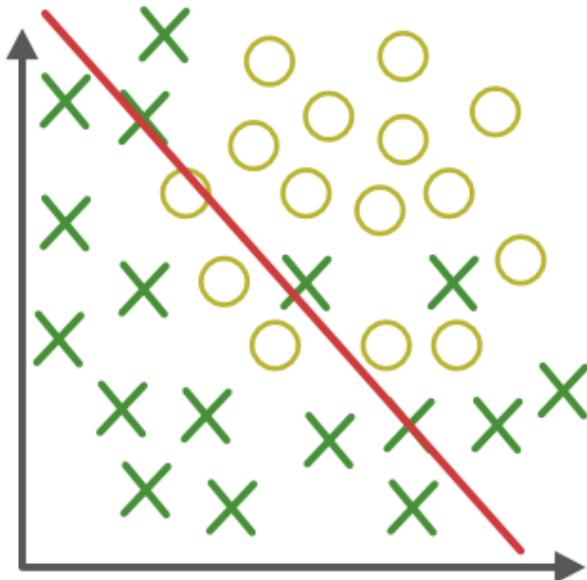


A photograph of a tropical beach at sunset. The sky is filled with warm, orange and yellow clouds. The ocean waves are crashing onto the light-colored sand. In the distance, there are some palm trees and buildings on the shore.

Very quickly, let's discuss  
some of practical neural  
networks....

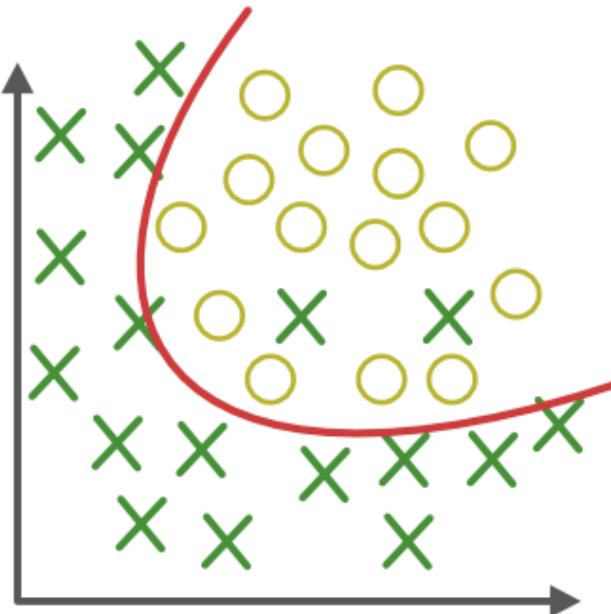
DEEP LEARNING EXPERTS SPEND MUCH TIME ON  
'ALCHEMY' – TWEAKING THIS AND TWEAKING THAT  
– TRYING TO AVOID OVERFITTING AND AVOID  
UNDERFITTING...



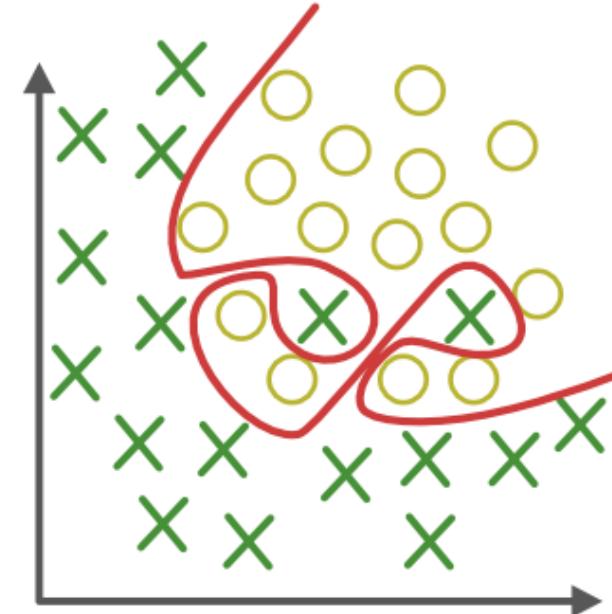


### Under-fitting

(too simple to explain the variance)



### Appropriate-fitting



### Over-fitting

(forcefitting--too good to be true)

DG

# TOOLS TO LET USERS EASILY CREATE AND USE NEURAL NETWORKS



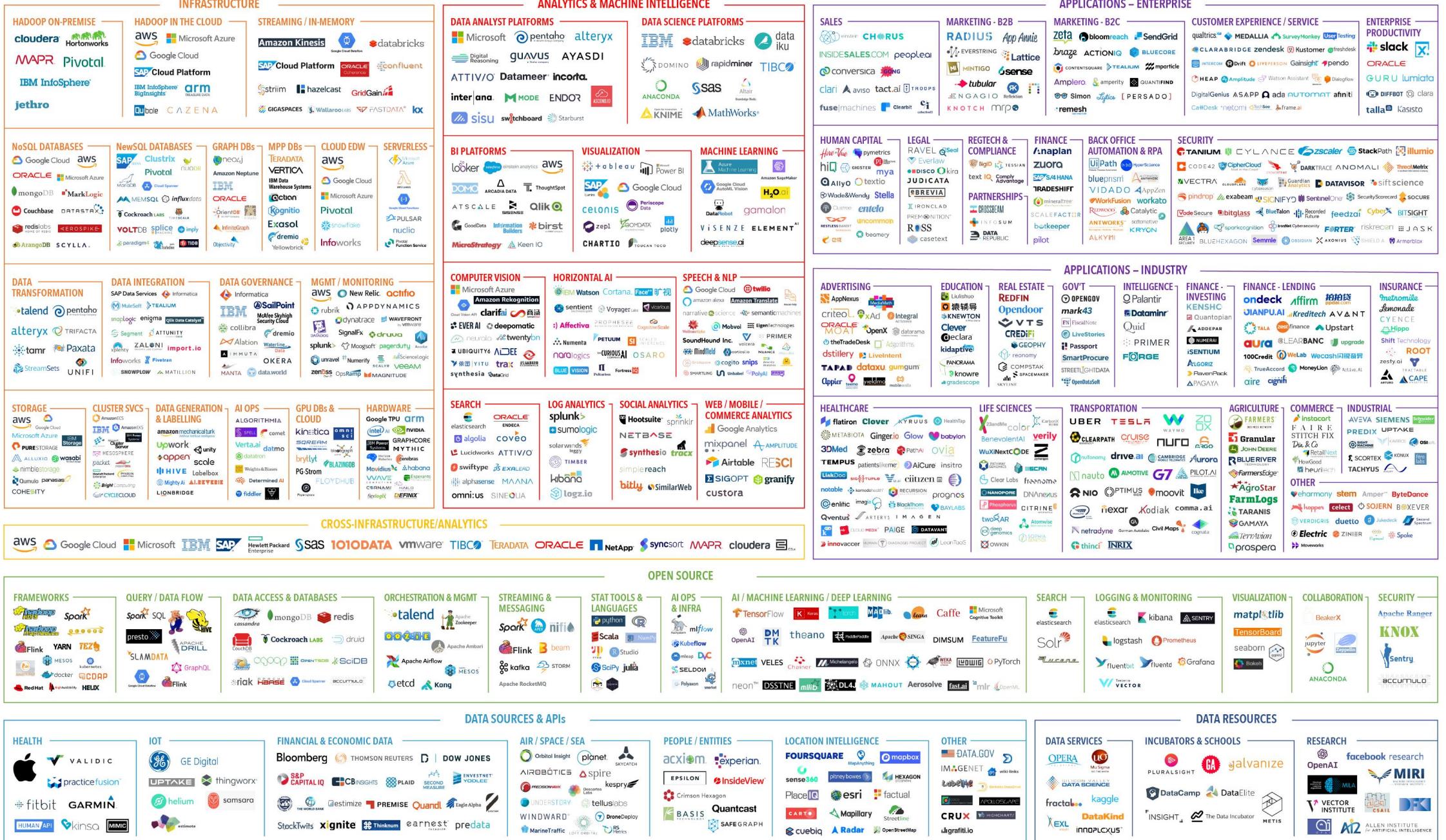
*Software to  
create your  
Deep  
Learning  
Neural  
Network*



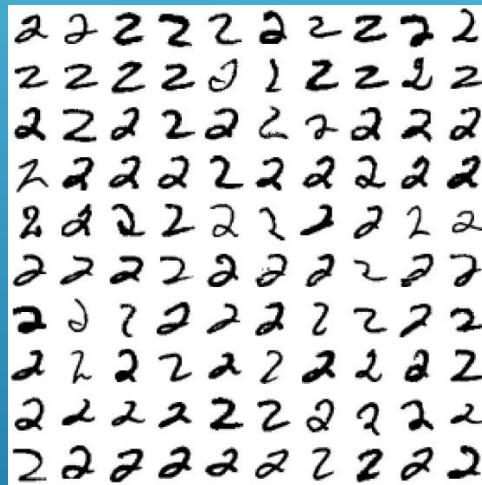
*'COMPUTE' to train and  
run your Deep Learning  
Neural Network*

# Too many tools??

DATA & AI LANDSCAPE 2019



# YOU CAN EVEN GET OTHER PEOPLE'S "BIG DATA" TO TRAIN NEURAL NETWORK (IF YOU DON'T HAVE YOUR OWN TRAINING DATA)



Part of MNIST  
numerals data set



ImageNet – 14 million images (20,000 categories) manually annotated with labels

*'Big Data'* to  
Train your  
Deep  
Learning  
Neural  
Network

YOU CAN EVEN GET COMPANIES TO LABEL YOUR OWN DATA (SO YOU CAN FEED IT INTO YOUR NEURAL NETWORKS) (EG, IS IT 'DOG' OR 'CAT'?)



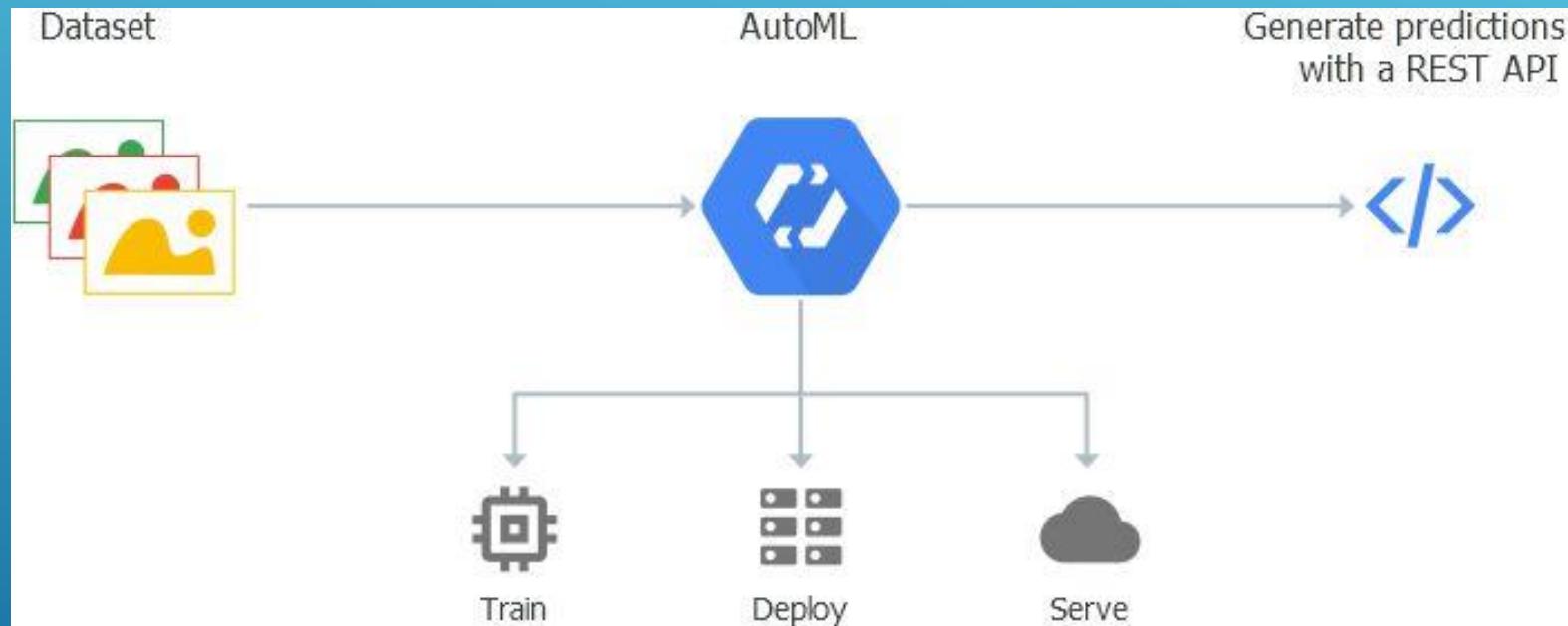
*"Labeled data is the key bottleneck to the growth of the machine learning industry. In fact, labeled data is even more essential than algorithms."*

*"Scale raises \$18 million to label data from autonomous car companies like Lyft and Embark"*

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March 2020

# 'AUTO ML' TOOLS TO LET NON-EXPERTS CREATE AND USE DEEP LEARNING NETWORKS



# DEEP LEARNING ALL AROUND US NOW: LONDON POLICE SURVEILLANCE CAMERAS WITH FACIAL RECOGNITION



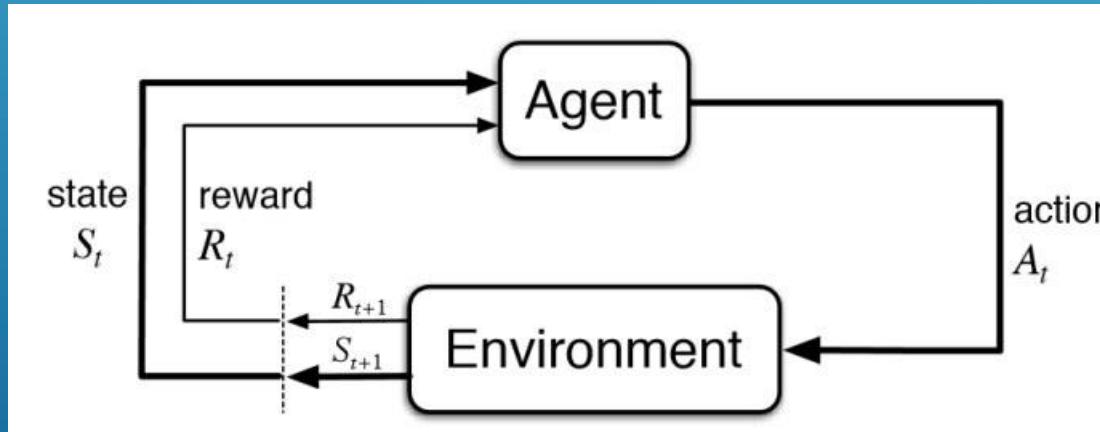
# DEEP LEARNING ALL AROUND US NOW: ALL AROUND US NOW: SELF DRIVING CARS....



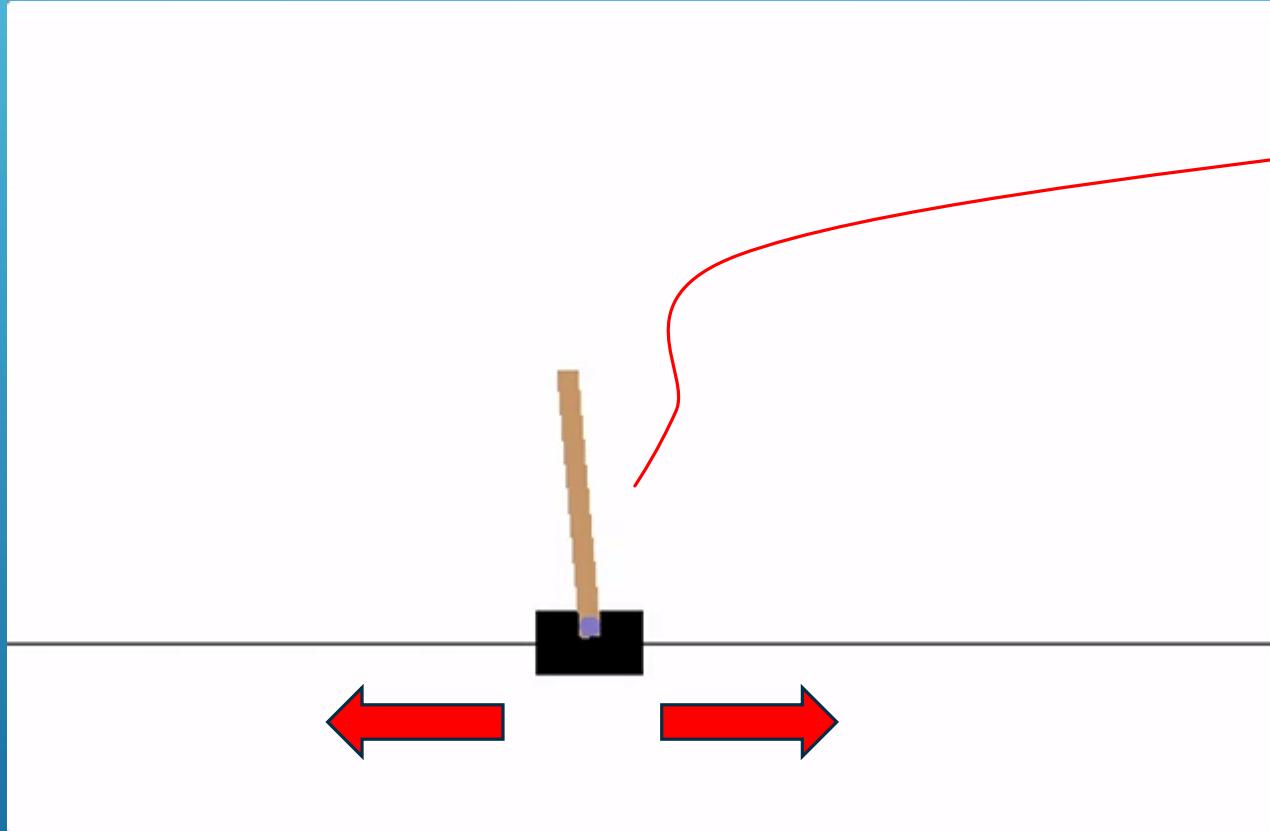
82

# REINFORCEMENT LEARNING

- DON'T NEED TO SUPPLY LABELED DATA
- AGENT (IE, NEURAL NETWORK) TRIES AN ACTION
- ENVIRONMENT GIVES A REWARD OR PUNISHMENT
- AGENT WILL FAVOR ACTIONS THAT GIVE A REWARD



# Reinforcement learning



## Cartpole example

-Can move cart to the left or right

-Reward keeping the stick upright, not falling over

# DeepMind AlphaZero (2017)

- ALPHAZERO – SUPERHUMAN PERFORMANCE IN CHESS, SHOGI & GO
- REINFORCEMENT LEARNING – PLAYED ITSELF OVER (+ OTHER AI TECHNIQUES)

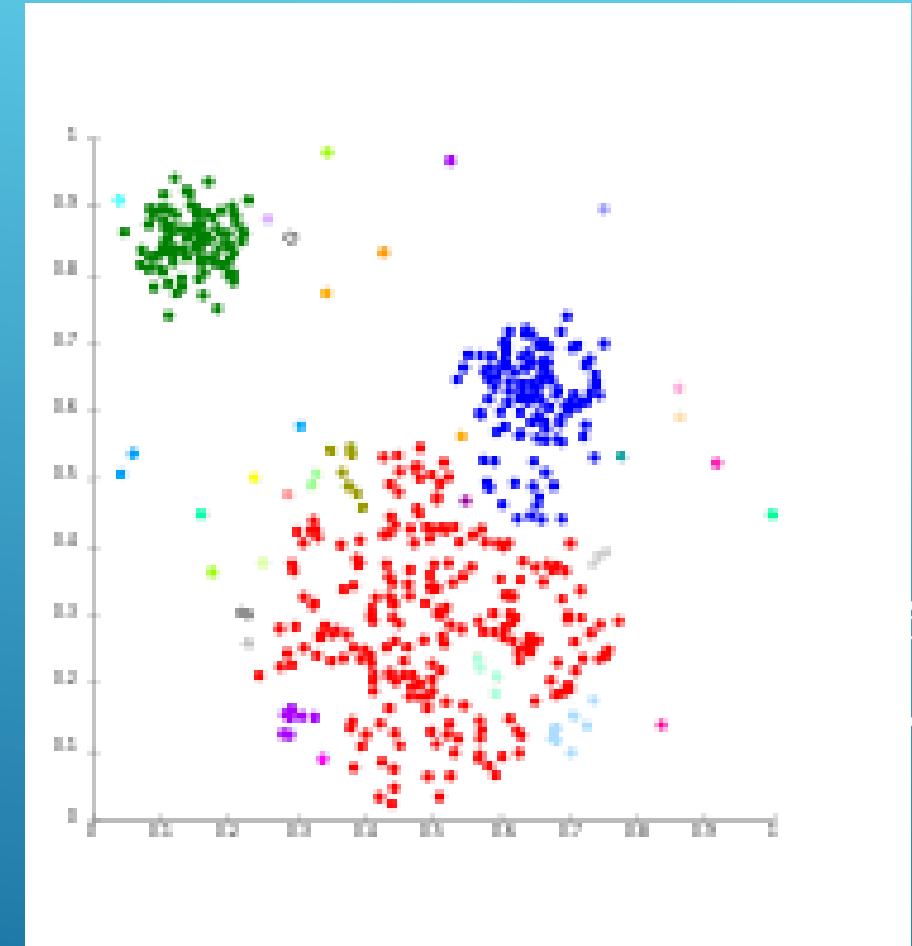


# TYPES OF MACHINE LEARNING

- SUPERVISED LEARNING** -- EG, DEEP LEARNING ANN  
DOG VS CAT, ETC
- REINFORCEMENT LEARNING** -- NETWORK TRIES TO  
MAXIMIZE REWARD IT GETS FROM ENVIRONMENT  
(EG, PLAY CHESS AGAINST ITSELF)
- UNSUPERVISED LEARNING** – NO LABELS, NETWORK  
HAS TO FIGURE THINGS OUT BY ITSELF

# Unsupervised Learning

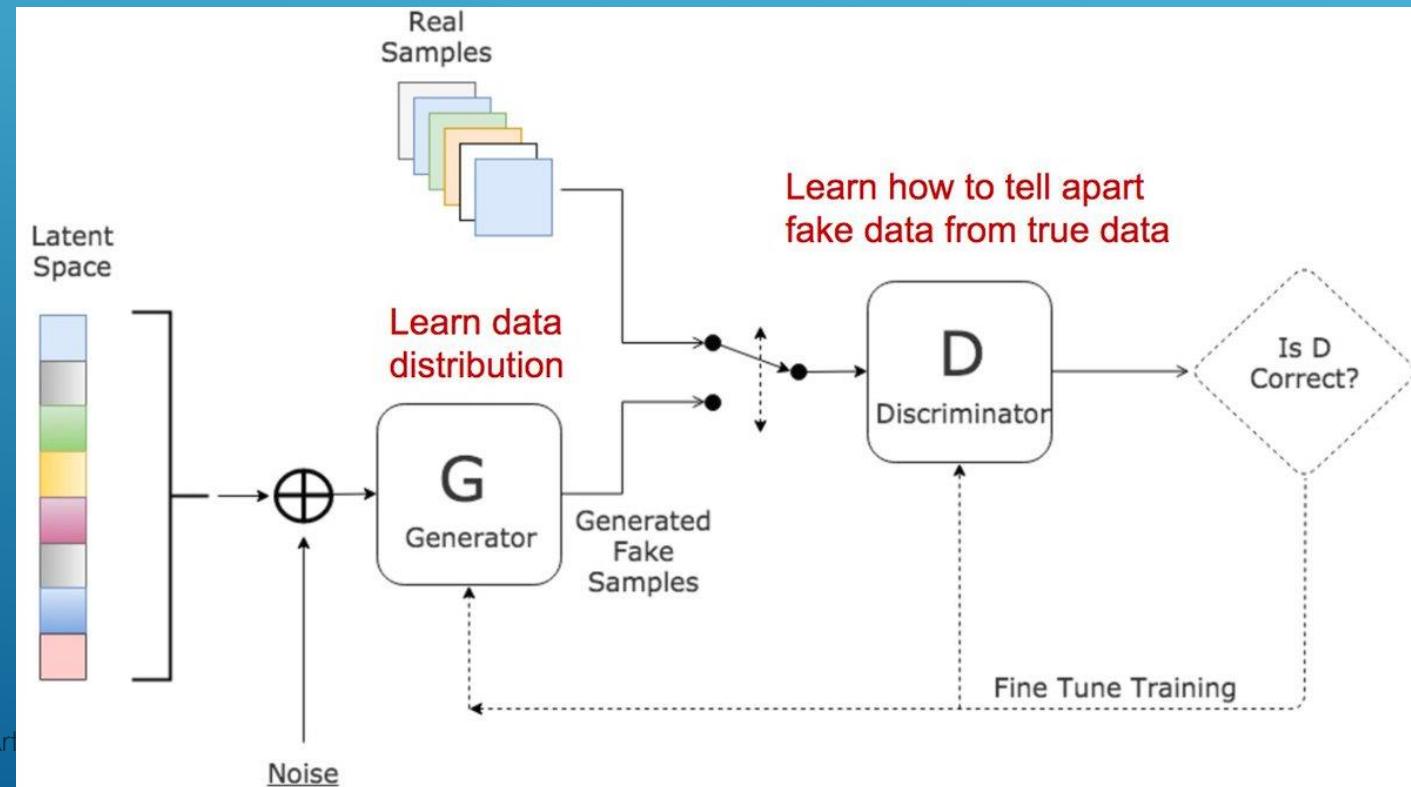
- No labels provided
- Various automatic methods
- eg, cluster analysis



# GAN – GENERATIVE ADVERSIAL NETWORK



- 'Generator Network' – generates new images
- 'Discriminator Network' – classifies “real” or “fake”
- Keep training over and over again → better images
- 'adversial' – Generator vs Discriminator game



# DON'T CONFUSE HYPED BUZZWORDS WITH AI

-BLOCKCHAIN IS NOT AI (CRYPTOGRAPHIC HASH OF PREVIOUS BLOCK, USE AS DISTRIBUTED LEDGER)(CAN USE WITH AI, OF COURSE)

-QUANTUM COMPUTING IS NOT AI (QM ENTANGLEMENT OF QUBITS, FACTORING SOL'N, QM SIMULATION )(IN SOME DISTANT FUTURE, COULD MASSIVELY SPEED UP AI)

-5G IS NOT AI (WIRELESS TECHNOLOGY, 24-72GHZ->SPEED) (CAN USE WITH AI, OF COURSE)

-IOT (INTERNET OF THINGS) IS NOT AI (INTERCONNECTED DEVICES)  
(CAN USE WITH AI, OF COURSE)

-INTERNET DOES NOT CREATE AI (GLOBAL COMPUTER NETWORK) (CAN USE WITH AI, OF COURSE)

-CLOUD COMPUTING IS NOT AI (INTERNET ON-DEMAND COMPUTING FROM DATA CENTERS) (CAN USE WITH AI, OF COURSE)

## QUIZ – QUESTION 1.

- 1A. A NEW EMR/EHR SYSTEM ALLOWS PATIENTS TO GET THEIR CHART RESULTS OVER THE INTERNET BY THEMSELVES. IS THIS IS AI?
- 1B. COULD SUCH AN EMR/EHR INCLUDE AI?

## QUIZ – QUESTION 2.

2A. 5G IS IN THE NEWS A LOT THESE DAYS. IS IT BECAUSE WE NEED 5G TO CREATE OUR ARTIFICIAL INTELLIGENCE (AI) SYSTEMS?

2B. COULD 5G MAKE IT EASIER TO BUILD AI SYSTEMS FOR PEOPLE TO USE?

## QUIZ – QUESTION 3.

3A. A STARTUP COMPANY JUST GOT \$4 MILLION IN VENTURE FUNDING FOR THEIR NEW AI APPLICATION THAT USES AI TO HELP HEALTH CARE SYSTEMS REDUCE HOSPITAL RE-ADMISSIONS. WHAT TYPE OF “AI” ARE THEY MOST PROBABLY USING?

3B. ARE THERE OTHER PARTS OF AI THAT DO NOT INVOLVE ANY DEEP LEARNING?

## QUIZ – QUESTION 4.

4A. WHAT IS A DEEP LEARNING (DL)NETWORK MADE OF?

4B. DO ARTIFICIAL NEURAL NETWORKS (ANN) REALISTICALLY DUPLICATE NEURONS OR ARE THEY JUST INSPIRED BY THE BRAIN?

## QUIZ – QUESTION 4.... CONTINUED

4C. ARE ANN'S PROGRAMMED BY A  
PROGRAMMER OR DO THEY LEARN BY THEMSELVES  
IN RESPONSE TO RIGHT AND WRONG  
PREDICTIONS?

4D. WHAT HAPPENS IN AN ANN AFTER RIGHT AND  
WRONG PREDICTIONS?

## QUIZ – QUESTION 5.

5A. HOW MANY EXAMPLES DO ANN'S (ARTIFICIAL NEURAL NETWORKS) NEED TO TRAIN ON TO BECOME 'TRAINED' AND BECOME ABLE TO MAKE GOOD PREDICTIONS?

5B. WHAT IS MEANT BY THE TERM 'BIG DATA'?

## QUIZ – QUESTION 6.

6A. CAN WE USE ANN'S WITH DIFFERENT TOPOLOGIES (HOW THE NEURONS ARE CONNECTED TO EACH OTHER) WITH DIFFERENT LAYERS FOR DIFFERENT PURPOSES, EG, VISION RECOGNITION, EG, HOSPITAL RE-ADMISSION DATA, ETC ?

6B. WHAT IS OVERFITTING (BIAS/VARIANCE)?

6C. WHAT IS UNDERFITTING (BIAS/VARIANCE)?

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# QUIZ – QUESTION 7.

7A. WHAT IS RE-INFORCEMENT LEARNING?

7B. THE COMPANY DEEPMIND CREATES INCREDIBLE AI SYSTEMS THAT BEAT THE BEST PLAYER IN THE WORLD IN GO, ETC. WHAT IS THE MAIN AI TECHNIQUE THEIR SYSTEM USES?

WE JUST COVERED A LOT A MATERIAL....  
AND SO MUCH MORE TO COVER STILL....



QUICK STRETCH AND MOVEMENT TO  
REFRESH OUR BRAINS....  
AND LET'S CONTINUE....



# LEARNING OBJECTIVES

- ▶ 1. Real understanding of what AI is:
- ▶ 1a. Deep Learning and Reinforcement Learning
- ▶ **1b. Field of Artificial Intelligence (AI)**
- ▶ 1c. Neuro-Symbolic Gap
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- ▶ 5. Discussion



← **HUGE AMOUNT OF MATERIAL**

1. Definition of AI
2. History of AI ←
3. Mathematical Primer
4. Computer Science Theoretical Concepts
5. Computational Devices
6. Programming Languages
7. ..... ..... .....

# INVENTED IN CANADA



- Richard Sutton** – ‘father of **reinforcement learning**’ – Univ of Alberta (then Google/DeepMind)
- Geoffrey Hinton** – ‘godfather of **deep learning**’ – University of Toronto (then Google Brain)
- Yoshua Bengio** – with Hinton, a founder of **deep learning** – Universite de Montreal
- Ian Goodfellow** – inventor of **GANs** (then Google Brain and then Apple)



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## 4 BORING DEFINITIONS OF AI (RUSSELL & NORVIG)

1. Decision making, problem solving, learning that human thinking can do
2. Actions that humans can do because of human intelligence
3. Ability to think rationally (perceive, reason)
4. Ability to act rationally

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OR....



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**AGI** (Artificial General Intelligence)  
== **HLAI** (Human Level Artificial Intelligence)  
== **Strong AI** (need consciousness??)

## Narrow AI – specific problem solving

**Turing Test** – Human has distant conversation with another human and an AI – can the AI fool the human into thinking it is human?

**Wozniak Test** – AI/machine must go into a typical home and figure out on its own how to make a cup of coffee

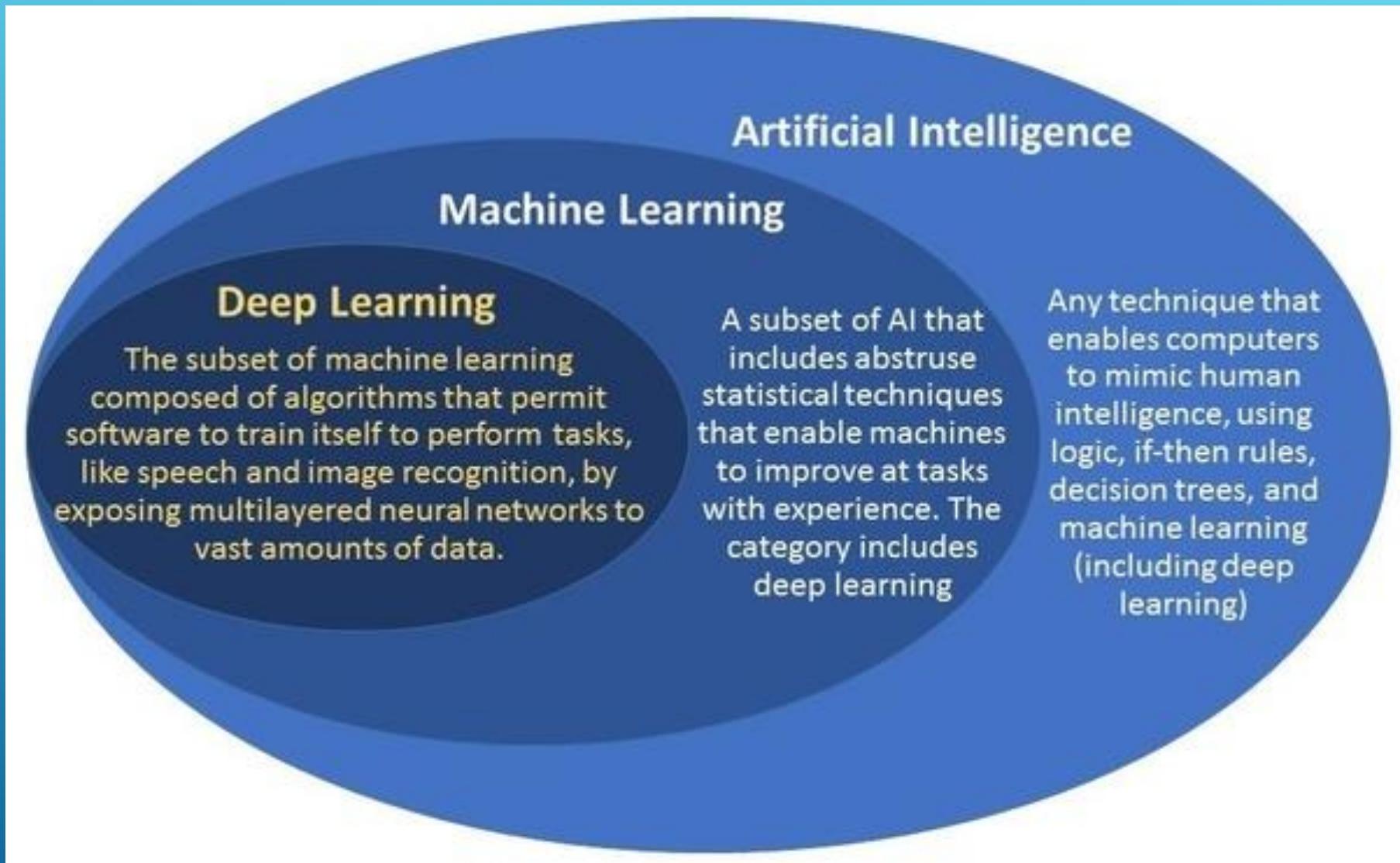
**Legg & Hutter** – Universal Intelligence (2007)

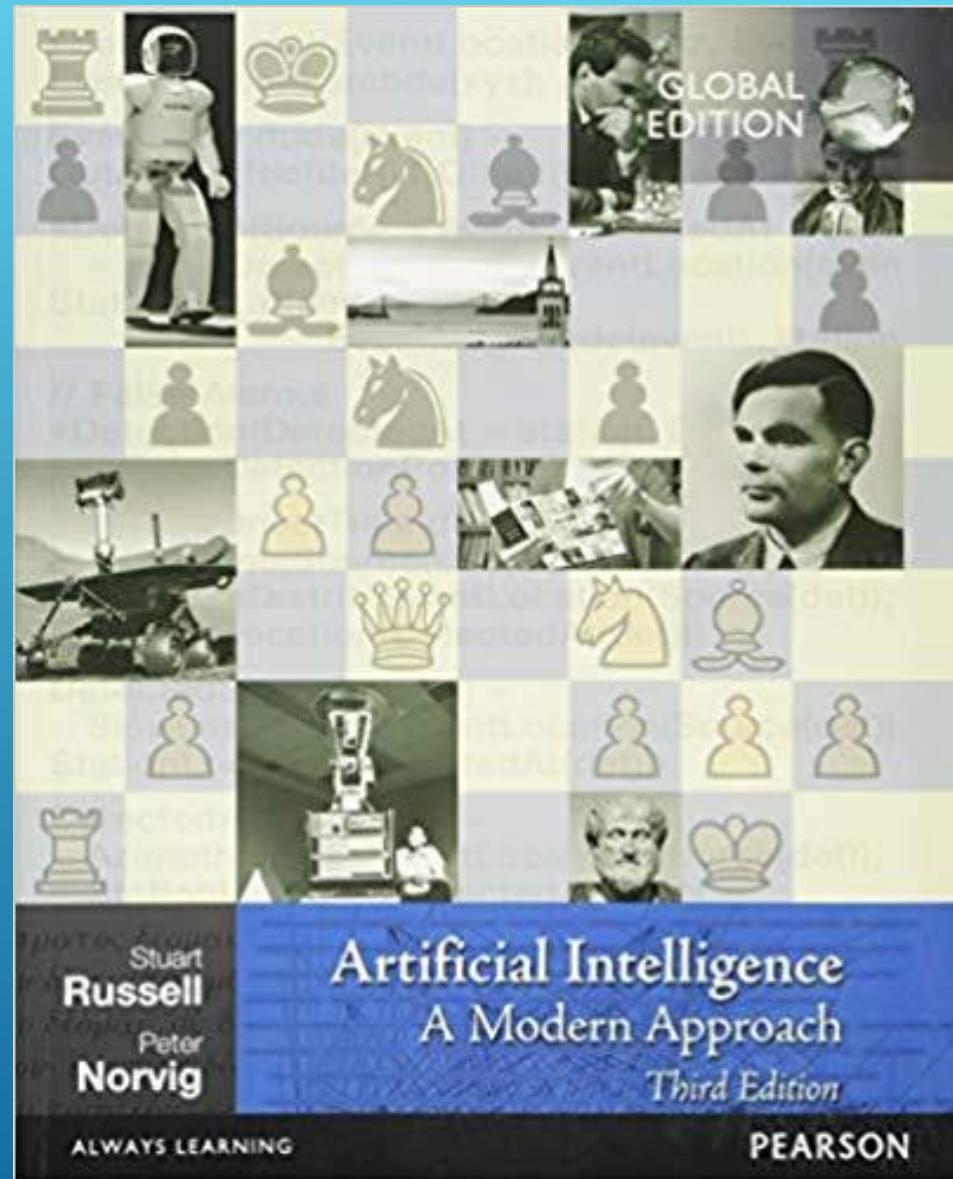
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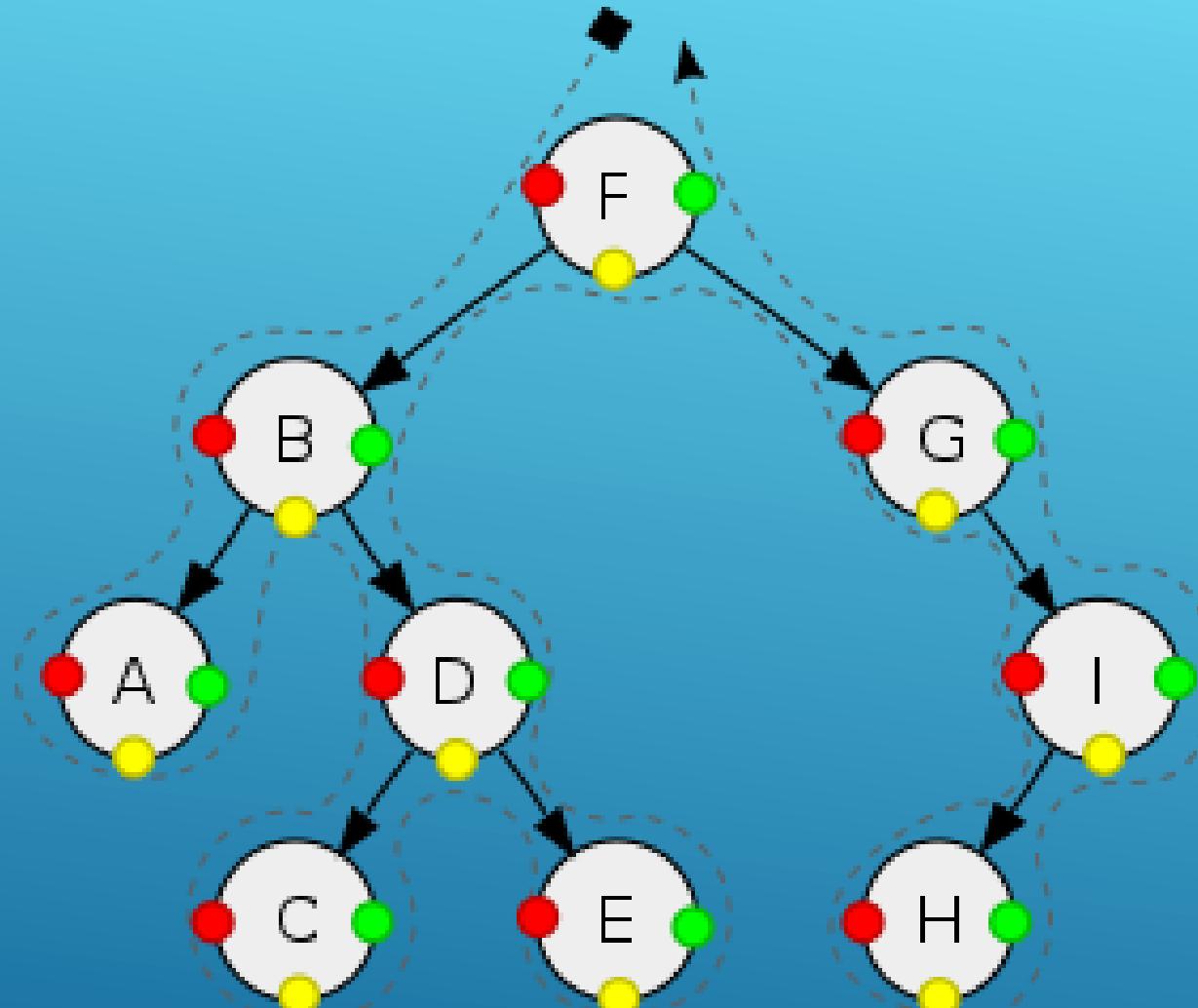
← Let's quickly try to make  
senses of where Deep  
Learning fits into all of this

1. Definition of AI
2. History of AI
3. Mathematical Primer
4. Computer Science Theoretical Concepts
5. Computational Devices
6. Programming Languages
7. ..... .....





# SEARCH



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# LOGIC

$\forall x \text{ King}(x) \wedge \text{Greedy}(x) \Rightarrow \text{Evil}(x)$  *← axiom*

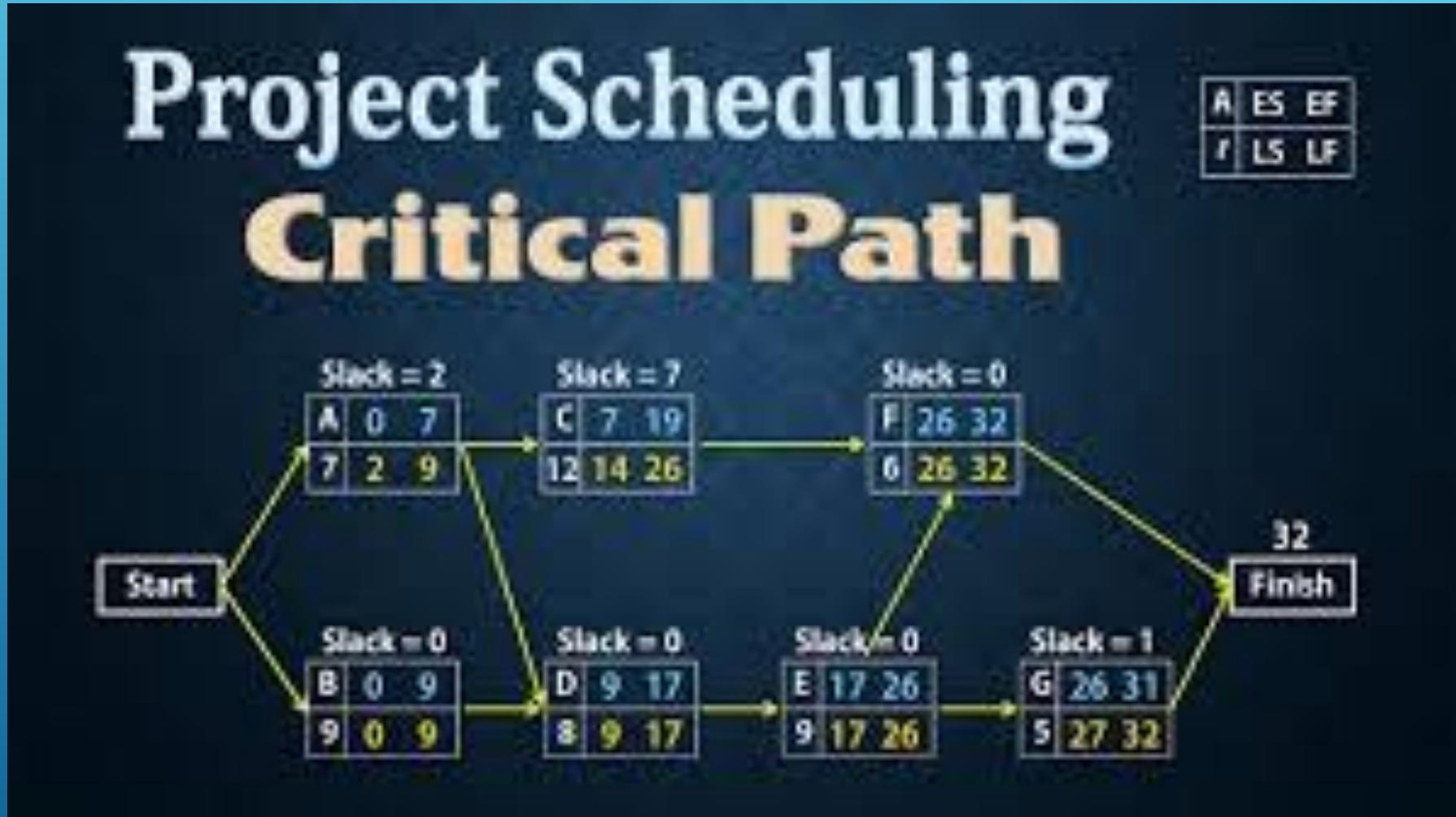
Given any x where it is a king and greedy this implies x is evil

*(“All greedy kings are evil”)*

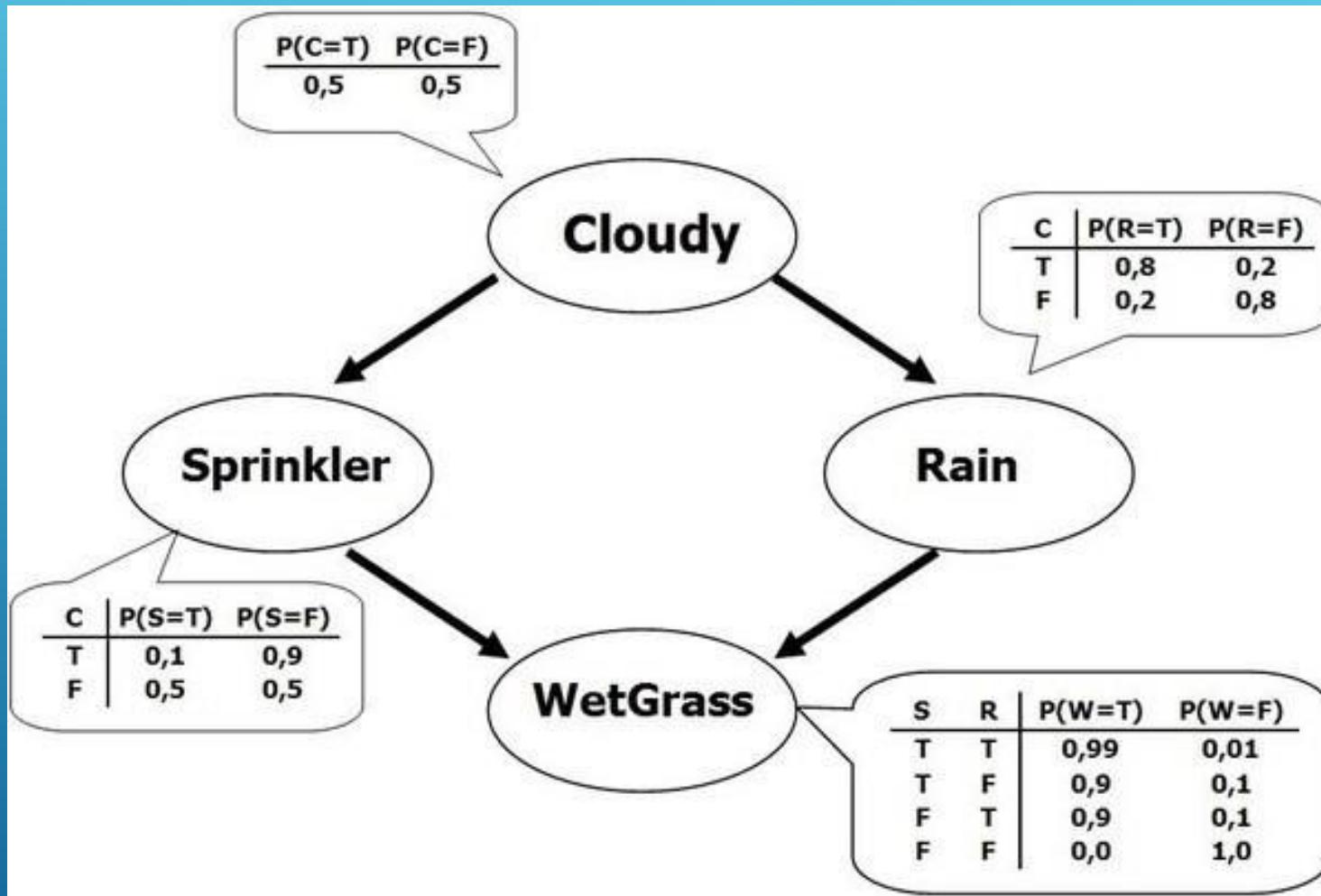
*Therefore can infer:*

$\text{King}(\text{John}) \wedge \text{Greedy}(\text{John}) \Rightarrow \text{Evil}(\text{John})$

# PLANNING



# PROBABILISTIC REASONING

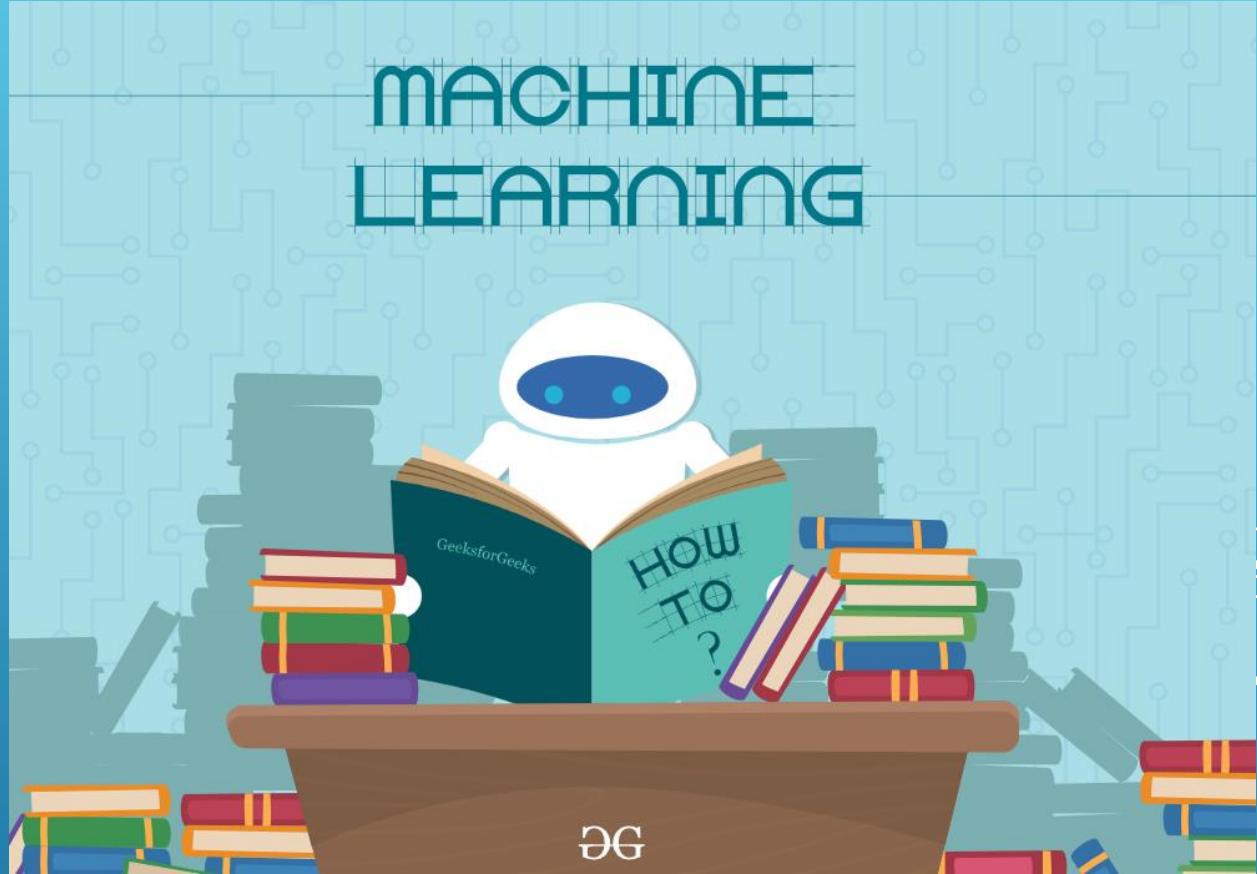


# LEARNING

Learn from examples  
Forms of learning  
Knowledge in learning  
Inductive learning

.....

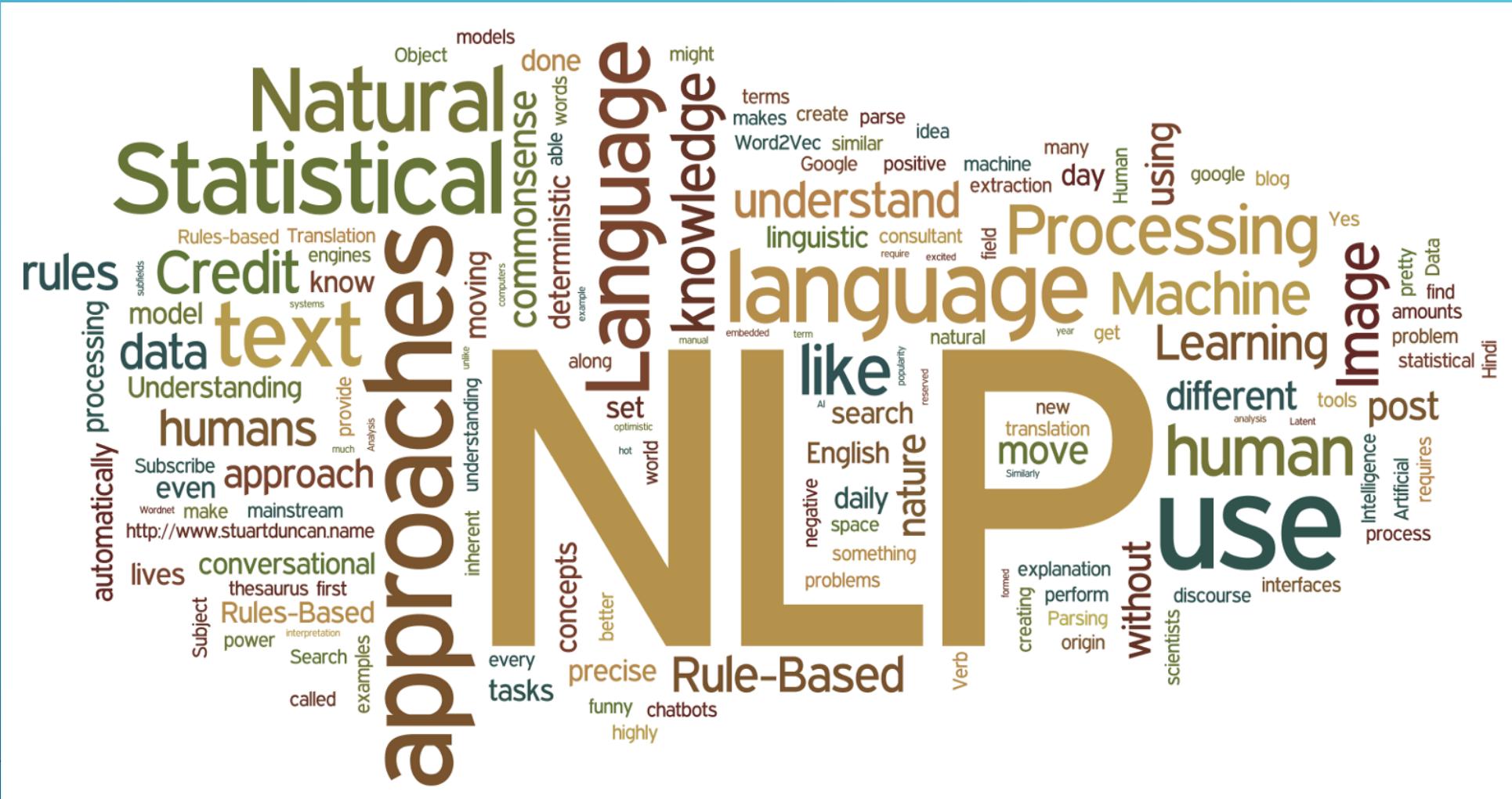
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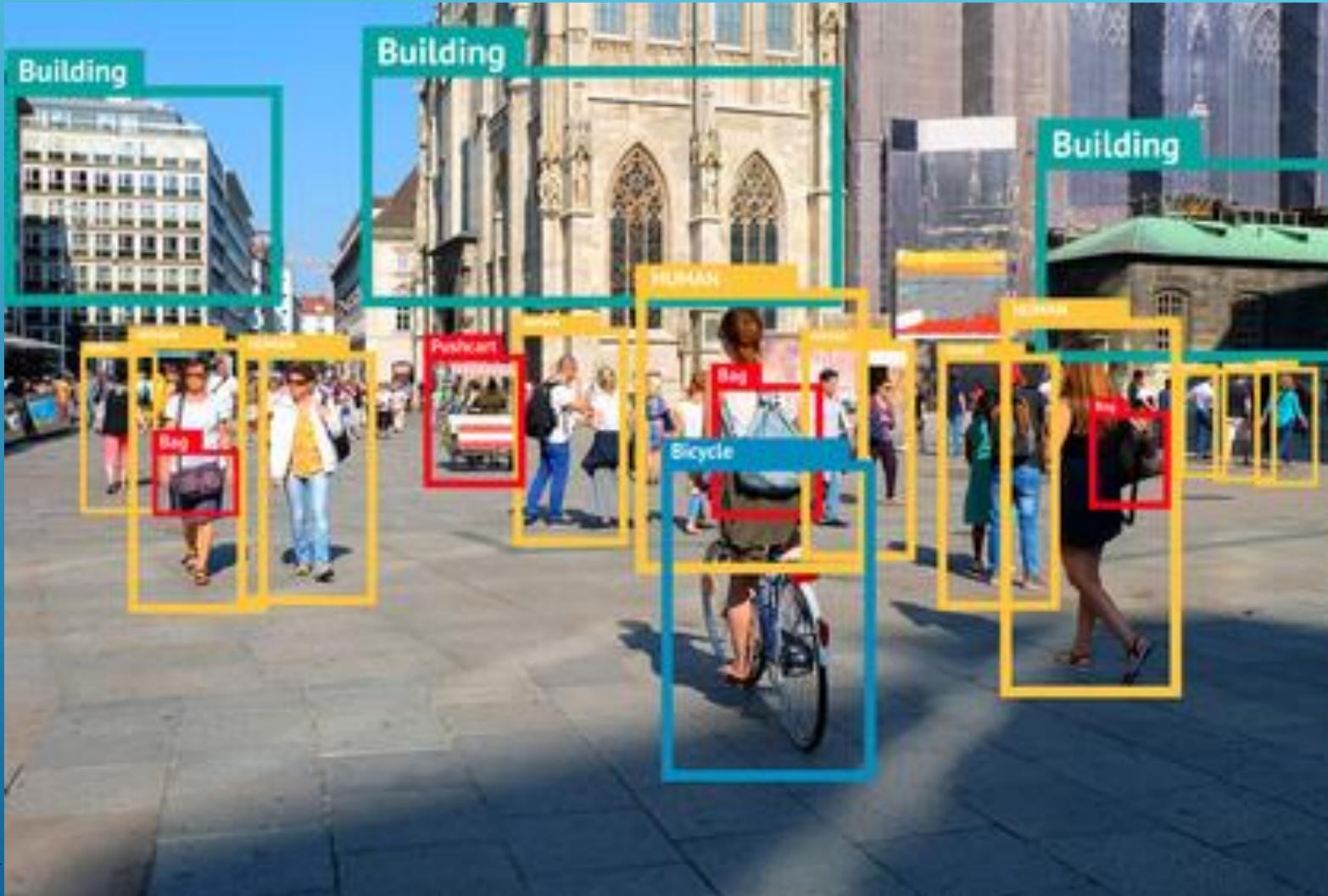
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# NATURAL LANGUAGE PROCESSING

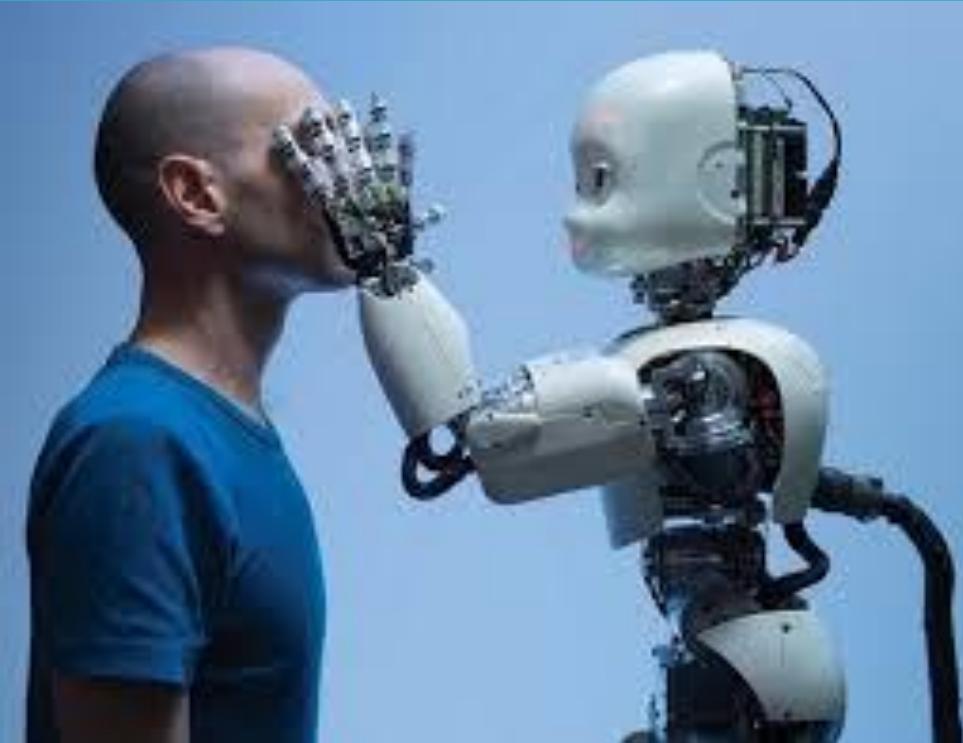


# VISION, PERCEPTION



# ROBOTICS

- EFFECTORS OF AN AI SYSTEM
- INTERNAL AI SYSTEMS TO ALLOW GOOD FUNCTIONING



# GOOD OLD FASHIONED ARTIFICIAL INTELLIGENCE (“GOFAI”) == “SYMBOLIC AI”

**1950s – 1974** – golden years of AI research but no truly useful products

**1974-1980** – first **AI winter**

**1980 – 1987** – **expert systems** (*symbols, production rules, if....then*), Japan  
5<sup>th</sup> Gen'n project seemed useful, more funding, but projects could not do truly useful tasks

**1987 – 1993** – second AI winter

**1993 – 2011** – faster, cheaper computer chips – parts of AI started to be used behind the scenes throughout computer technology

**2012 – present** – era of deep learning neural networks, big data

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# LOGIC

$\forall x \text{ King}(x) \wedge \text{Greedy}(x) \Rightarrow \text{Evil}(x)$  *← axiom*

Given any x where it is a king and greedy this implies x is evil

*(“All greedy kings are evil”)*

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## QUIZ – QUESTION 1.

WHAT IS REINFORCEMENT LEARNING?

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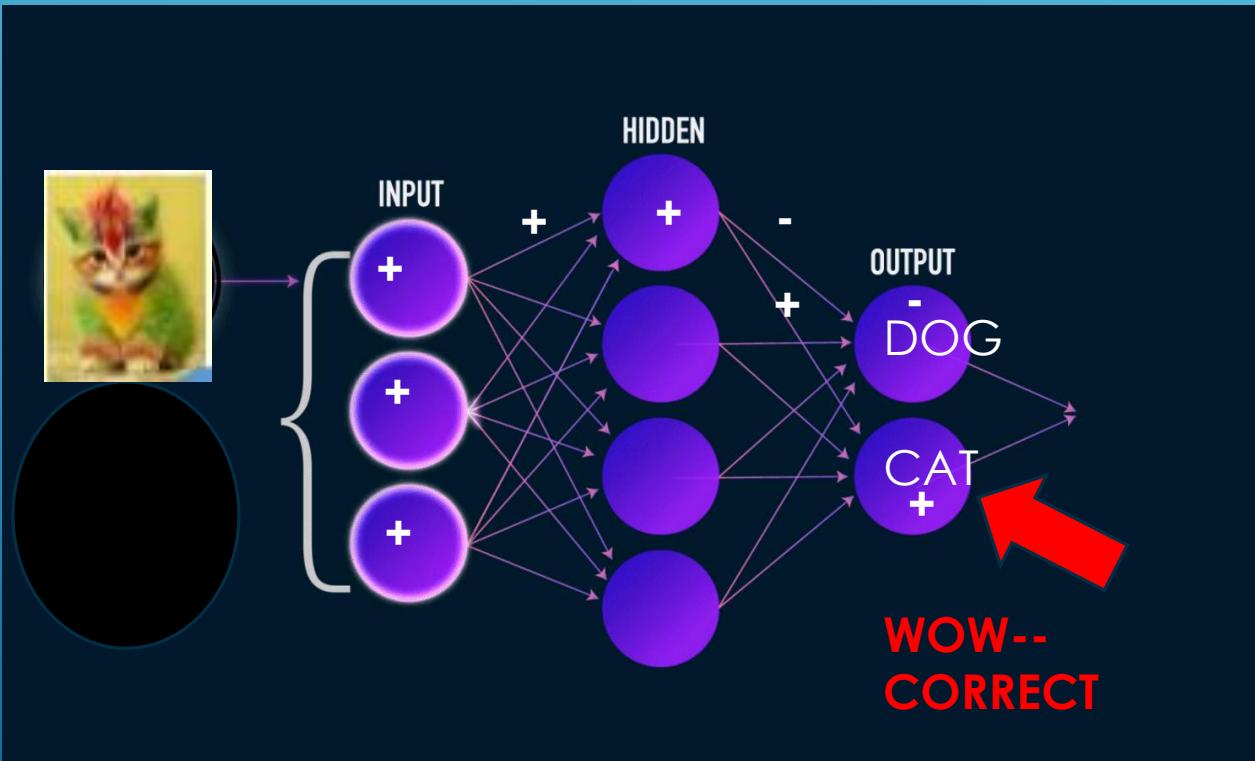
# REINFORCEMENT LEARNING

-NETWORK ('AGENT') TRIES TO MAXIMIZE THE REWARD  
EG, PLAYS CHESS/SHOGI/GO AGAINST ITSELF MILLIONS  
AND MILLIONS OF TIMES

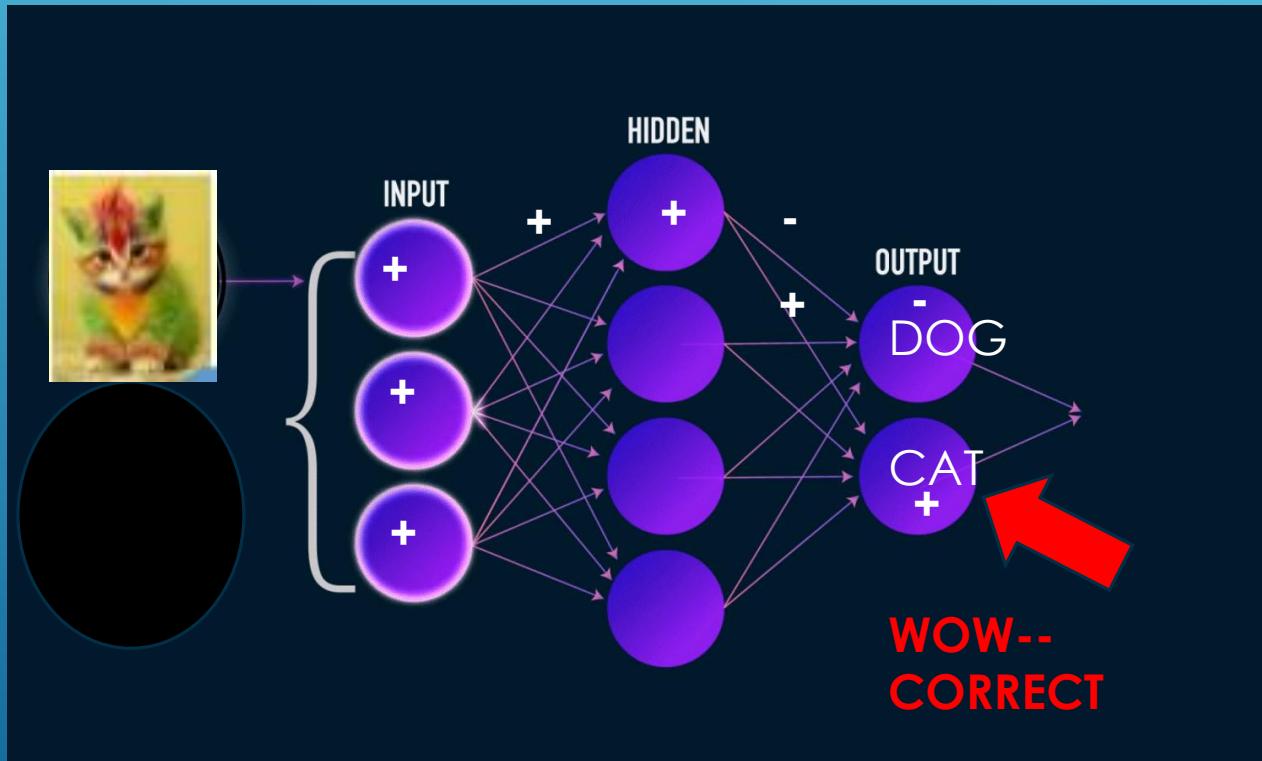


Deepmind 2017: Alphazero –  
superhuman performance in  
chess, shogi & go

# QUIZ – QUESTION 2. WHAT KIND OF SYSTEM IS SHOWN BELOW?



# DEEP LEARNING TO RECOGNIZE ALL SORTS OF CATS AND DOGS



“Connectionism”  
“Neural Network”  
“Deep Learning Network”

# DEEP LEARNING CAN RECOGNIZE OR ASSOCIATE ALL KINDS OF INFORMATION – IMAGES, FACES, SPEECH, DATA, ETC OR MARKETING DATA.....



## QUIZ – QUESTION 3. WHAT KIND OF COMPUTER SYSTEM HANDLES THE LOGIC SHOWN BELOW?

$\forall x \text{King}(x) \wedge \text{Greedy}(x) \Rightarrow \text{Evil}(x)$  *← axiom*  
*(“All greedy kings are evil”)*

*Therefore can infer:*

$\text{King}(\text{John}) \wedge \text{Greedy}(\text{John}) \Rightarrow \text{Evil}(\text{John})$

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# GOOD OLD FASHIONED ARTIFICIAL INTELLIGENCE ("GOFAI") "SYMBOLIC AI"

$\forall x \text{King}(x) \wedge \text{Greedy}(x) \Rightarrow \text{Evil}(x)$  *← axiom*  
*("All greedy kings are evil")*

*Therefore can infer:*

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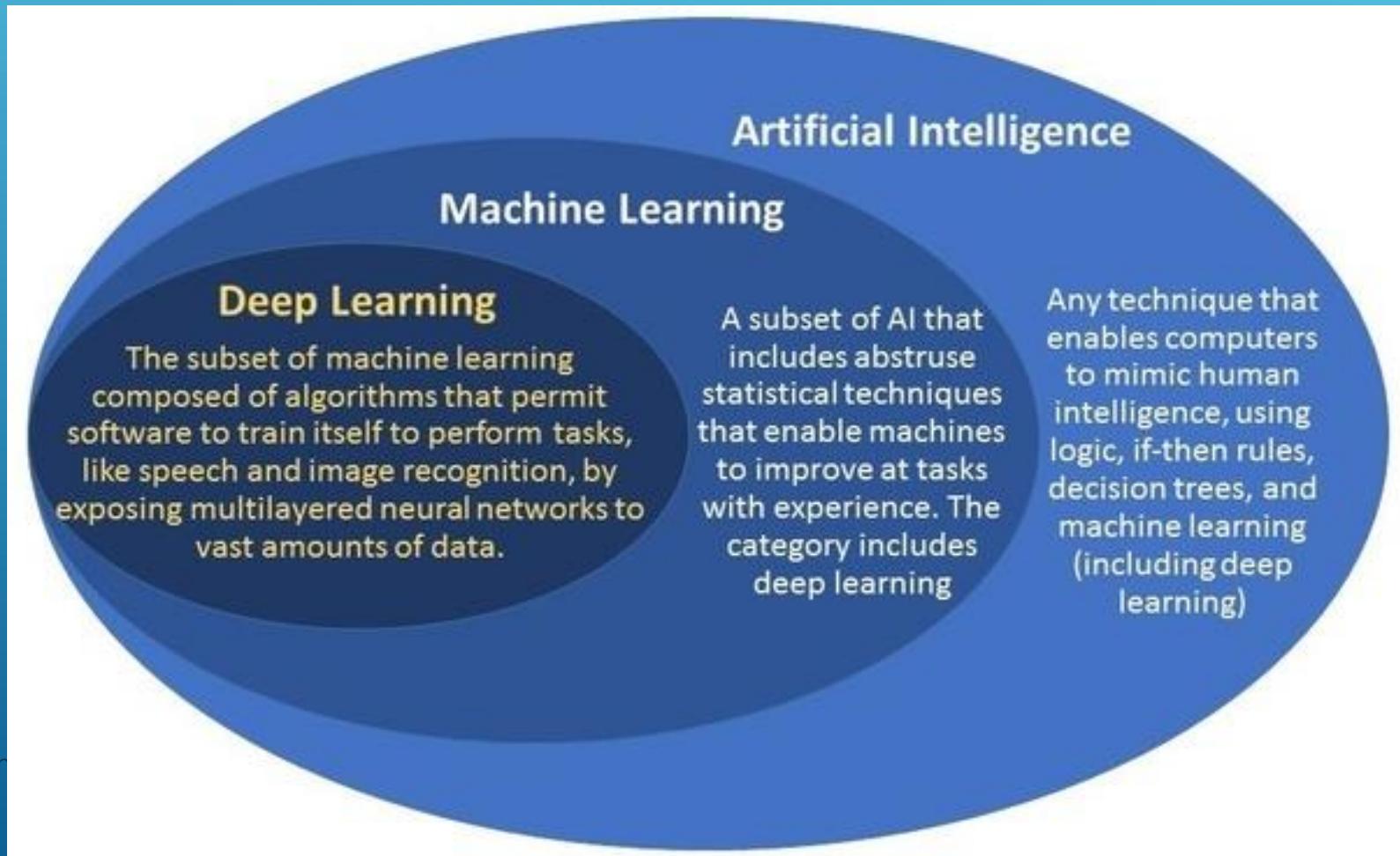
# GOOD OLD FASHIONED ARTIFICIAL INTELLIGENCE “GOFAI” == “SYMBOLIC AI”

```
yes_synonyms = ['y', 'Y', 'yes', 'Yes', 'T', 'true']
x = input('What is the name of the person? ')
king = input(f'Is {x} a king? ')
if king in yes_synonyms:
    king = True
else:
    king = False
greedy = input(f'Is {x} greedy? ')
if greedy in yes_synonyms:
    greedy = True
else:
    greedy = False
if king and greedy:
    print(f'{x} is an evil king')
else:
    print(f'We cannot infer that {x} is an evil king')
```

```
C:\Users\howar>kings.py
What is the name of the
person? Sebastian
Is Sebastian a king? yes
Is Sebastian greedy? yes
Sebastian is an evil king
```

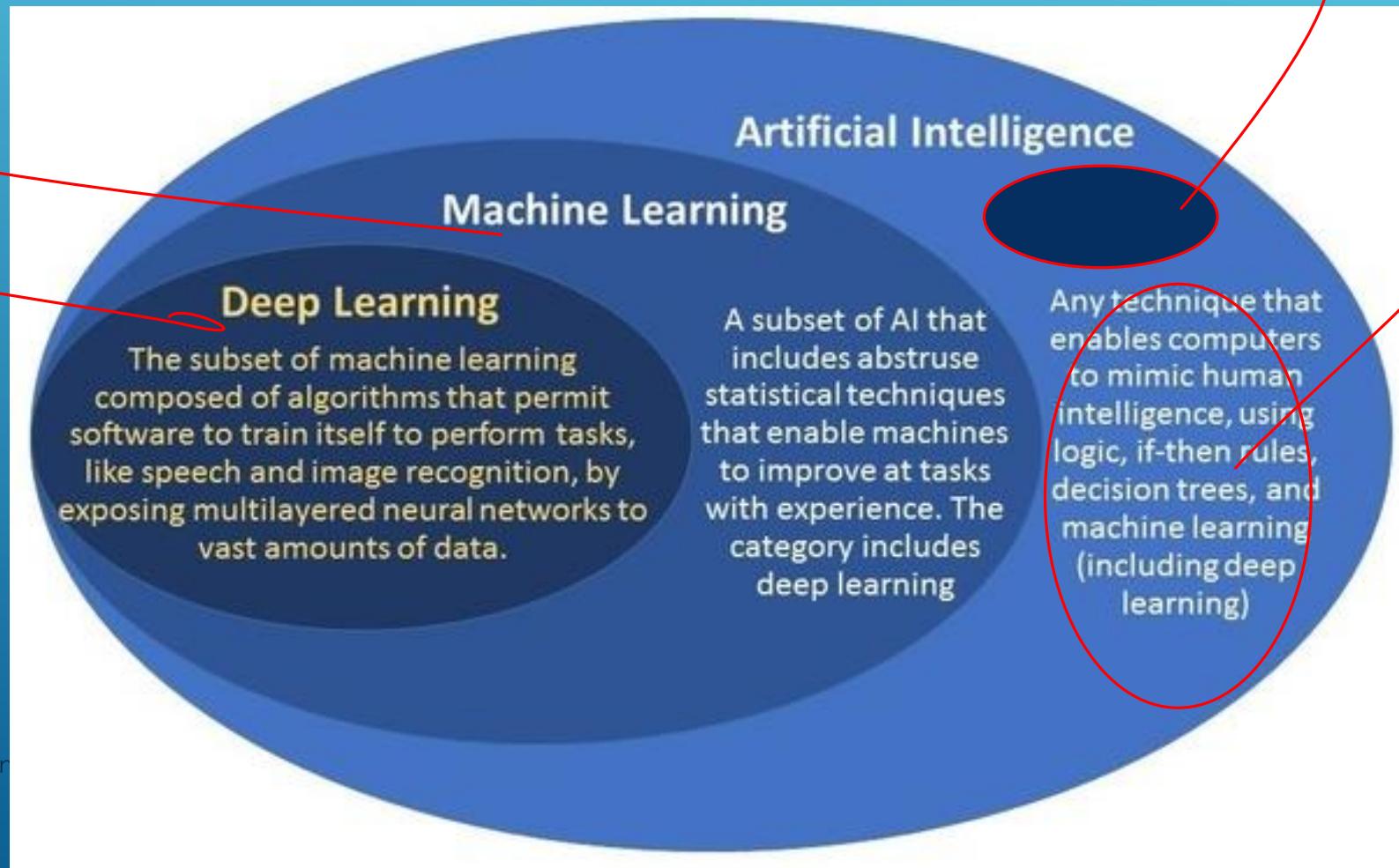
## Quiz – question 4

Where are Neural Networks in the diagram below?  
Where is Symbolic (GOFAI) in the diagram below?



# Neural networks

## Symbolic AI



# LEARNING OBJECTIVES

- ▶ 1. Real understanding of what AI is:
- ▶ 1a. Deep Learning and Reinforcement Learning
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- ▶ 5. Discussion

WE HAVE COVERED :

-DEEP LEARNING (**NEURAL** NETWORKS AI)  
ASSOCIATIONS, RECOGNITION (IMAGES, SPEECH, ETC....)  
*BIG SUCCESSES!!*

-**SYMBOLIC** AI

LOGIC

*BIG FAILURES!! EG, EXPERT SYSTEMS -> AI WINTERS!!*

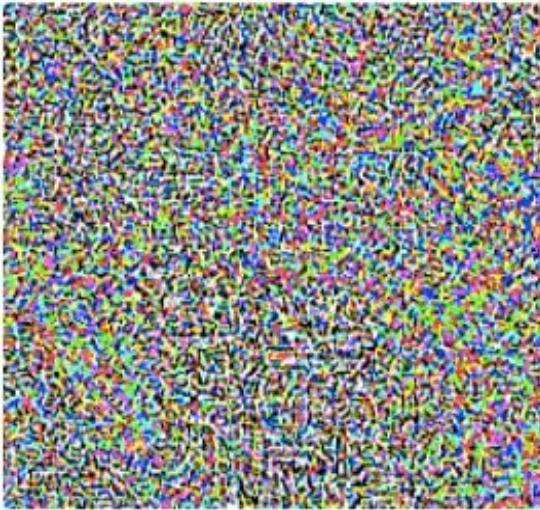
# The Neural Symbolic Gap



- **Neural Network** – phenomenal image processing and reinforcement learning
- **Child** – phenomenal causal symbolic learning with 134 few examples (eg, Gopnik)



+



=

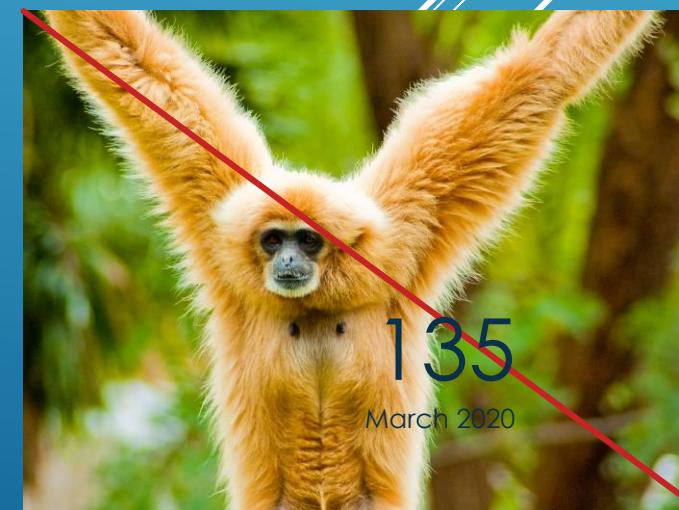


**“panda”  
57.7% confidence**

**“gibbon”  
99.3 % confidence**

Goodfellow,I.J., Shlens,J. and Szegedy,C. (Google Mountainview), Explaining and Harnessing Adversarial Examples, ICLR 2015.

It's still a Panda – and the 3 year old boy would know this!!  
(and.... 3 year old only needs 1 or 2 photos for training, not 1000s)





## Deep Learning Neural Network

Pattern Recognition  
→Recognize the World

Need 1000's examples for learning

## 3 Year Old Human Child

Model Building +also Pattern Recognition  
→Explain the World

A few examples enough

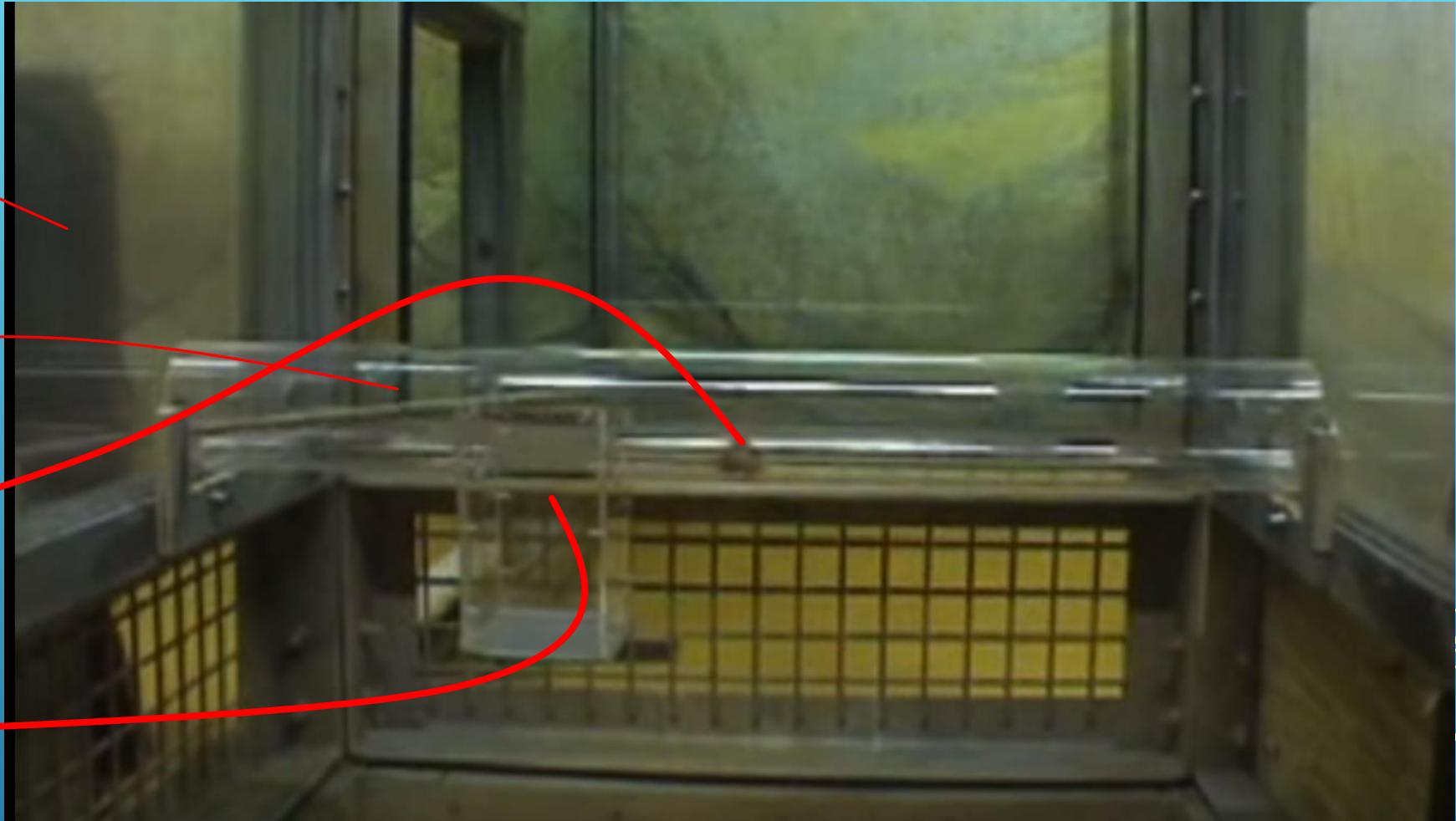
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Chimpanzee (behind plexiglass)

Stick to push or pull food

Food

Gravity trap



Chimpanzees **do not** have full causality

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Deep Learning has zero Understanding  
**Deep Learning gets more powerful by brute force**

Compute for Deep Learning has been doubling q3 months

300,000x increase in computing power the last few years

NOT SUSTAINABLE -- There is a deep flaw in deep learning

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Humans have causality.

Animals do not. ← associations

Deep Learning does not. ← associations

**Humans** (me😊) learn to drive with 5 hours of driving in a driver's ed course. I do not need to be programmed with every possible scene on the road – I can figure it out (eg, bag on road).

**Deep Learning autonomous driving system** – must get training data showing \*everything\* since **it cannot causally reason**

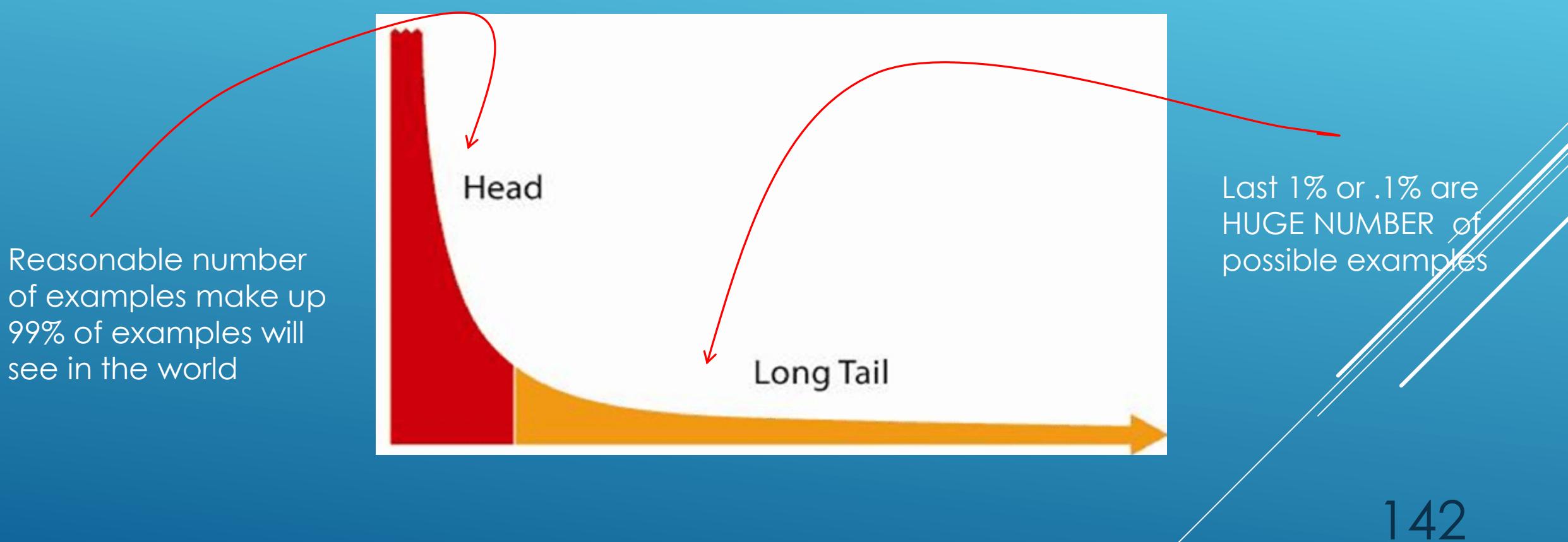
Eg, Tesla has about a billion miles of driving experience of its cars as training data now.

Classic example: unless explicitly programmed, an autonomous driving system will follow road and drive off a cliff (because it understands nothing!!)

(programmers add symbolic rules to autonomous driving systems and probably this one has been added already)



# Without causality need loads and loads of experience to see everything: ‘long-tail problem’



March 18, 2018 – Uber self driving car kills Elaine Herzberg in Tempe, Arizona

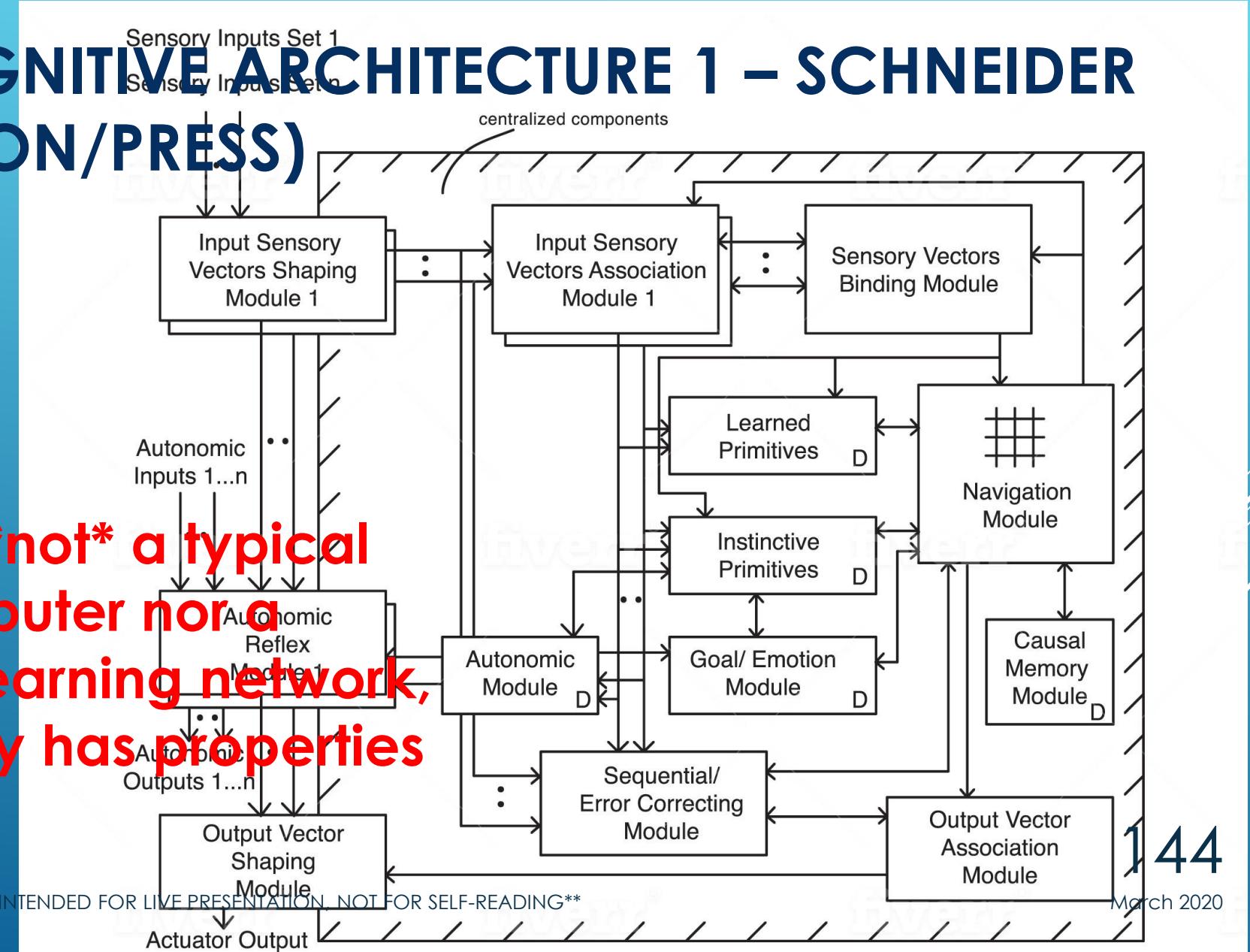
-Uber's system never had training with image of pedestrian pushing bike across the middle of the street  
-Volvo normal system: did detect (6secs) but ignored



G\*\*

# CAUSAL COGNITIVE ARCHITECTURE 1 – SCHNEIDER (IN SUBMISSION/PRESS)

System that is **\*not\*** a typical symbolic computer nor a typical deep learning network, but intrinsically has properties of both



# Organizations Focused on Developing AGI



Musk, Altman, MS \$1B



Fei-Fei Li (ImageNet)



1000+, Google



Ben Goertzel, AGI Conf

# LEARNING OBJECTIVES

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- ▶ 5. **Discussion**

# **THIS DECADE (MY OPINION)**

- OTHER FACTORS OF MORE IMPORTANCE, EG, GLOBALIZATION, COVID-19, ETC**
- IMPROVEMENTS IN OFFICE AUTOMATION AND FACTORY AUTOMATION (EVEN WITHOUT AI) WILL AFFECT JOBS (IN GOOD AND BAD WAYS)**
- DEEP LEARNING CAN SPEED THIS UP**

# MIT REPORT: “THE WORK OF THE FUTURE: SHAPING TECHNOLOGY AND INSTITUTIONS”

- "**SENSE OF POWERLESSNESS – WORRY...**" → MIT TASK FORCE
- TECHNOLOGY ADVANCES → RECORD LEVELS OF INEQUALITY,  
LOWER SOCIAL MOBILITY
- EVIDENCE – USA 500 WORKER FACTORIES NOT USING MANY  
ROBOTS BUT TROUBLE FINDING SPECIALIZED WORKERS
- “HYPE ABOUT ROBOTS HAVE FOCUSED OUR ATTENTION IN THE  
WRONG PLACE”**

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- HOWEVER, TECH USE IN **HIGH SKILL JOBS** MAKES THESE JOBS MORE PRODUCTIVE & PAYING VS **LOW SKILL JOBS**
  - MIDDLE SKILL JOBS** EASIER TO AUTOMATE & OFF-SHORE (NOT REALLY AI BUT JUST COMPUTER TECHNOLOGY)
  - MEN WITHOUT COLLEGE DEGREES, RURAL WORKERS, CERTAIN USA MINORITIES – AFFECTED MORE BY CHANGES
  - MOST OF REPORT'S SUGGESTIONS ON **FIXING IMBALANCE** BETWEEN WORKERS HELPED AND HURT BY NEW ECONOMY
- **NOT REALLY DUE TO AI AT THIS POINT**

# NEXT DECADE (MY OPINION)

- ONCE THE **NEURO-SYMBOLIC GAP IS SOLVED**, AI SYSTEMS SHOULD BE ABLE TO DO THE WORK ALMOST ANY WORKER CAN DO
- MASSIVE JOB SHIFTS AND REPLACEMENTS**, UNLIKE ANYTHING IN THE PAST
- TIME OF STRESS FOR OUR PATIENTS WITHOUT APPROPRIATE SOCIETY PROGRAMS IN PLACE

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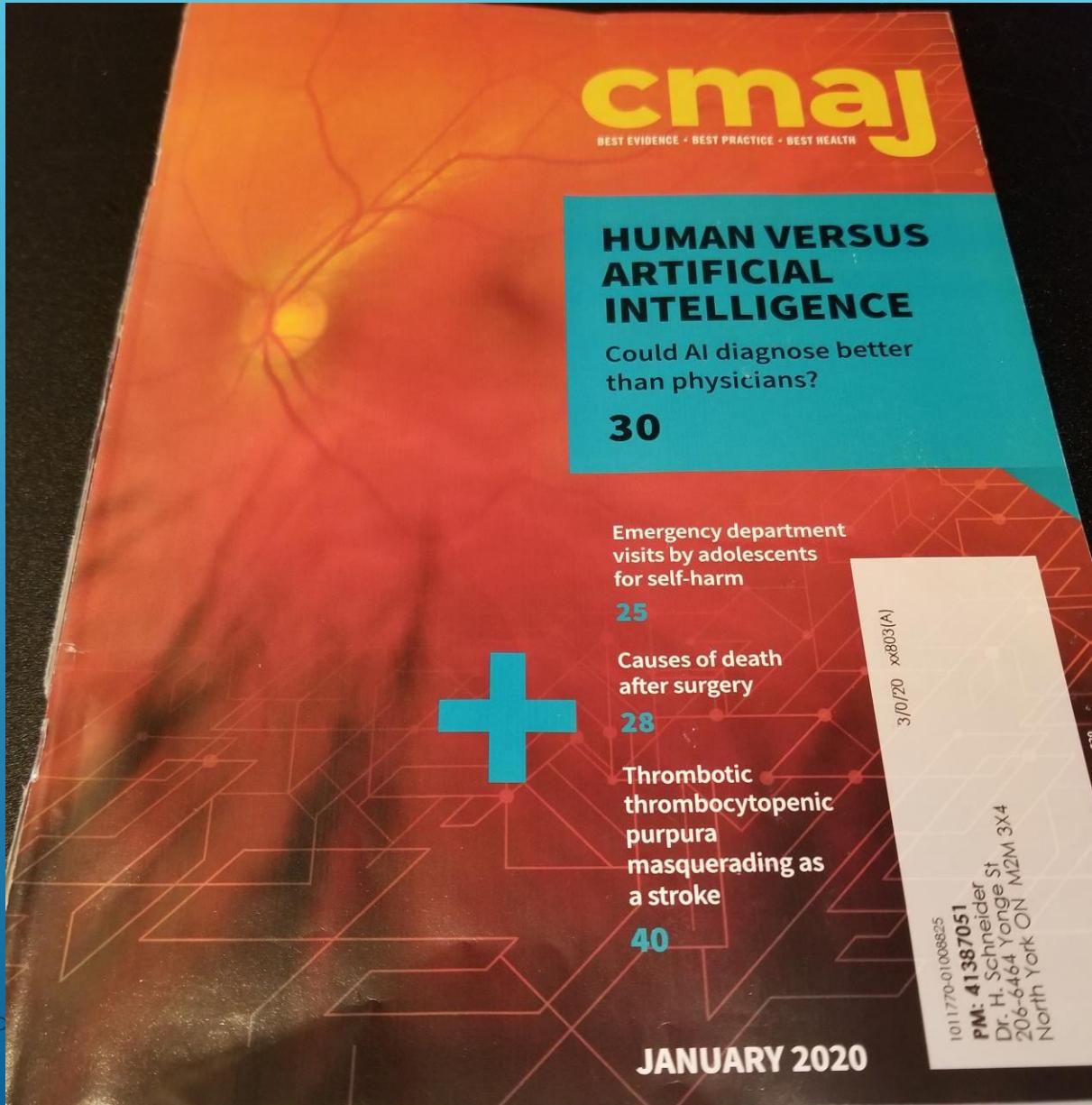
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- ▶ 5. Discussion

# MEDICAL AI SYSTEMS

- NO UNDERSTANDING OF WHAT THEY ARE DOING
- NO/POOR CAUSALITY
- THEY CAN'T EVEN EXPLAIN WHAT THEY ARE DOING

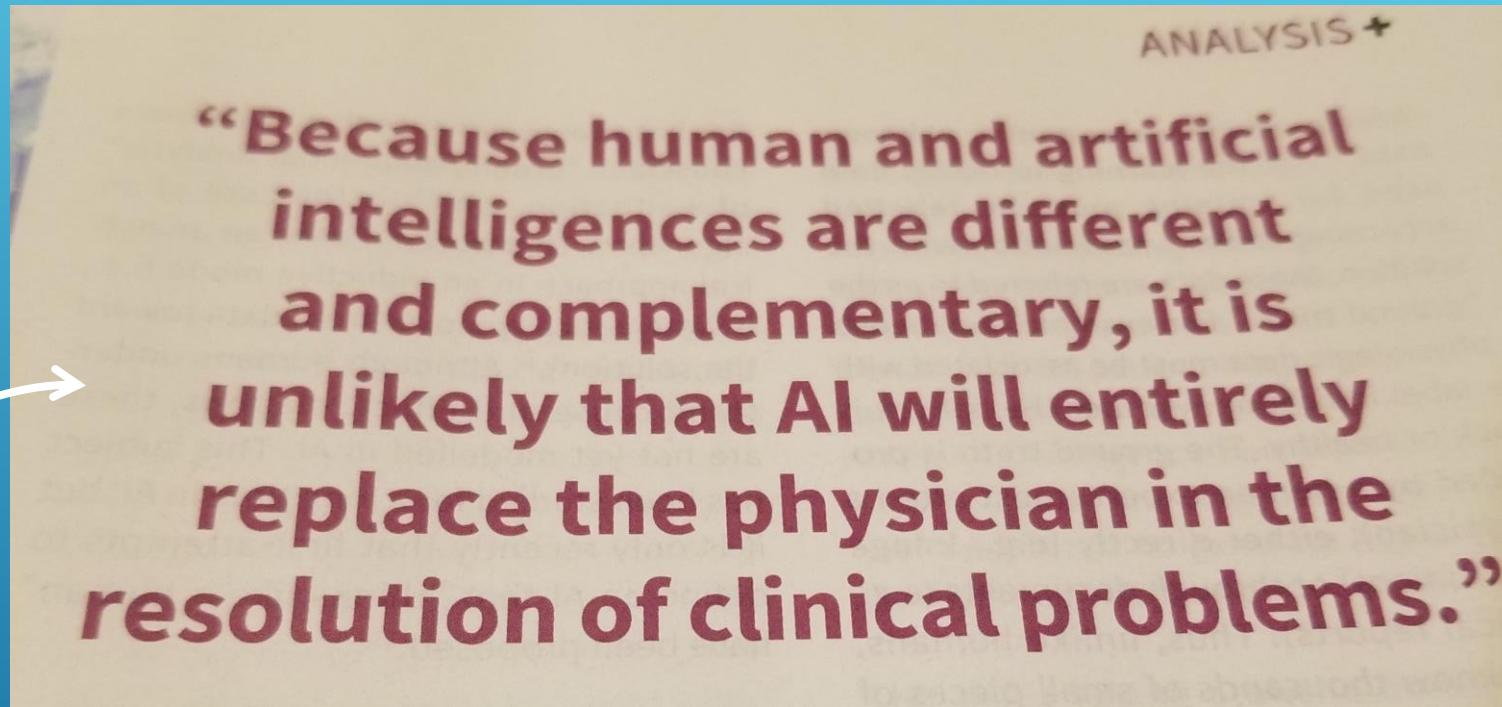
# COVER STORY OF JANUARY 2020 PRINT CMAJ



Dr Howard Schneider - Artificial

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March 2020

# THE ARTICLE TALKED ABOUT INTELLIGENCE IN HUMANS AND MACHINES IN VAGUE WAYS....



Current AI – Has no model of the world, and cannot perform causal reasoning. Instead functions as a massive association machine.

# DEEP LEARNING FOR RADIOLOGY (REQUIRES MILLIONS XRAYS AS TRAINING DATA)

- USEFUL 3AM IN ER
  - USEFUL SCREENING
  - BUT.... NO CAUSALITY
- CLINICAL CORRELATION**  
**DISEASE PROGRESSION**  
**TEAM COLLABORATION**

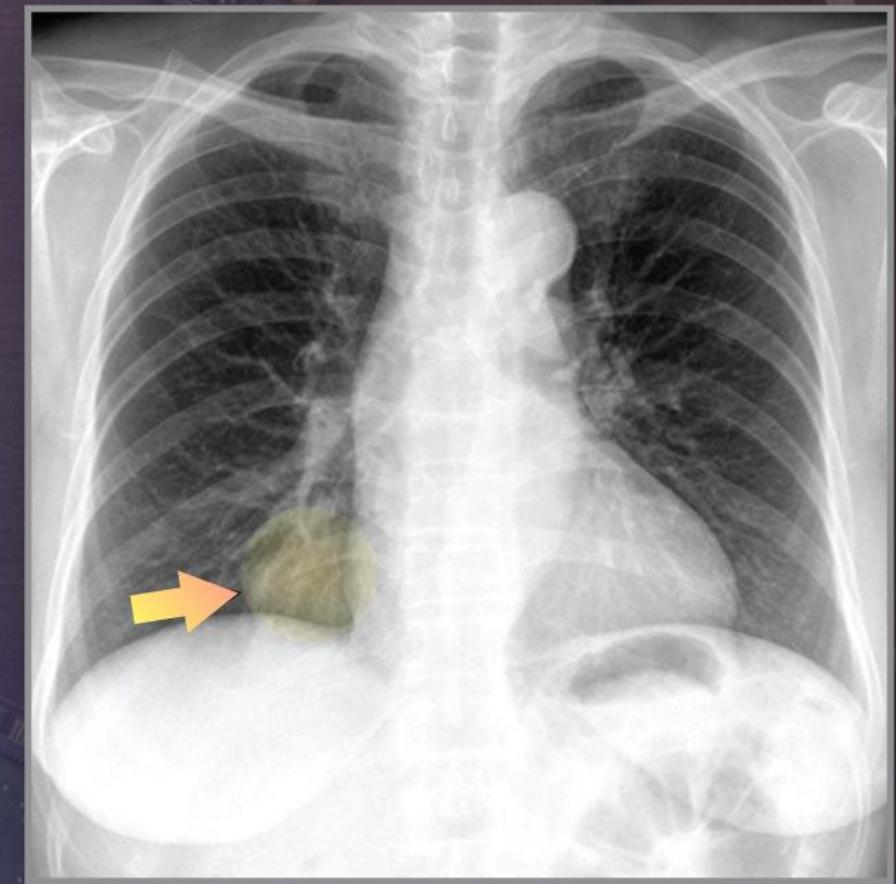
## Human vs Machine: Lung Tumor

Chest X-Rays image the lungs, heart, blood vessels, and bones. AI has been used to read and understand them.

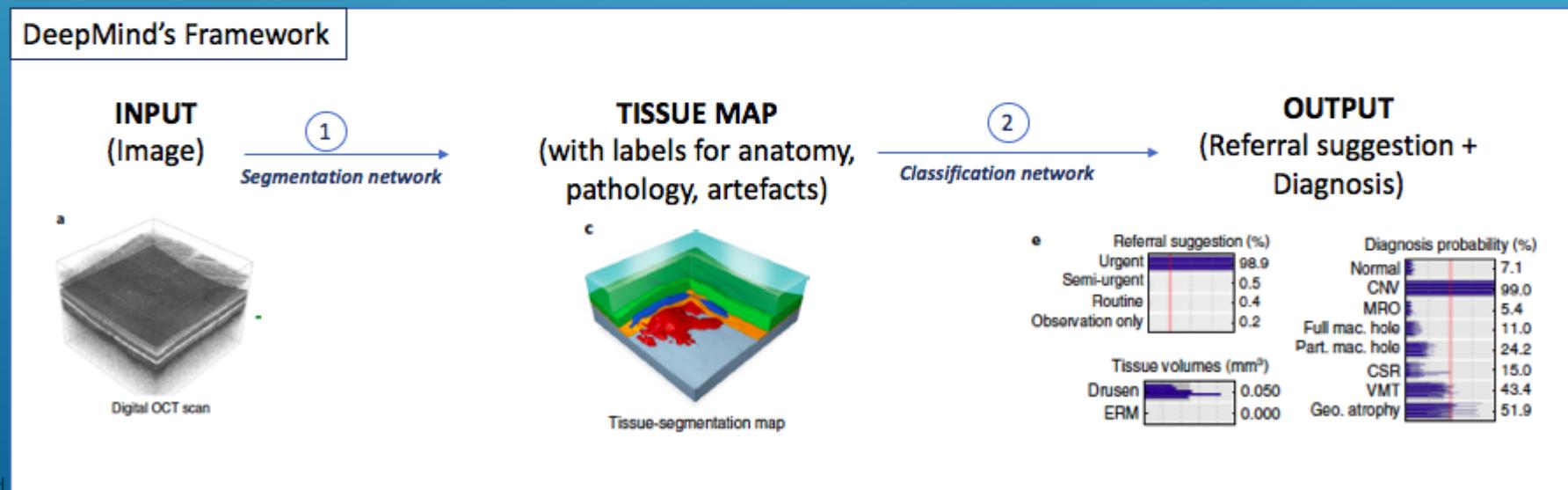
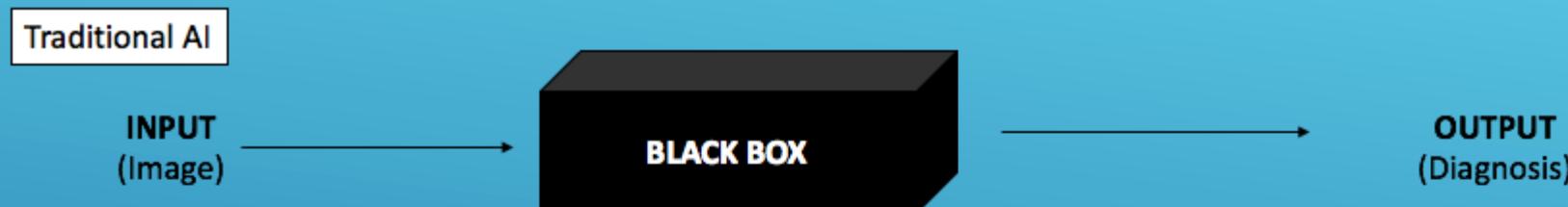
Example:  
**Lung Tumor**

**Computers:**  
**Score: 0.291**

**Doctors:**  
**2/15 Detected**



# DEEPMIND RETINAL SCANS DIAGNOSIS



# A DEEP LEARNING APPROACH TO ANTIBIOTIC DISCOVERY – STOKES ET AL (MIT), CELL 2020

- TRAINED A **DEEP NEURAL NETWORK** CAPABLE OF PREDICTING MOLECULES WITH ANTIBACTERIAL ACTIVITY
- PREDICTIONS ON MULTIPLE **CHEMICAL LIBRARIES**
- DISCOVERED A **MOLECULE**—HALICIN—THAT IS STRUCTURALLY DIVERGENT FROM CONVENTIONAL ANTIBIOTICS AND DISPLAYS BACTERICIDAL ACTIVITY

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# Artificial Intelligence in Medicine

Volume 103, March 2020, 101785

The impact of machine learning on patient care: A systematic review

Ben-Israel and colleagues - Neurosurgery, University of Calgary

*“Despite the expanding use of machine learning (ML) in fields such as finance and marketing, its application in the daily practice of clinical medicine is almost non-existent.”*

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Dr Sidney Kennedy, University of Toronto

Machine Learning to identify early predictors  
of relapse, and increased risk of suicidal  
behaviour.

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# Brain activity can help predict who'll benefit from an antidepressant

Amit Etkin, Stanford University



# AI Therapists

- OFFERS PROMISE OF THERAPY FOR ALL AT LOW COST
- ONLINE CBT
- CHATBOTS: "SIRI, I FEEL DEPRESSED"
- CHATBOTS, EG, WOEBOT



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# Computer-Assisted CBT ('CCBT') for Depression

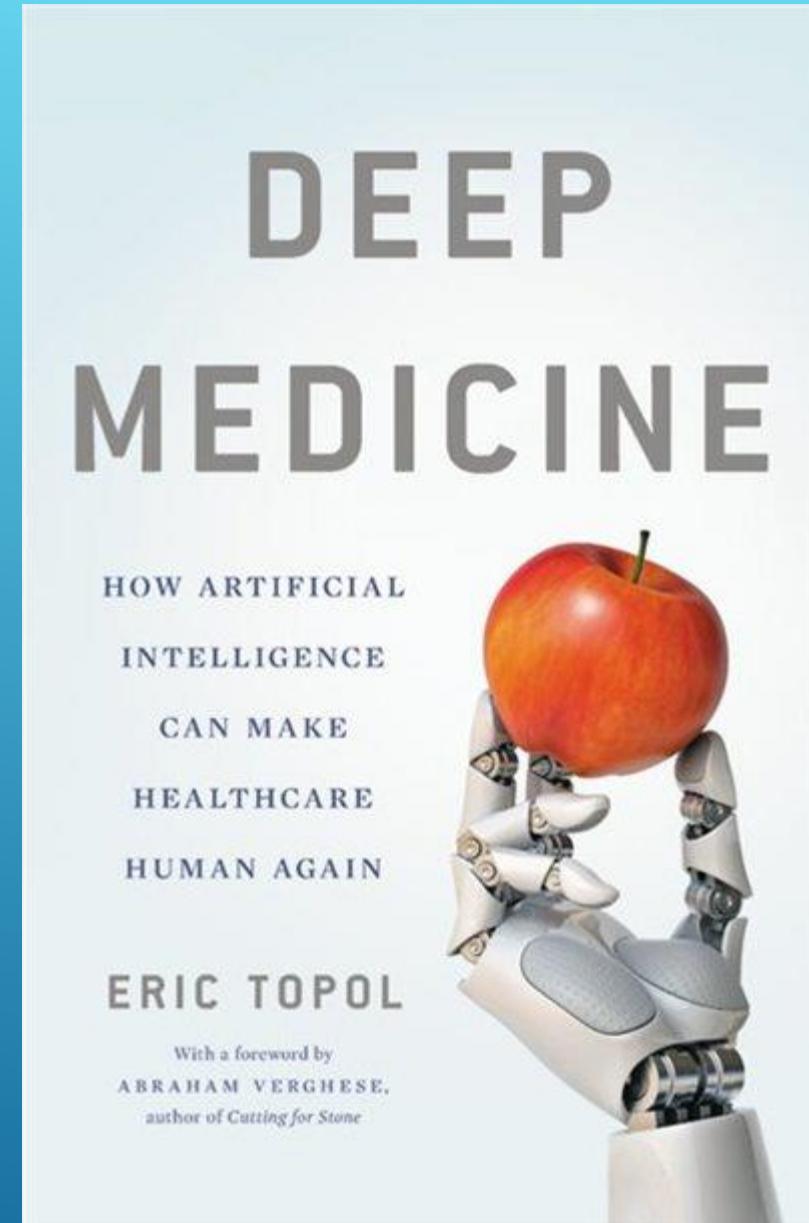
- JESSE WRIGHT ET AL, 2019, J CLIN PSYCHIATRY
- META-ANALYSIS 40 RCT STUDIES CCBT FOR DEPRESSION
- CCBT WITH MODEST SUPPORT FROM CLINICIAN EFFECTIVE
- CCBT FULLY SELF-GUIDED MUCH LESS EFFECTIVE  
(TYPES, AMOUNT AI IN CCBT STUDIED??)

→ AT THIS POINT IN TIME AI **CANNOT**  
REPLACE DOCTORS -- **NOT TECHNICALLY**  
**POSSIBLE**

-**BETTER SOFTWARE** CAN IN THEORY **REDUCE** HEALTH  
CARE **STAFF** HOWEVER, AND DEEP LEARNING CAN  
SPEED THIS UP (DEPENDS ON FIELD)

# DR ERIC TOPOL

- CARDIOLOGIST
- SCRIPPS, LA JOLLA
- DEVELOPED T-PA,  
ANTI-CLOT MEDS
- PROPOONENT OF  
AI IN MEDICINE



# LEARNING OBJECTIVES

- ▶ 1. Real understanding of what AI is:
- ▶ 1a. Deep Learning and Reinforcement Learning
- ▶ 1b. Field of Artificial Intelligence (AI)
- ▶ 1c. Neuro-Symbolic Gap
- ▶ 2. How will AI in next decade (or two) affect my patients' lives?
- ▶ 3. How will AI affect my practice of medicine including psychotherapy?
- ▶ 3a. How is AI affecting medicine at present?
- ▶ **3b. How will AI affect medicine in the next decade?**
- ▶ 4. How will AI affect the future of mankind?
- ▶ 5. Discussion

# NEXT DECADE (MY OPINION)

- ONCE THE **NEURO-SYMBOLIC GAP IS SOLVED**, AI SYSTEMS SHOULD BE ABLE TO DO THE WORK ALMOST ANY HEALTHCARE WORKER CAN DO
- HUMANS PROVIDE EMPATHIC & **EXISTENTIAL LIAISON** TO AI HEALTH SYSTEMS (**THUS KEY FOR PSYCHOTHERAPY**)
- HUMANS PROVIDE **OVERSIGHT** (FOR A WHILE....) OF AI HEALTH SYSTEMS

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# LEARNING OBJECTIVES

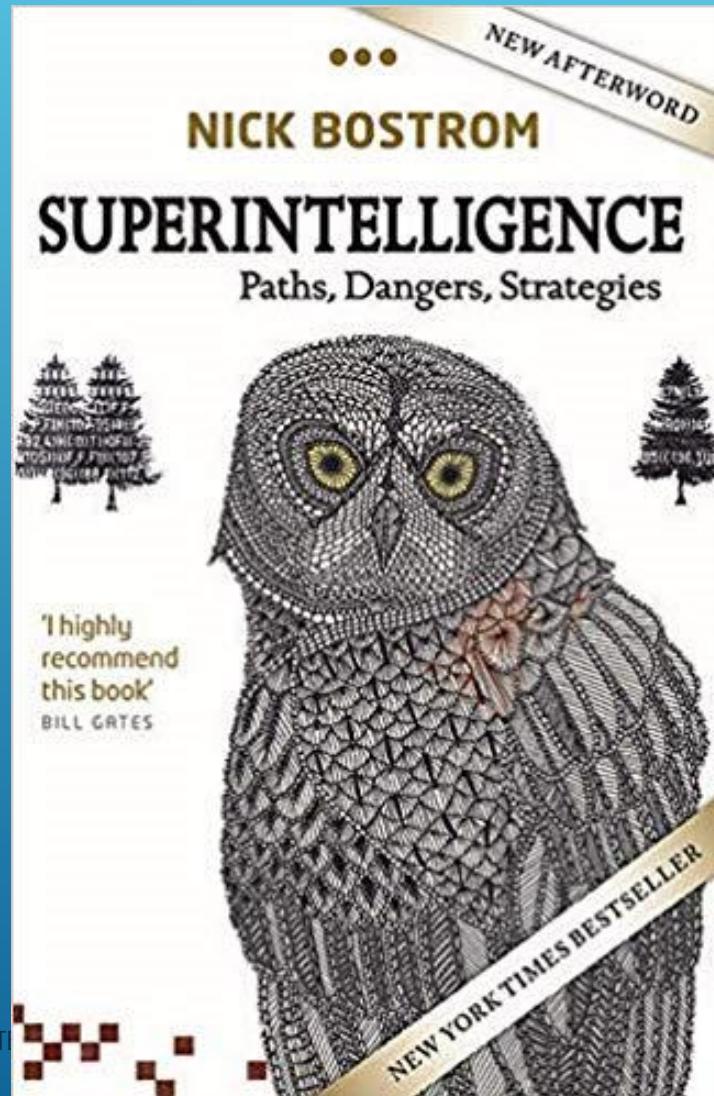
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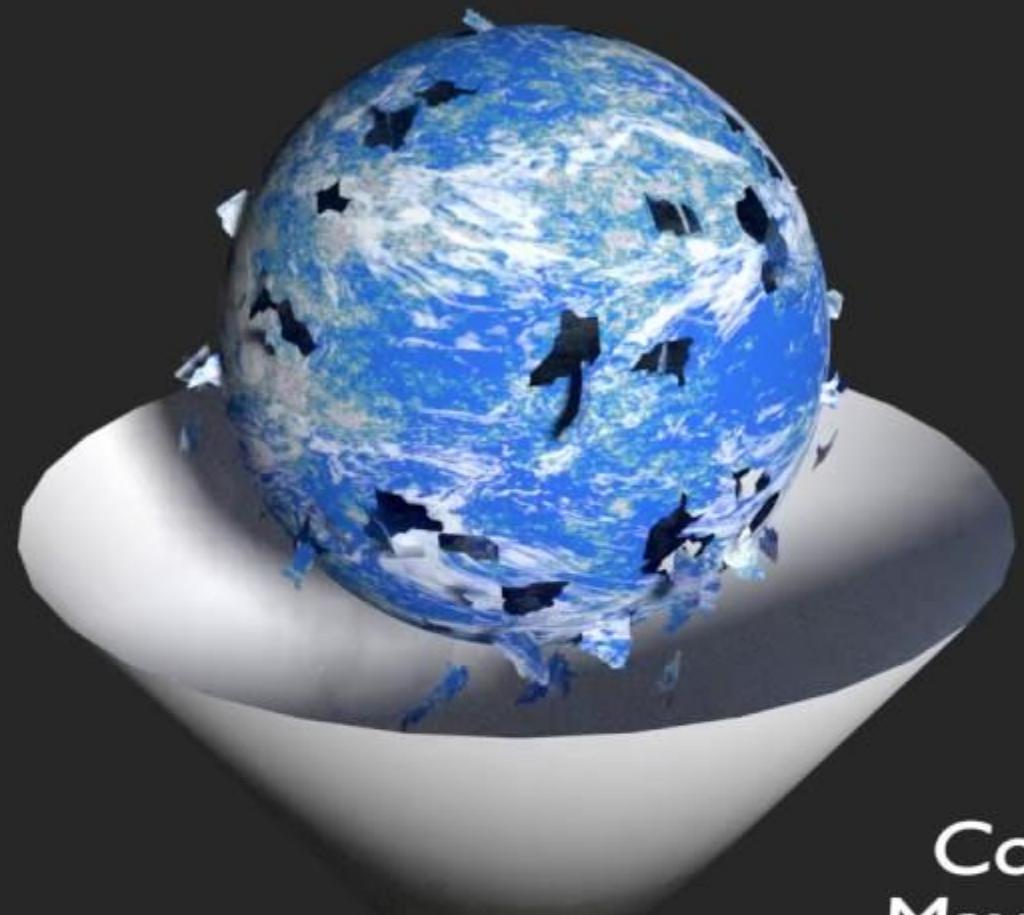
# DEEP LEARNING ALL AROUND US NOW: LONDON POLICE SURVEILLANCE CAMERAS WITH FACIAL RECOGNITION

## PSYCHOLOGY OF CONSTANT SURVEILLANCE??



# Bostrom – SuperIntelligence



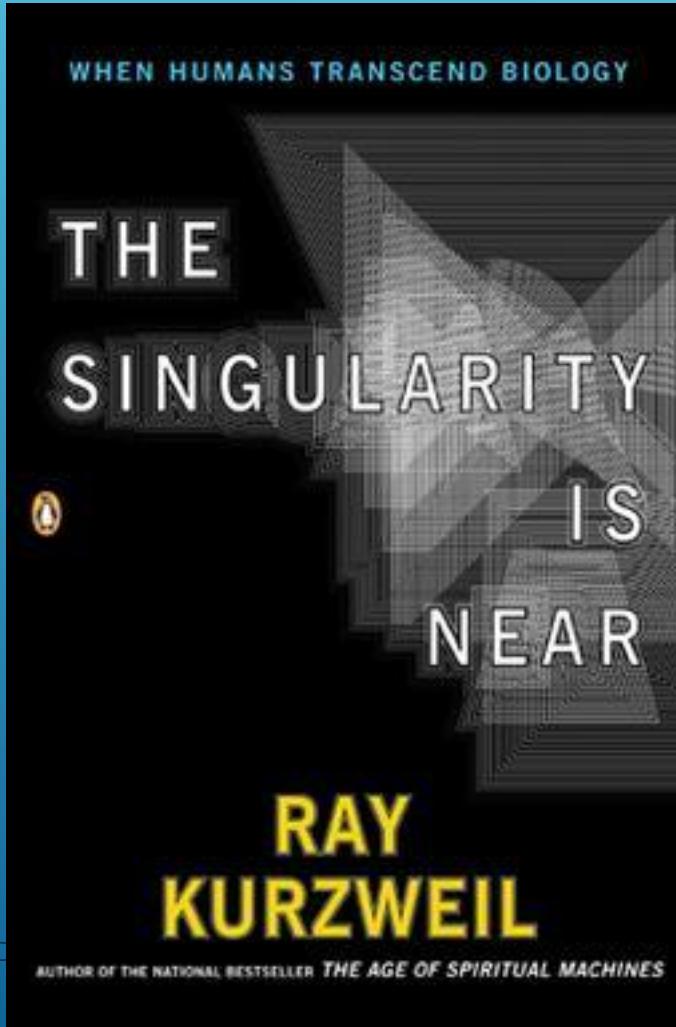


*Could an AI Paperclip  
Maximizer machine turn  
the earth into paperclips?*

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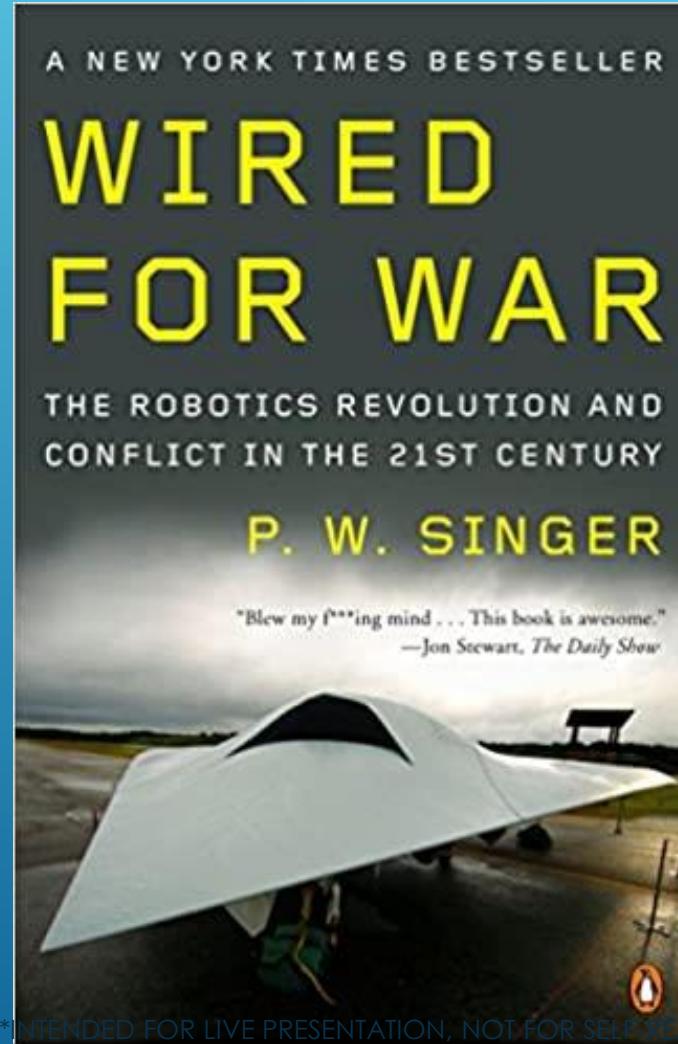
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# Kurzweil – AI Exceeding Human Intelligence and Merging with Humans

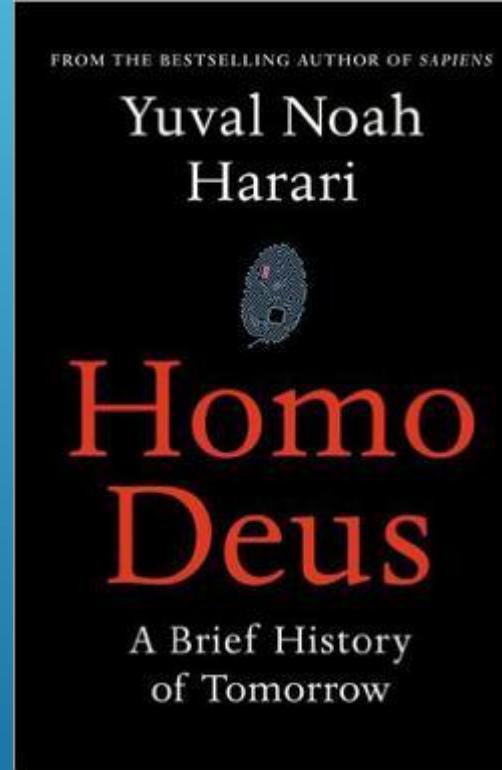
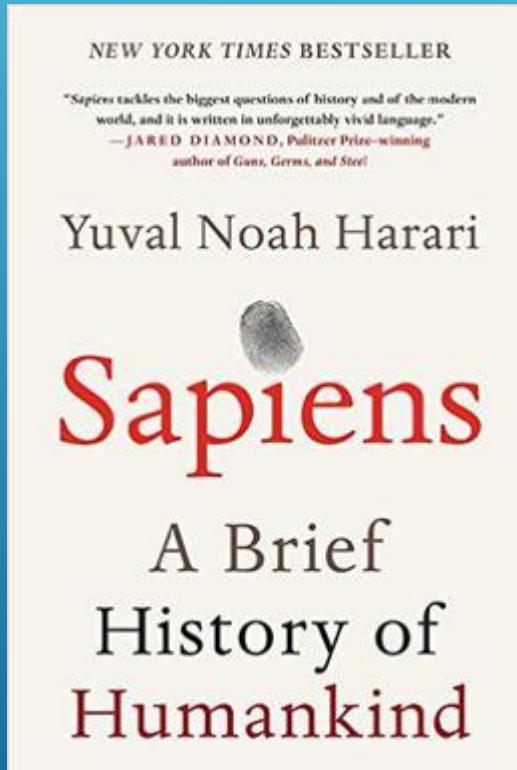




# SINGER'S 2009 BOOK – WIRED FOR WAR



- Continued technological powers.
- We lose meaning in our lives
- Replacement of H Sapiens with H Deus



## RIGHT NOW

- AI (= DEEP LEARNING) IS A PHENOMENAL COMPUTER SCIENCE TECHNIQUE
- LIKELY TO **IMPROVE OUR LIVES**
- TERMINATOR NOT POSSIBLE

## FUTURE

- THAT'S ANOTHER STORY
- **AI SAFETY CONCERNS**

# OK.... WE'VE MADE IT....



# LEARNING OBJECTIVES

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# Artificial Intelligence and the Future of Medicine/Mankind

Thank You

howard.schneider@gmail.com