

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)



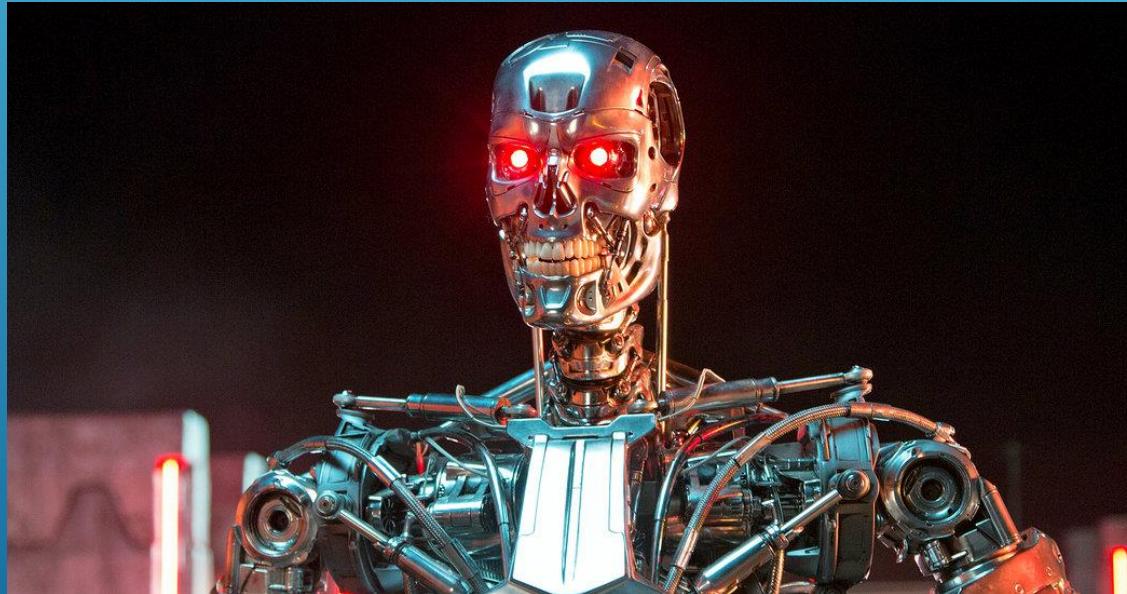
NOT REQUIRED.... BUT.....
CONSIDER MAKING NOTES IF THIS HELPS
YOU LEARN....



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**

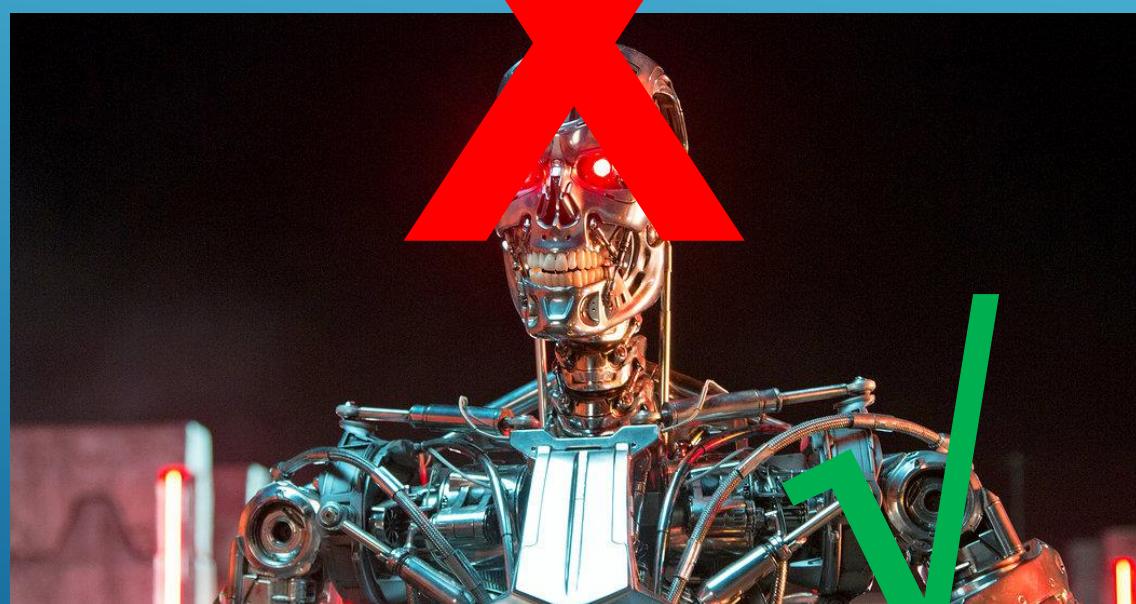
FORGET ABOUT CURRENT HYPE YOU SEE
ABOUT AI (ARTIFICIAL INTELLIGENCE) ALL
AROUND YOU IN THE MEDIA....



10

March 2020

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



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:
- ▶ **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

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

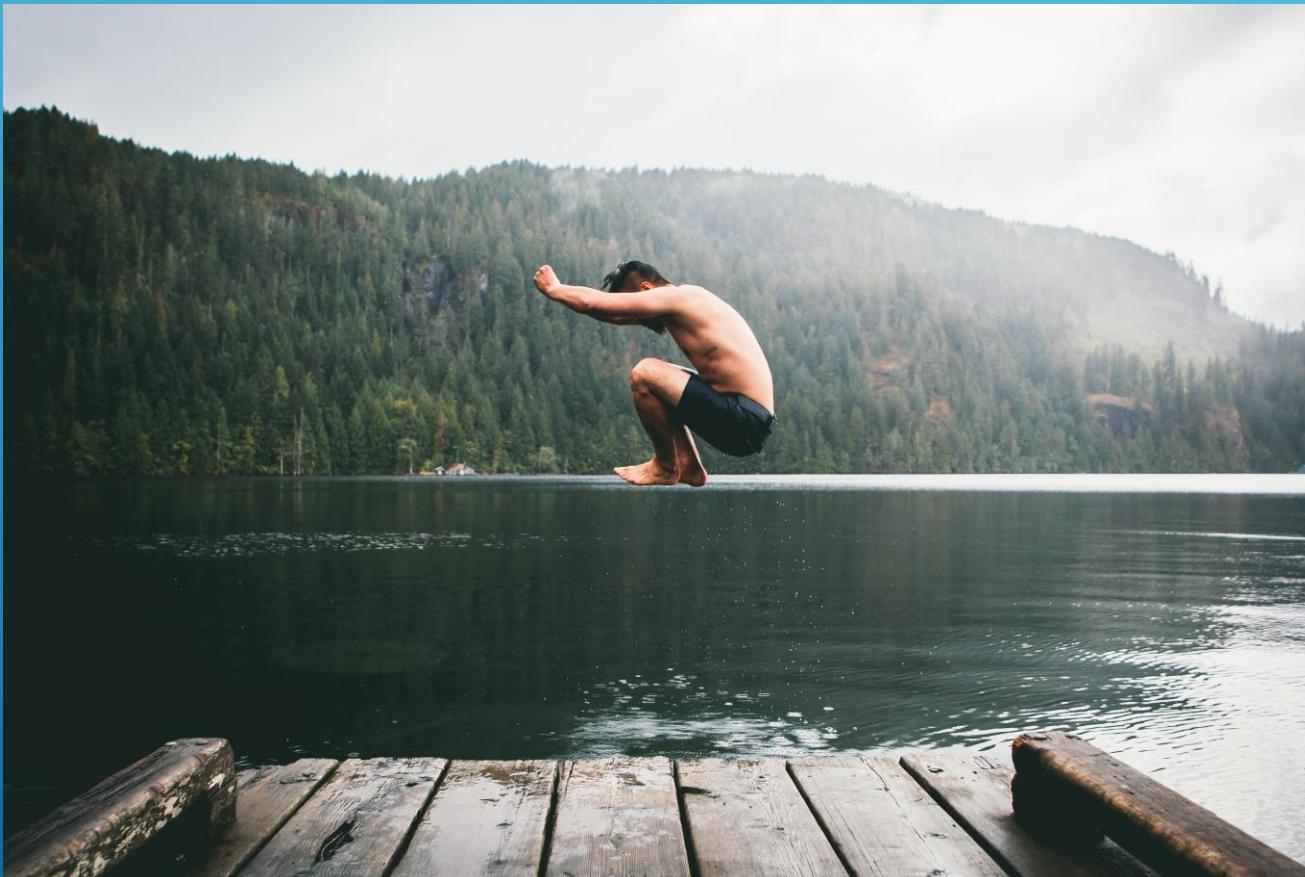
Of course, AI is much more than ‘Deep Learning’ – we’ll talk about that later.



← **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....**

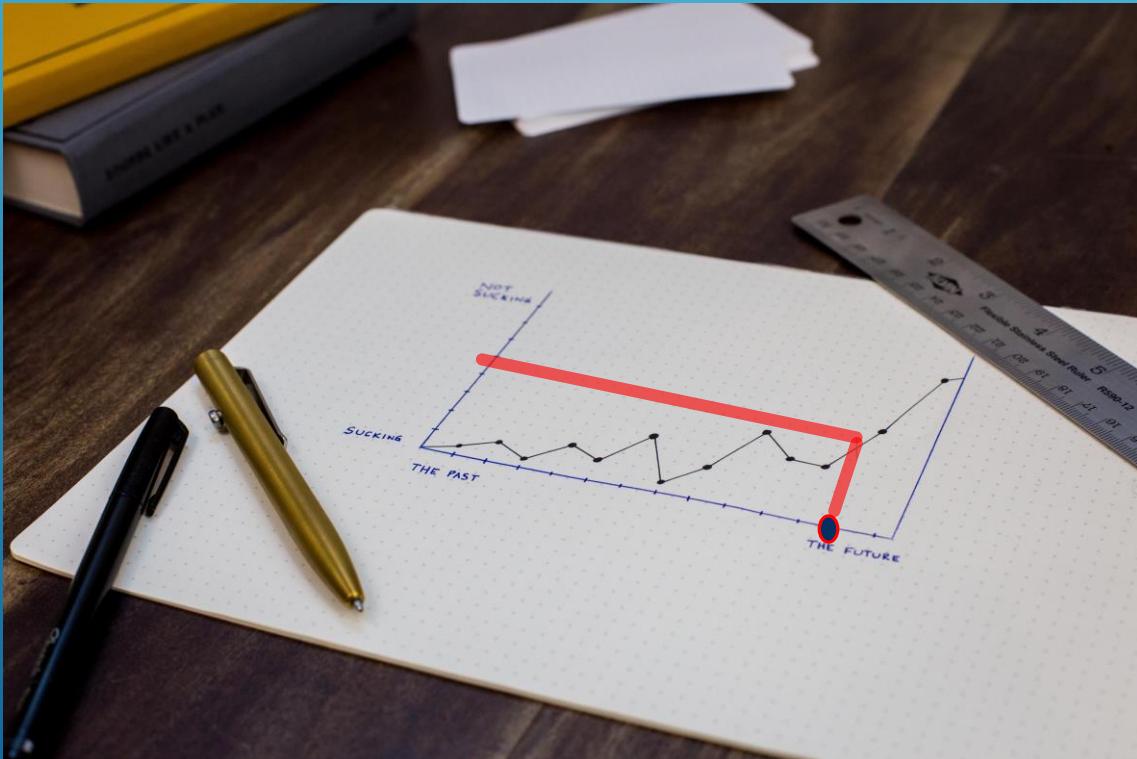


OK.... WHAT IS DEEP LEARNING?

19

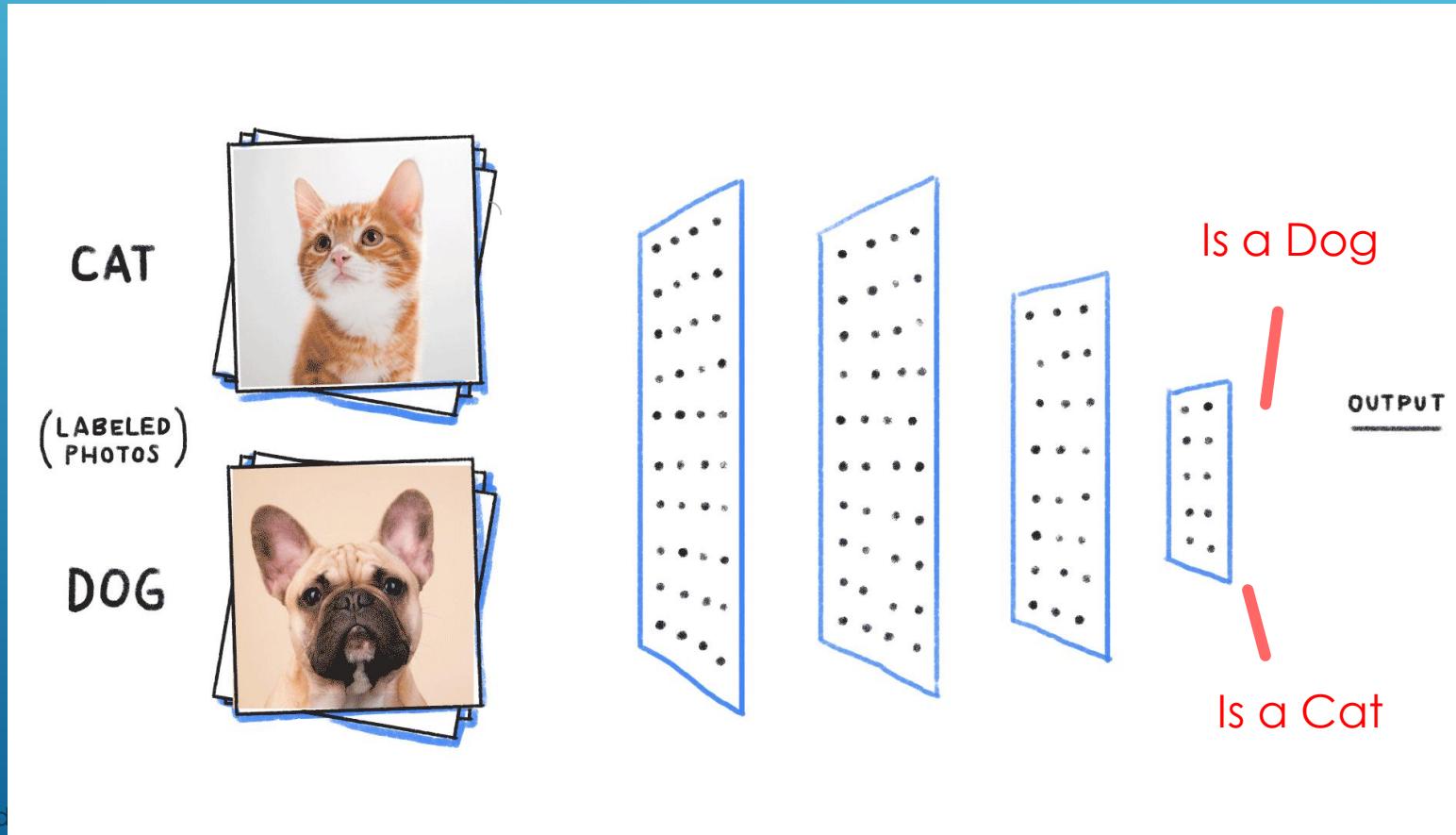
March 2020

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

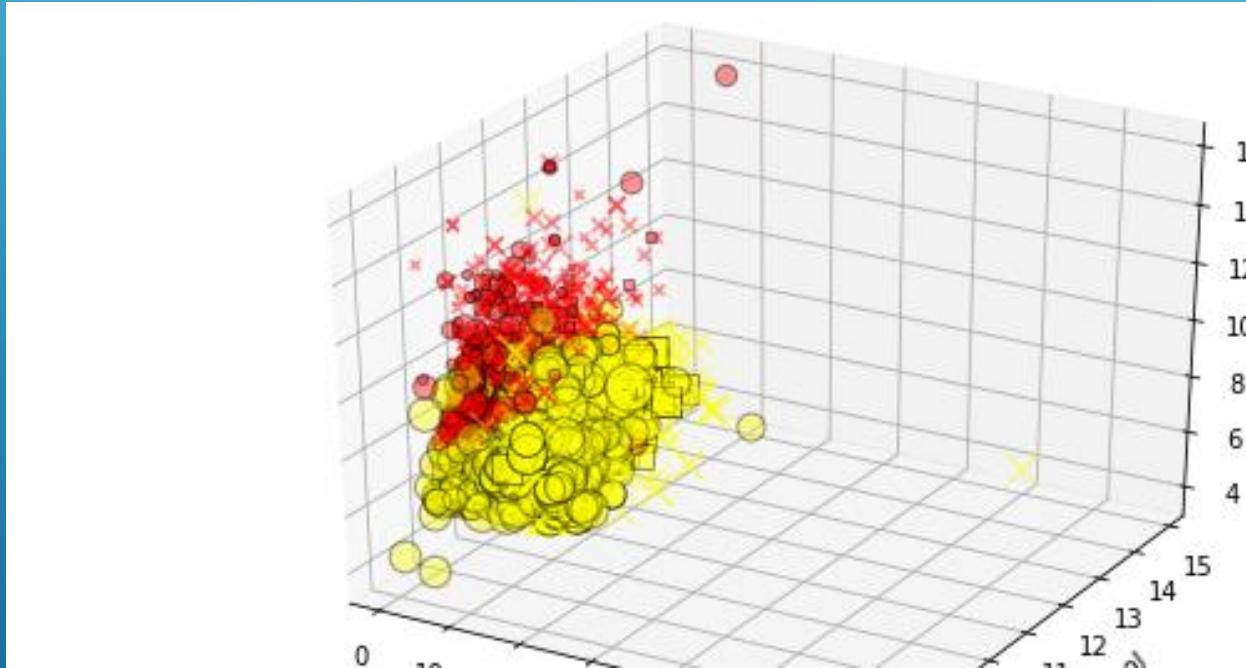


New X value never seen before, you can predict the Y value

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

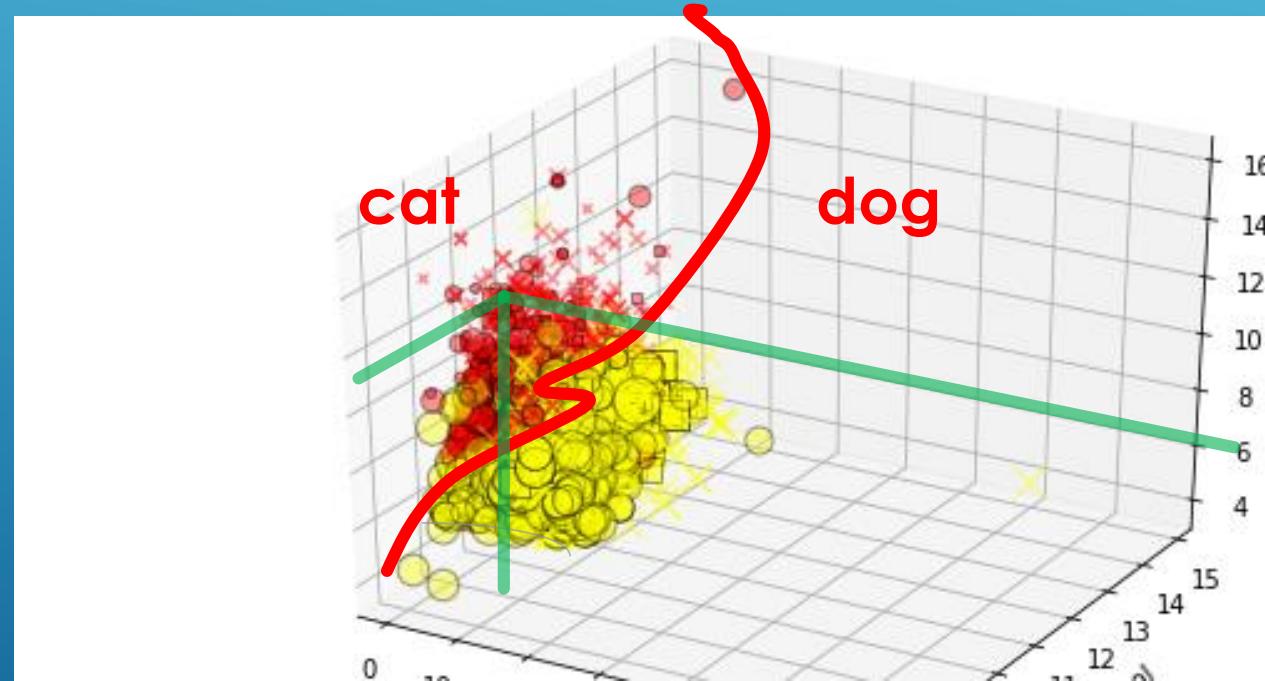


- CONSIDER DIFFERENT FEATURES OF DIFFERENT DOGS AND CATS
- PLOT THEM
- BELOW IS 3-D BUT MAYBE REALLY NEED 1000-D (OR 64,000 DIMENSIONS!!)



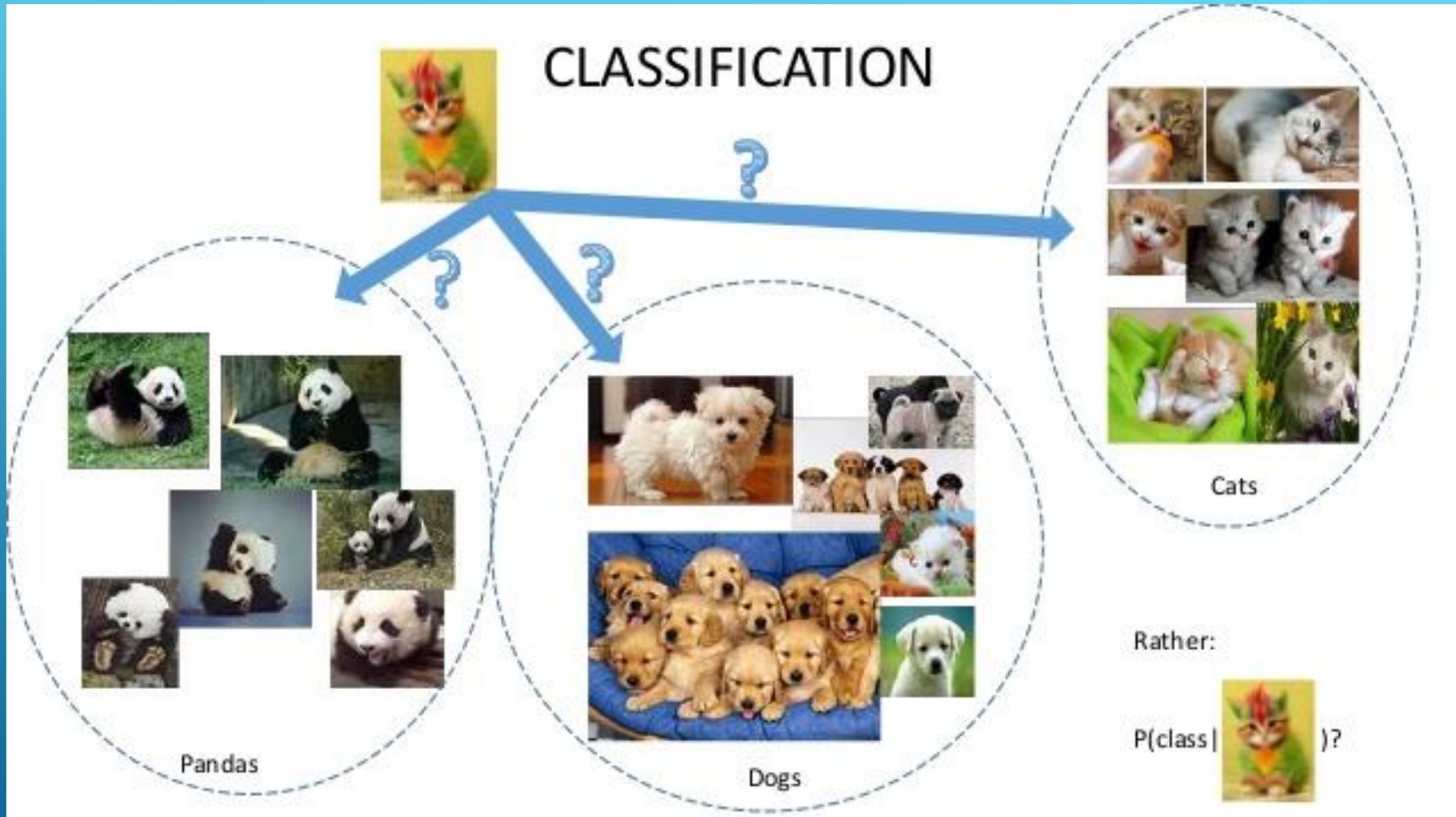
22

- CONSIDER DIFFERENT FEATURES OF DIFFERENT DOGS AND CATS
- PLOT THEM
- BELOW IS 3-D BUT MAYBE REALLY USE 1000-D

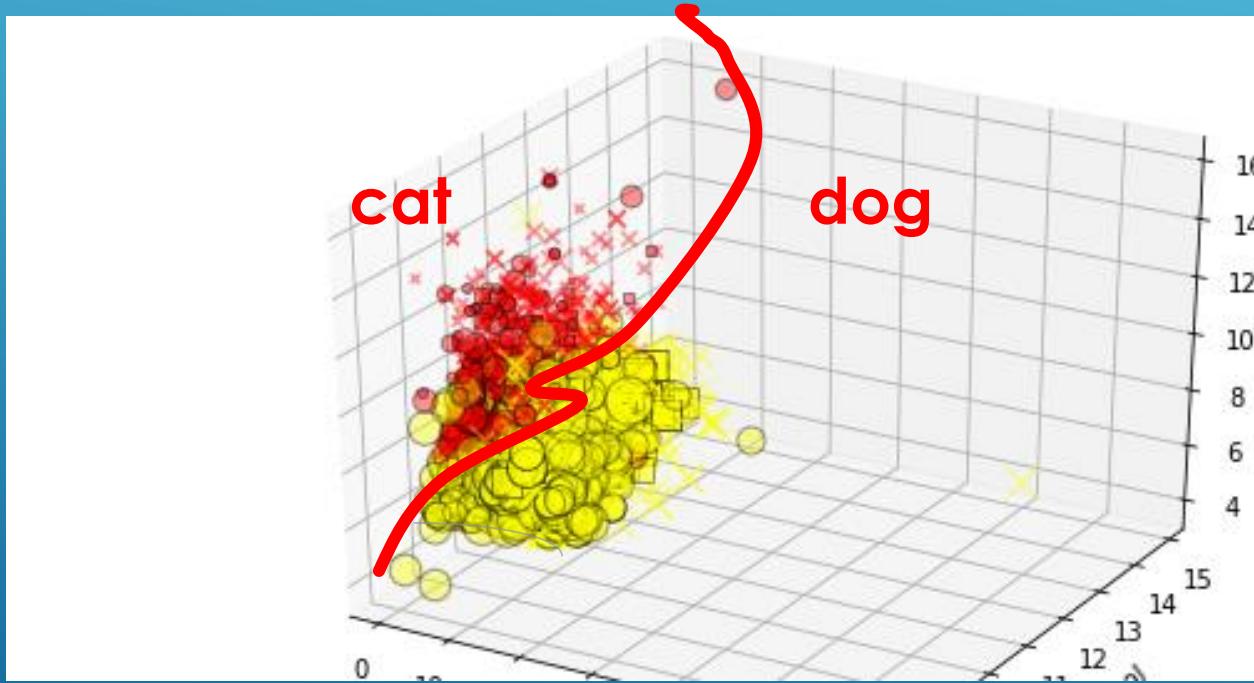


23

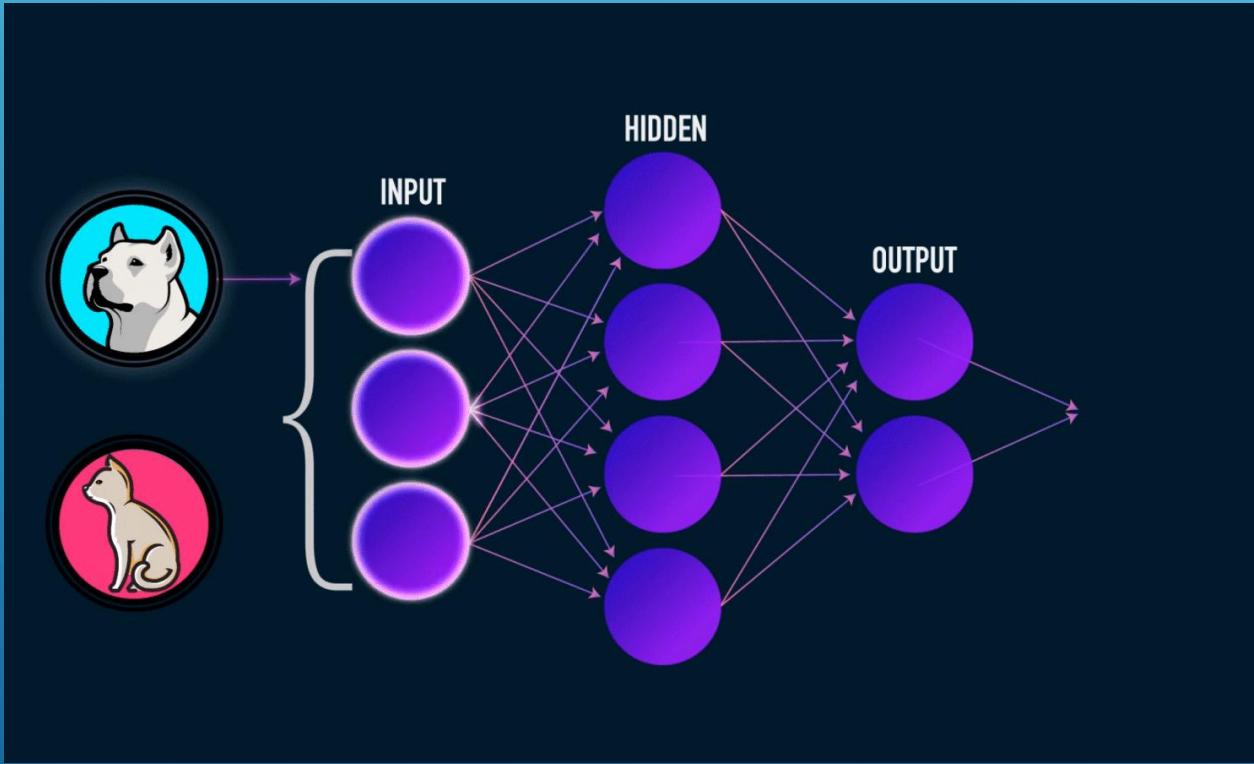
CLASSIFICATION



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

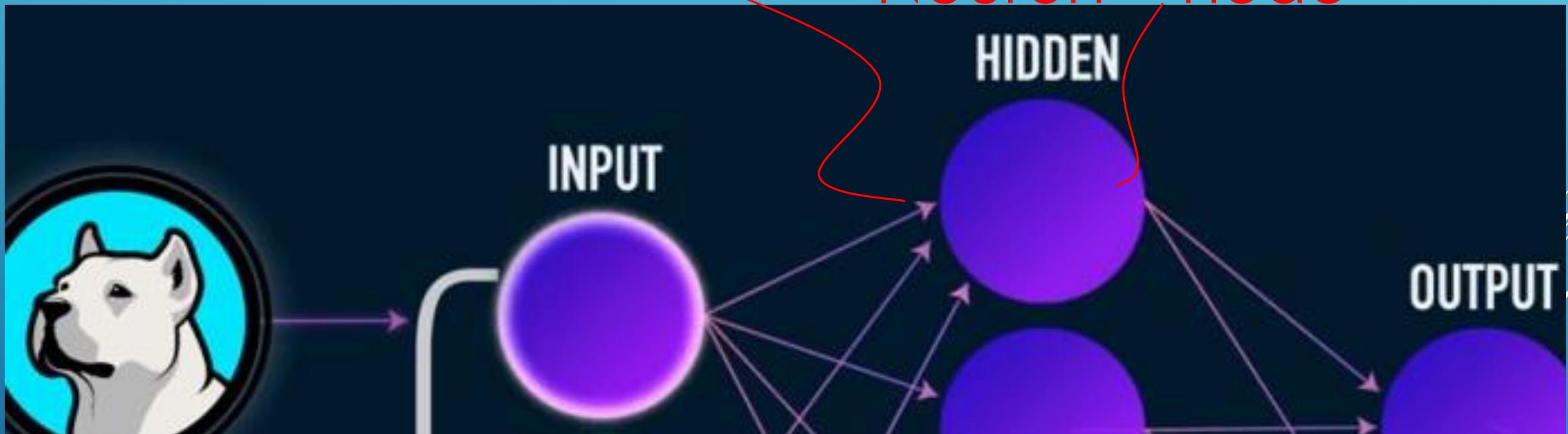


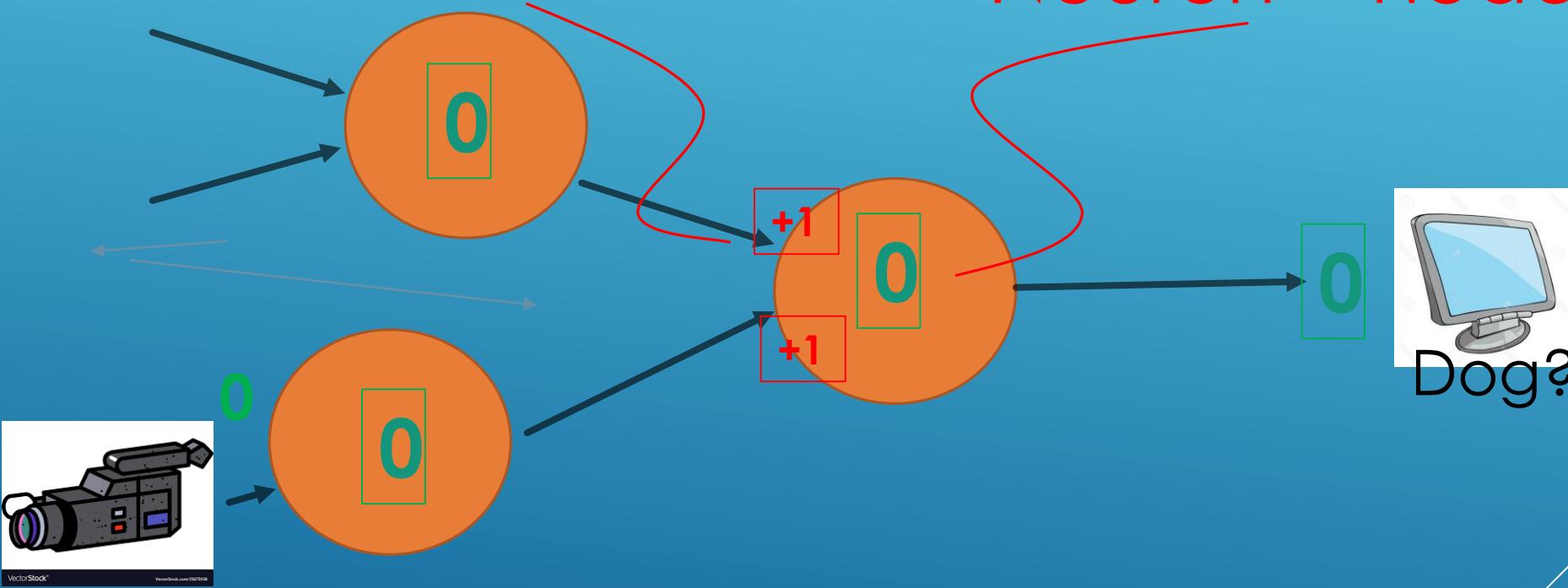
NEURAL NETWORK TO 'AUTOMATICALLY' LEARN TO TELL A DOG FROM A CAT



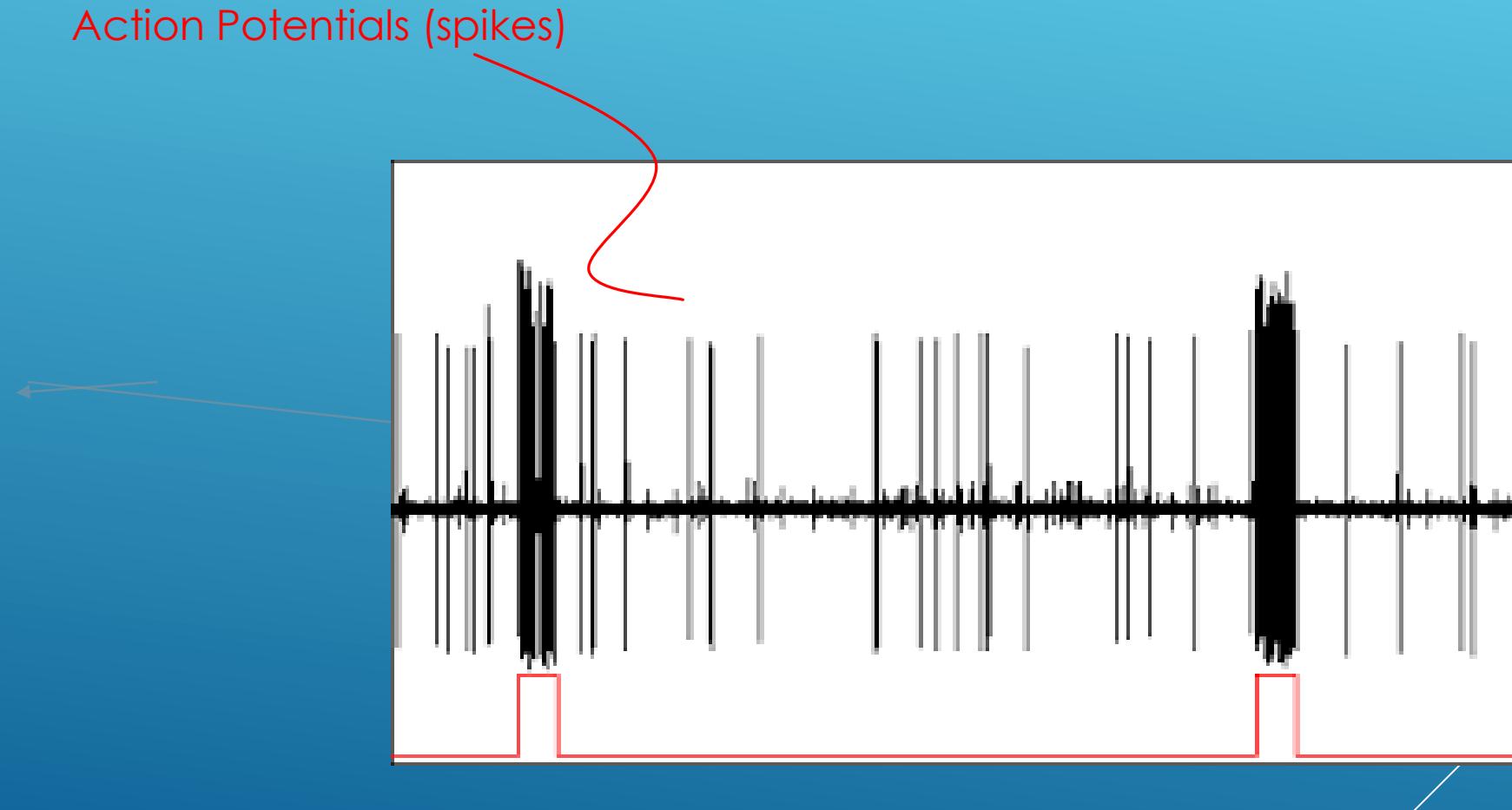
Synapse = weight

Neuron = node





Real Neural Networks

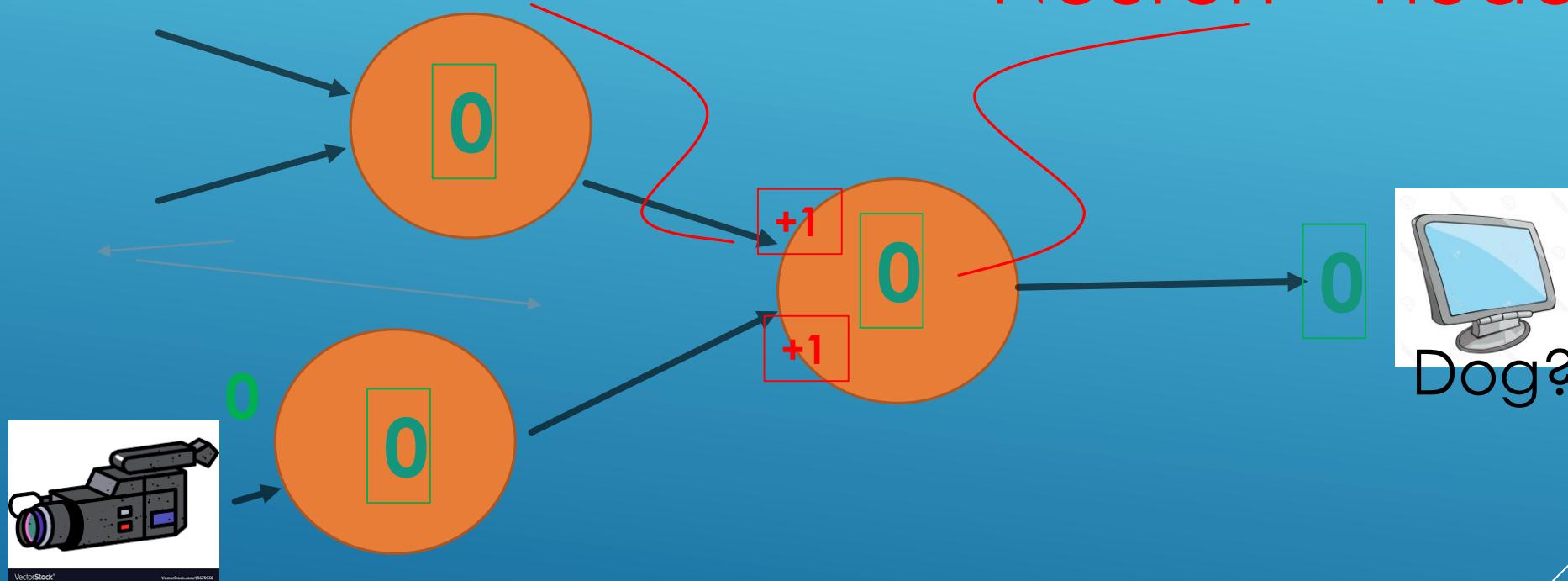


29

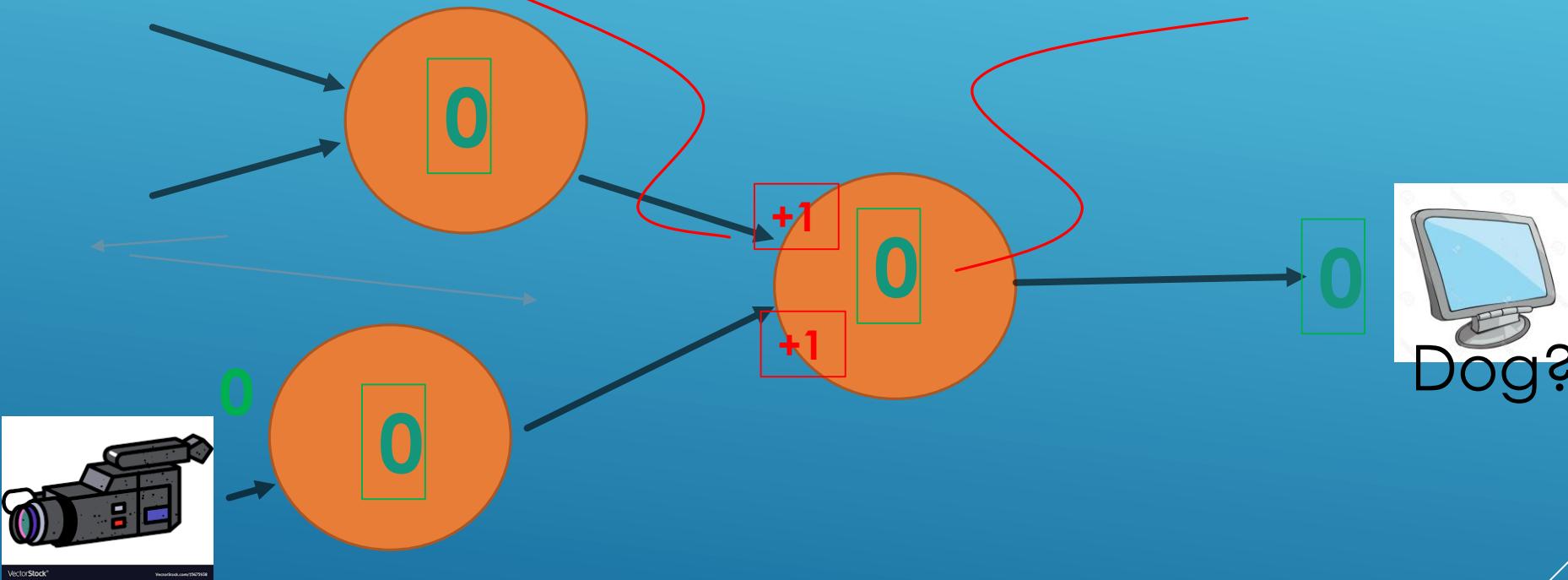
March 2020

“Artificial Neural Network” (ANN)

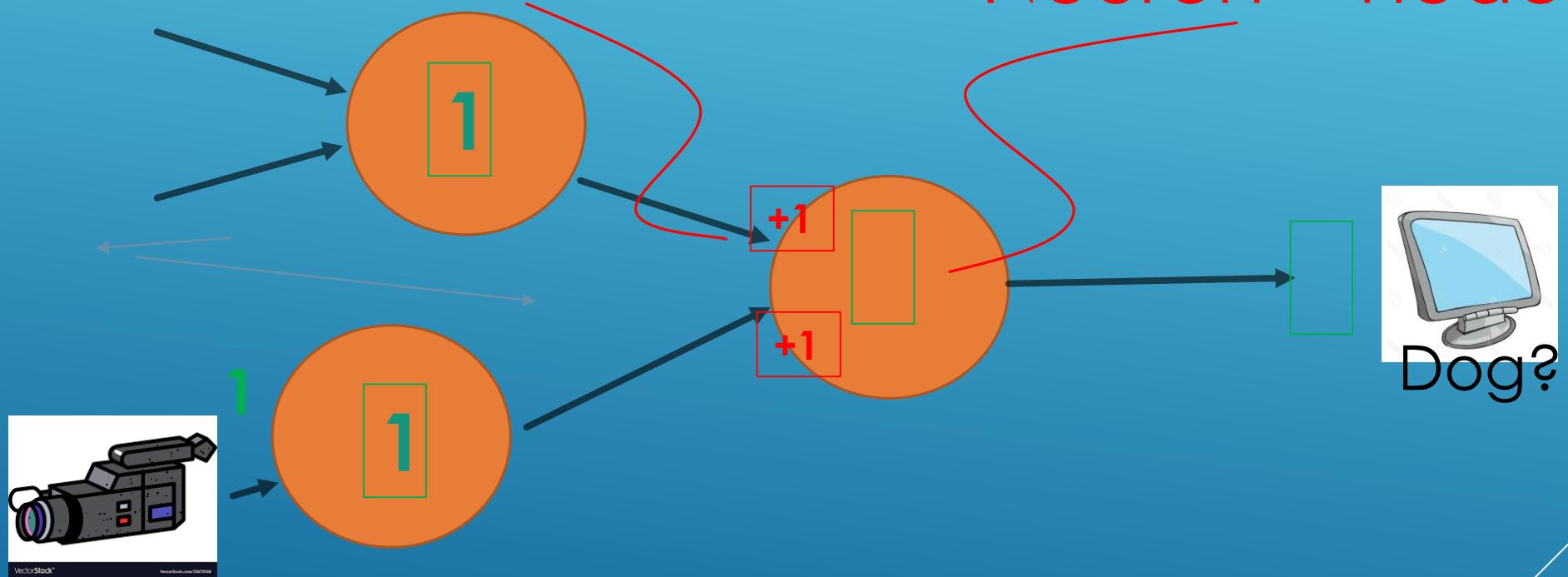
Synapse = weight



Neuron = node

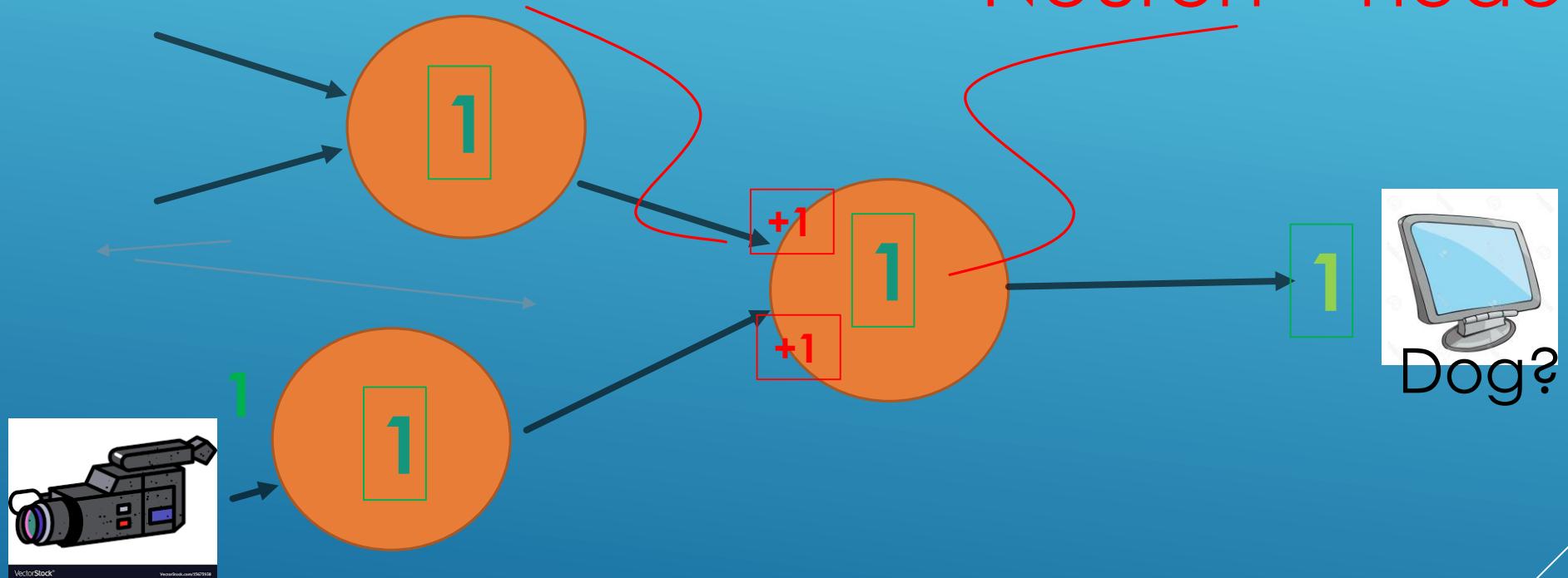


Synapse = weight



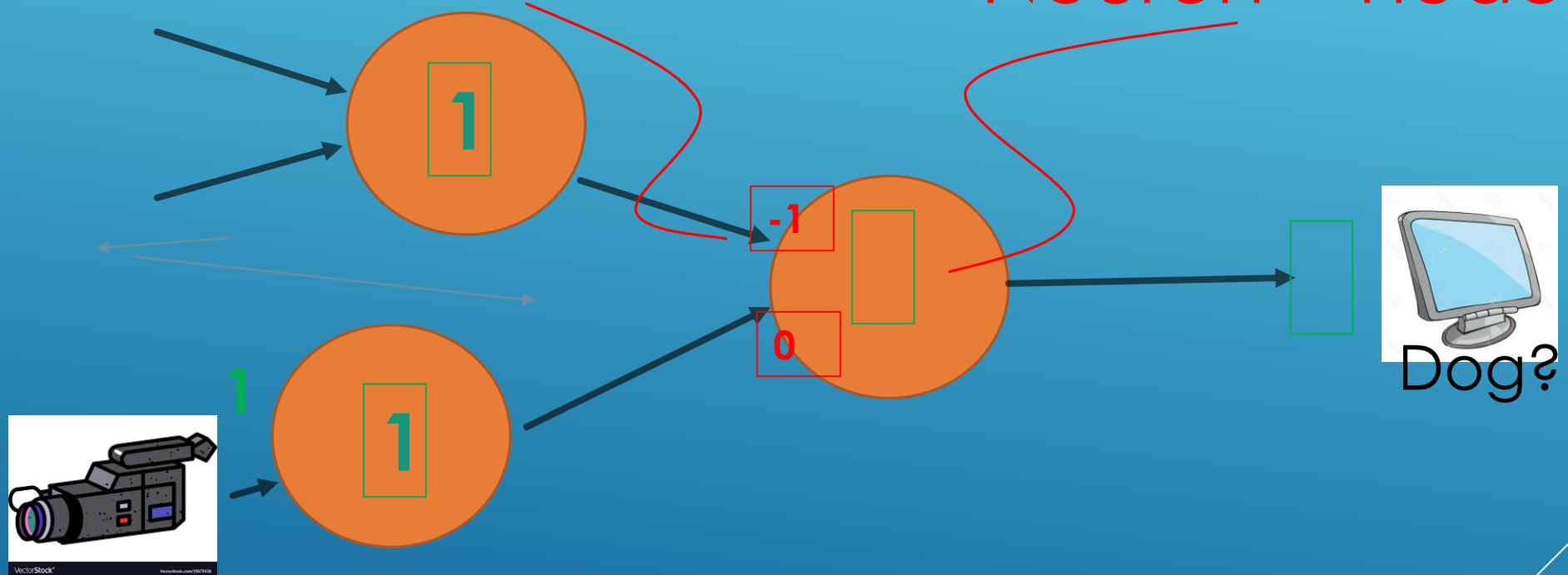
Neuron = node

Synapse = weight



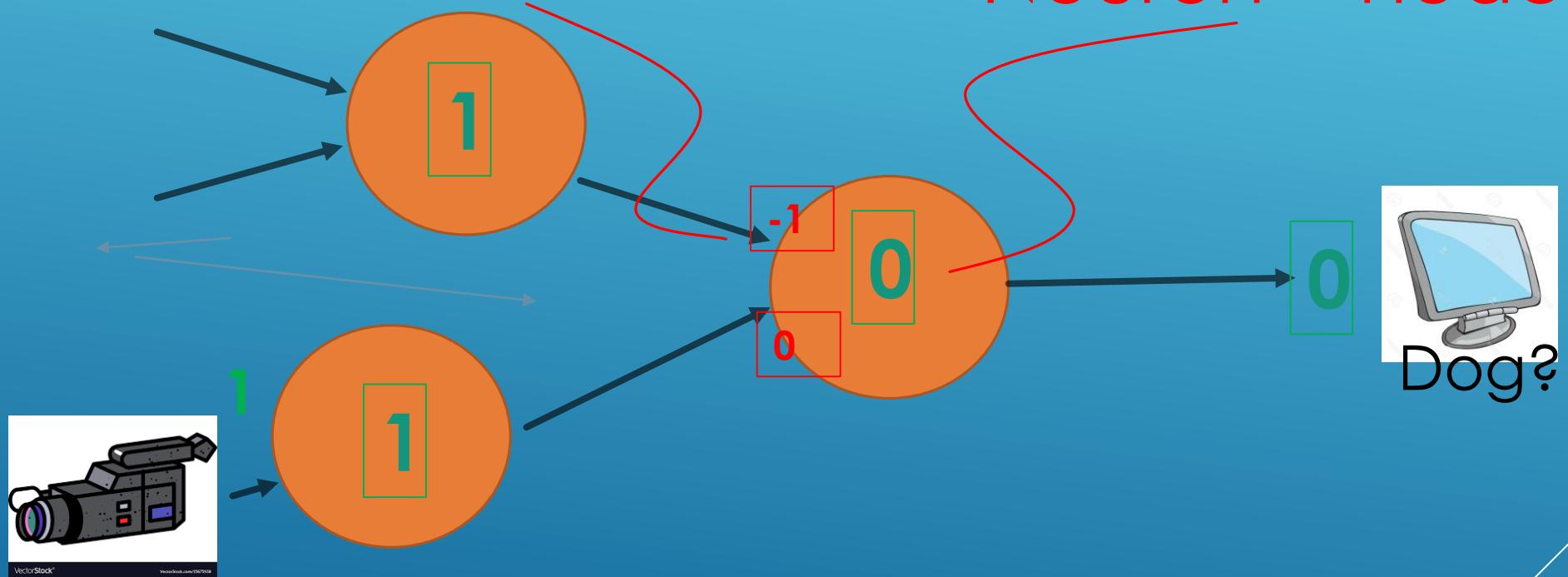
Neuron = node

Synapse = weight



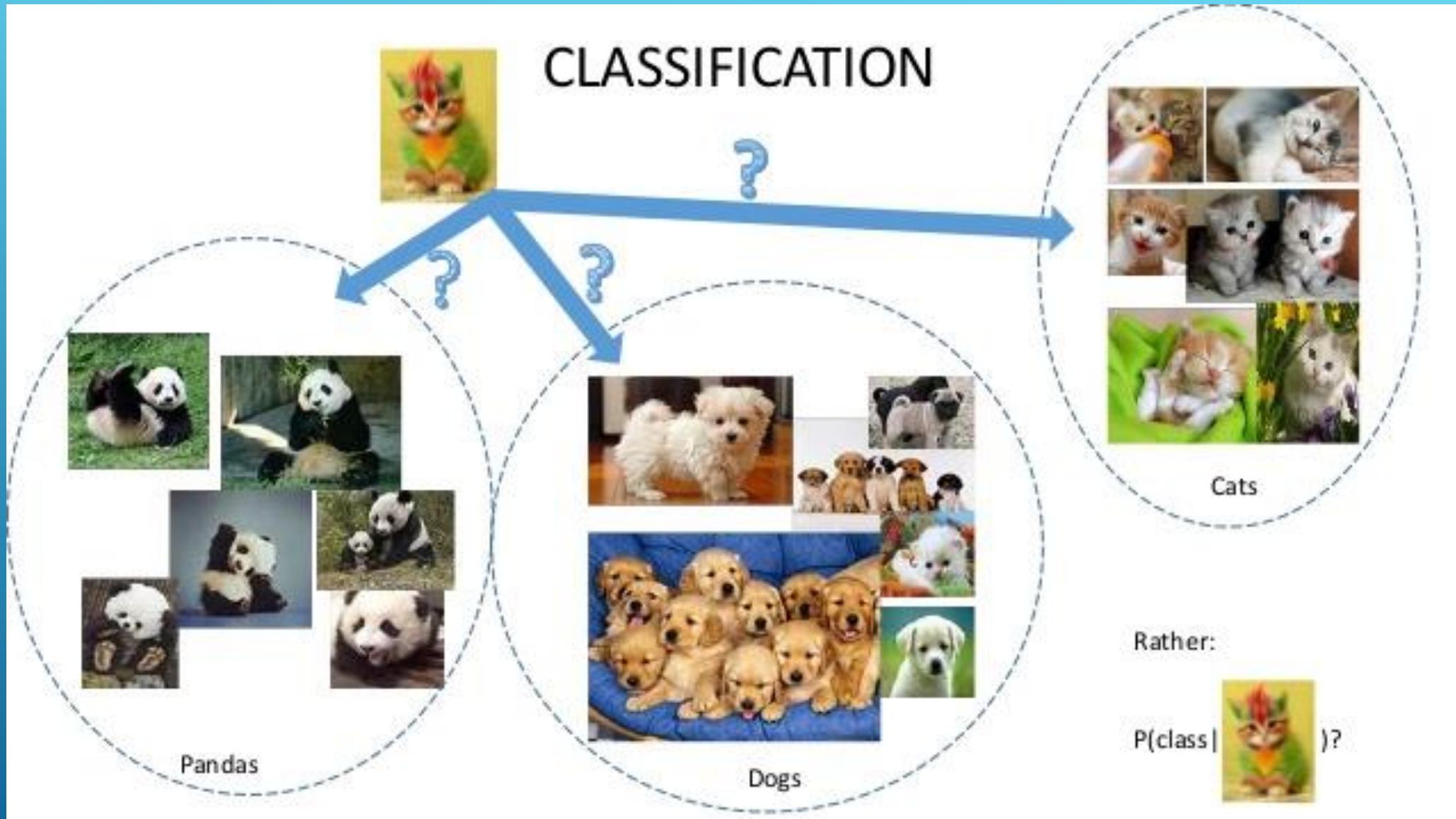
Neuron = node

Synapse = weight

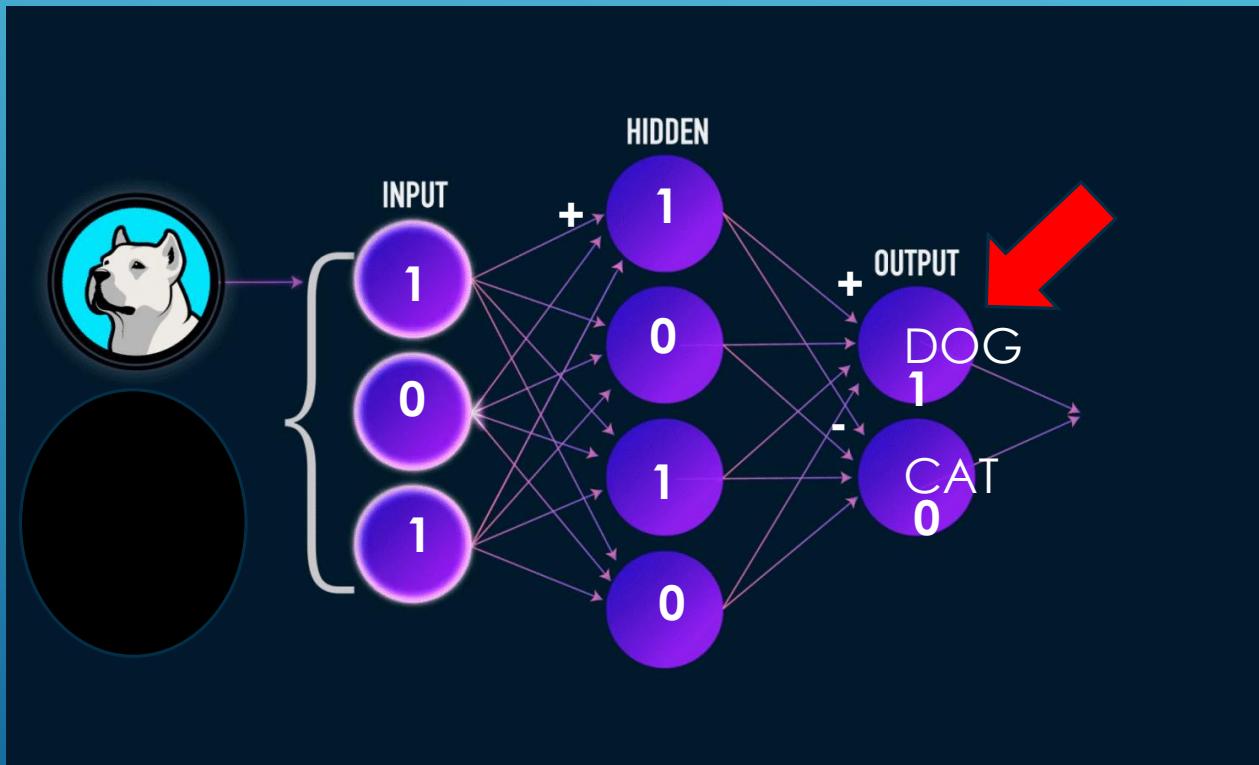


Neuron = node

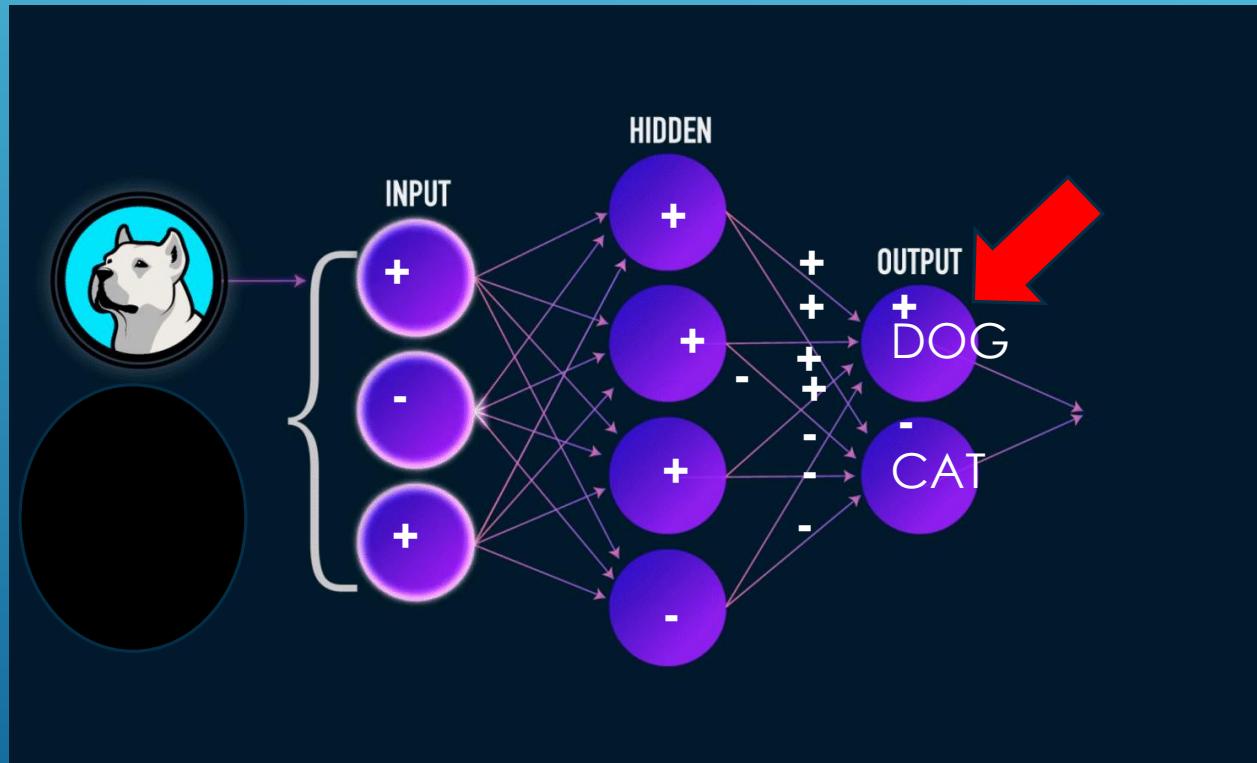
CLASSIFICATION



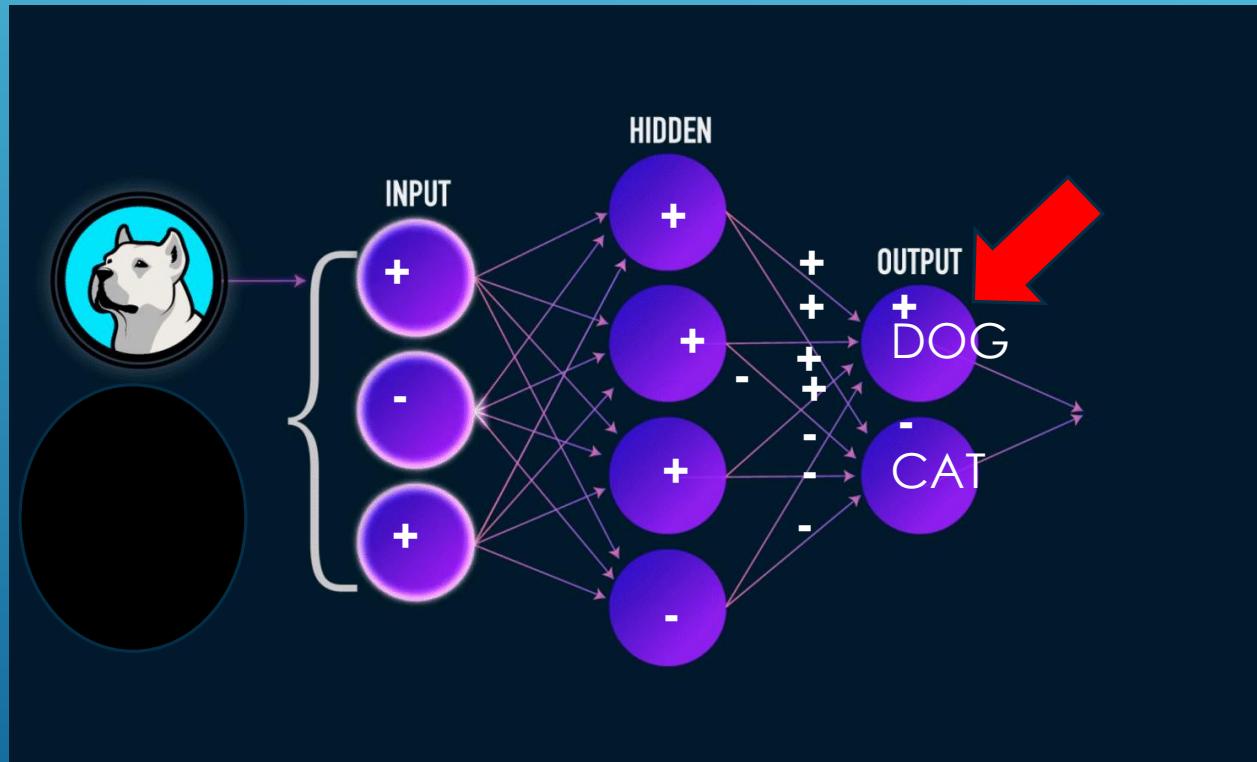
“ANN” == ARTIFICIAL NEURAL NETWORK
("DEEP LEARNING") == ANN WITH LOTS OF LAYERS



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

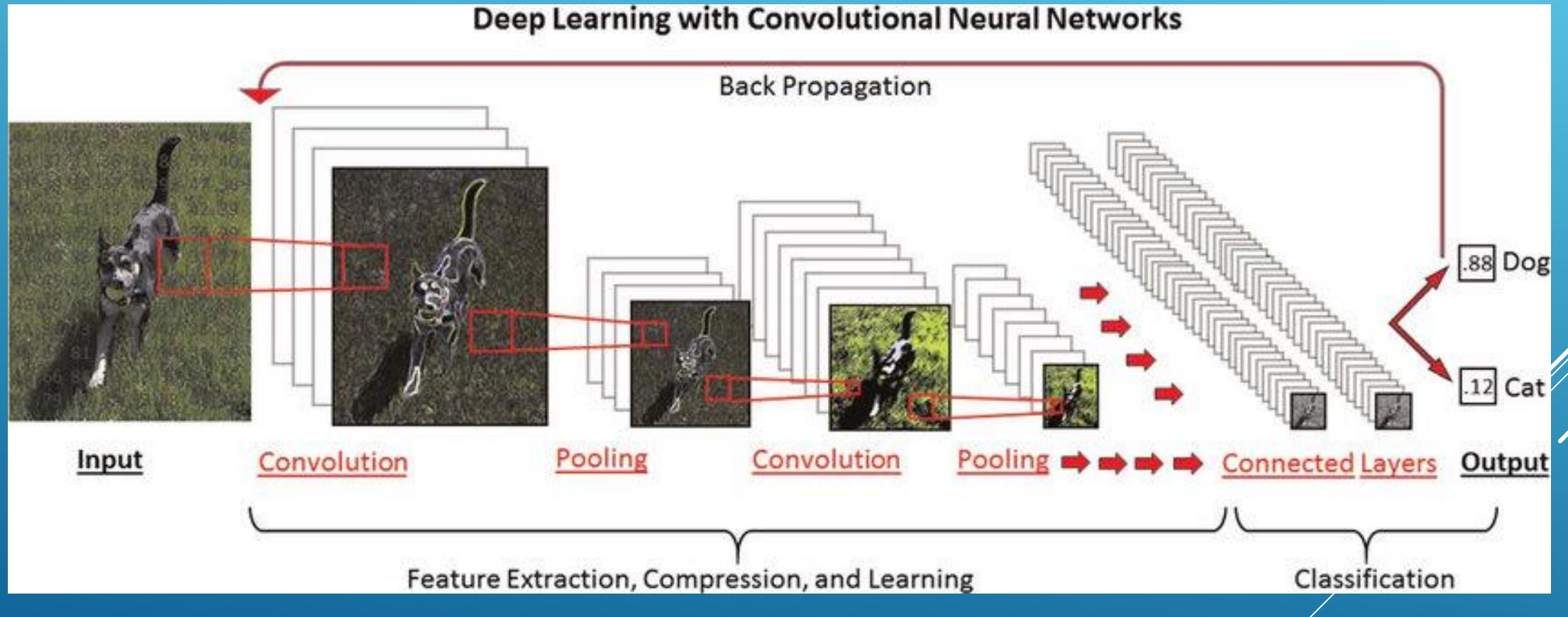


HOW DID THE NEURAL NETWORK (“DEEP LEARNING NETWORK” IF MORE LAYERS) GET WIRED UP LIKE THIS TO GIVE US THIS ANSWER?



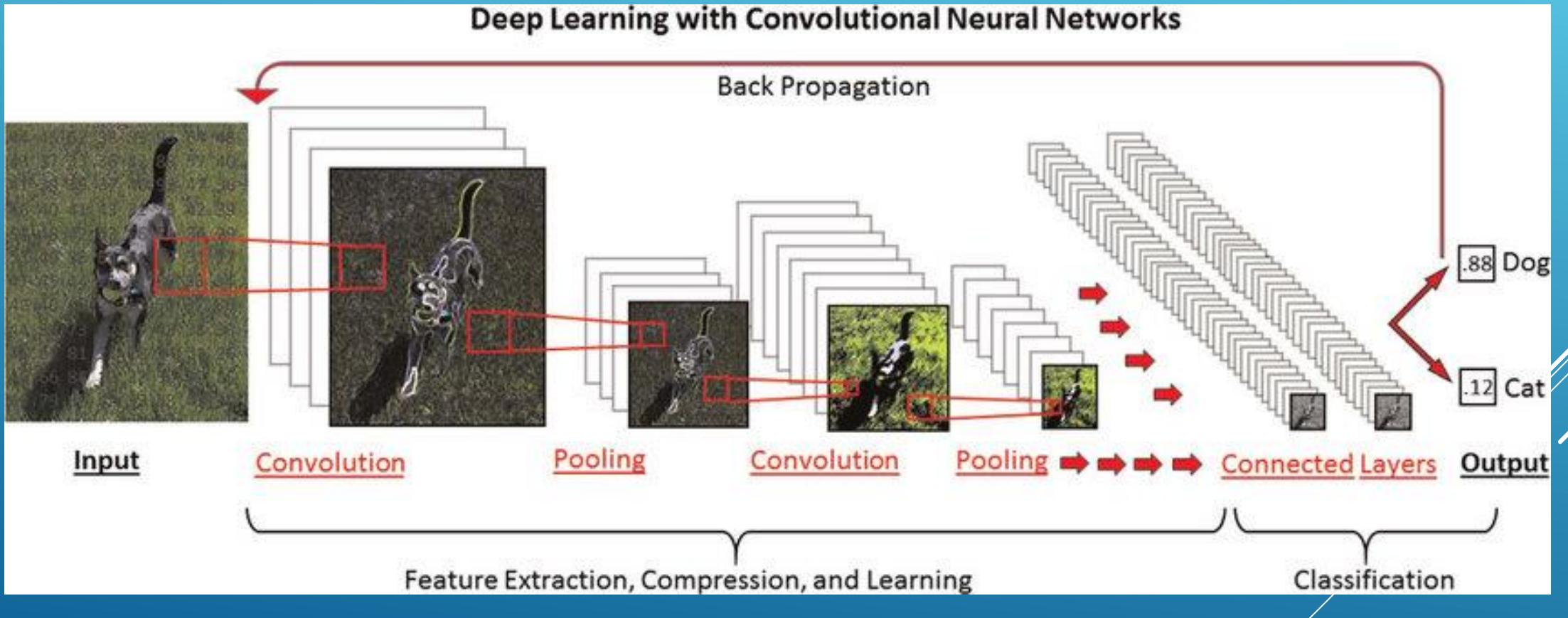
REALLY LOOKS MORE LIKE THIS

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

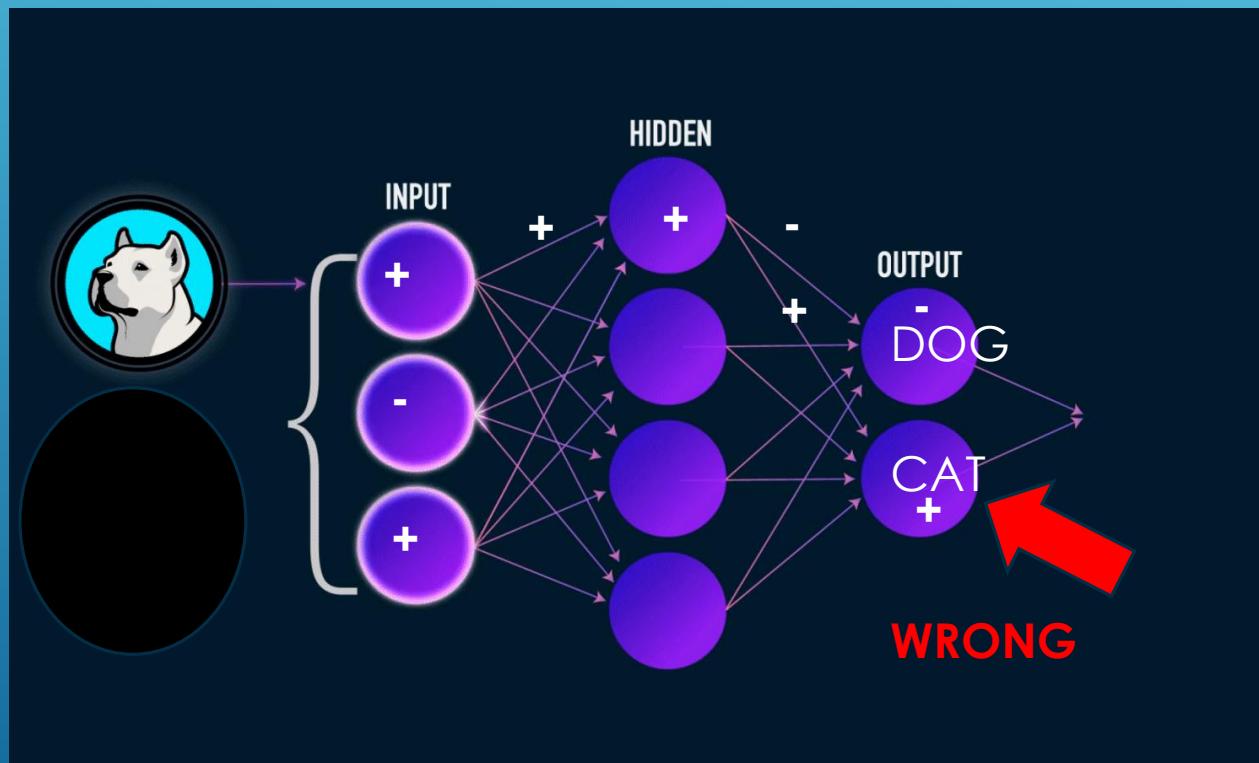


40

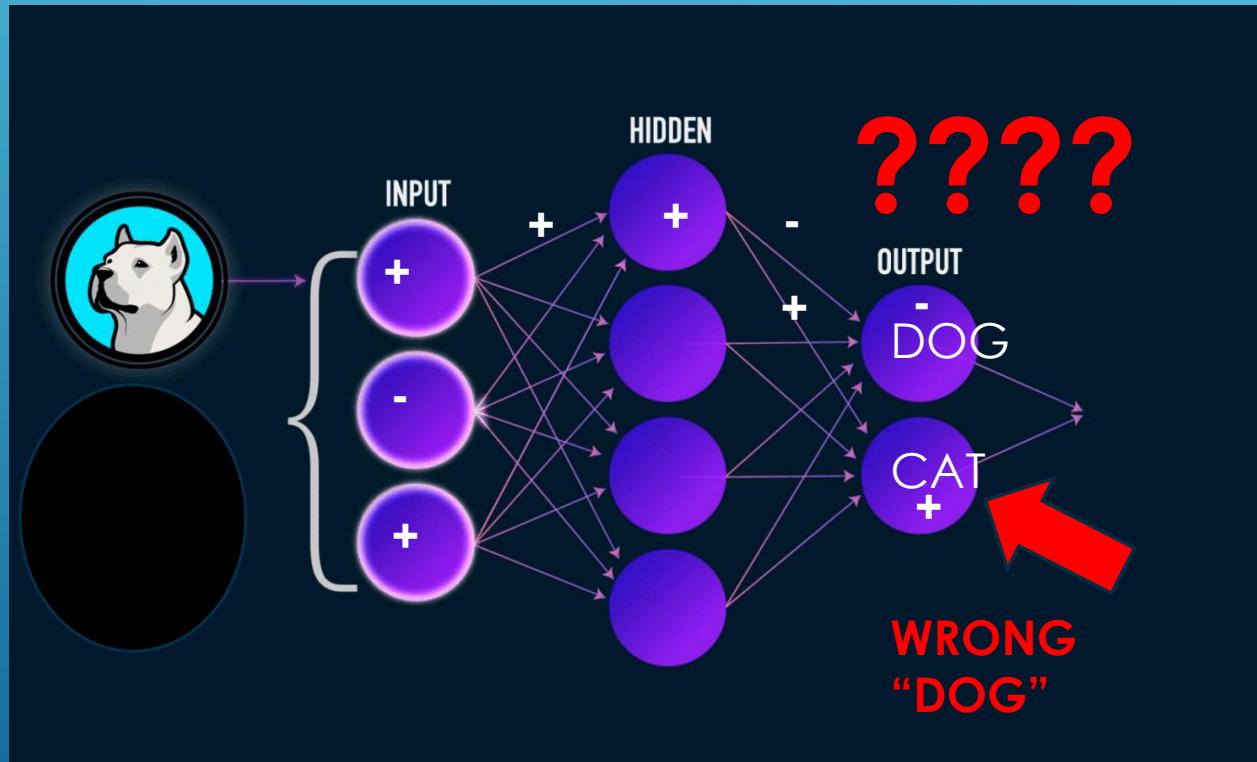
DON'T HAVE TO BUILD THIS UP BY HAND (MASSIVE EFFORT, POOR RESULTS)



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

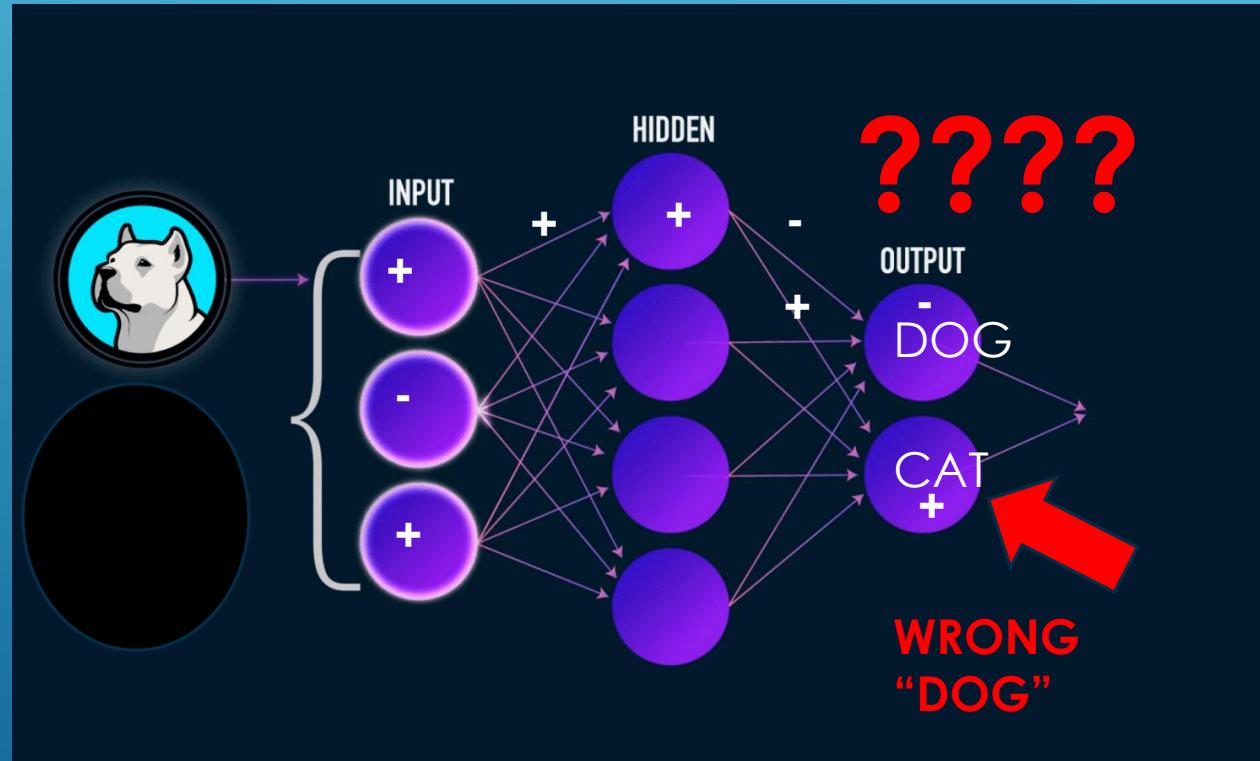


HOW TO FIX THIS AUTOMATICALLY? (WELL....SEMI-AUTOMATICALLY SINCE NEED HUMAN TO HAVE ALREADY FIGURED OUT THIS IS A DOG)

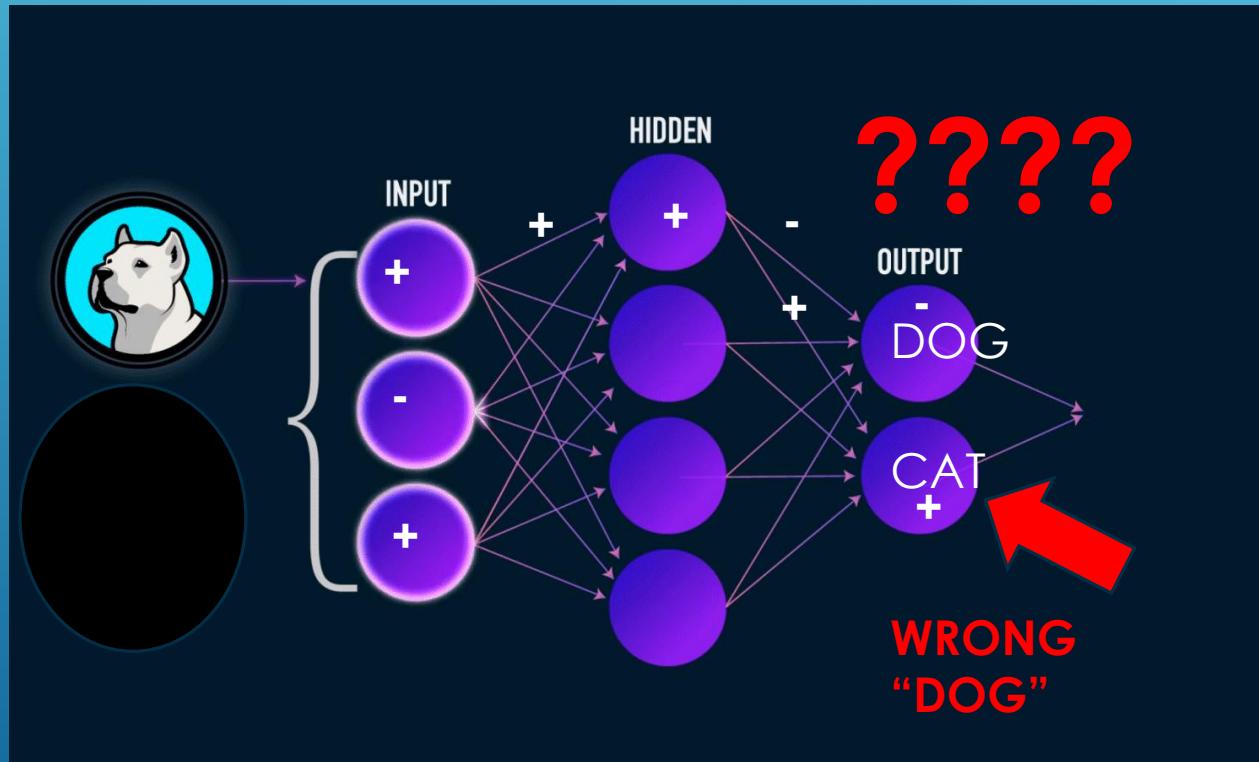


Supervised Learning ("SL")

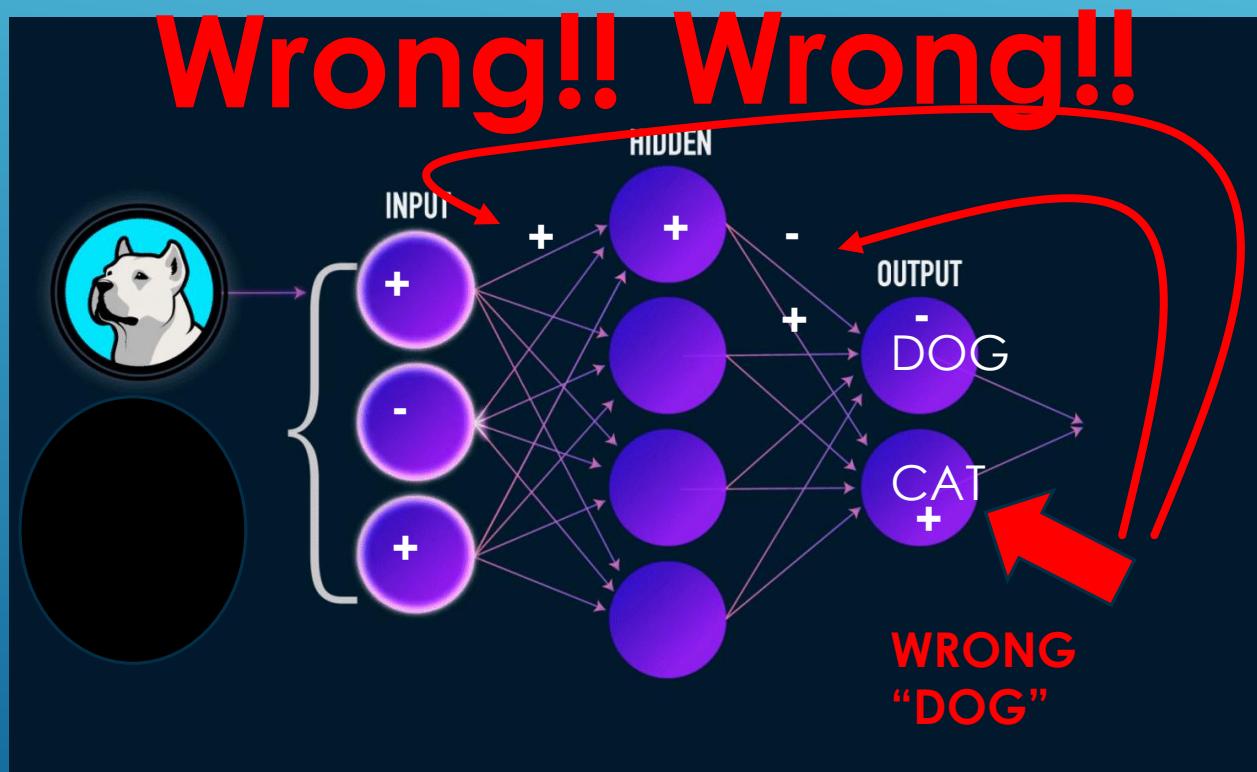
HOW TO FIX THIS AUTOMATICALLY?
(WELL....SEMI-AUTOMATICALLY SINCE NEED HUMAN
TO HAVE ALREADY FIGURED OUT THIS IS A DOG)



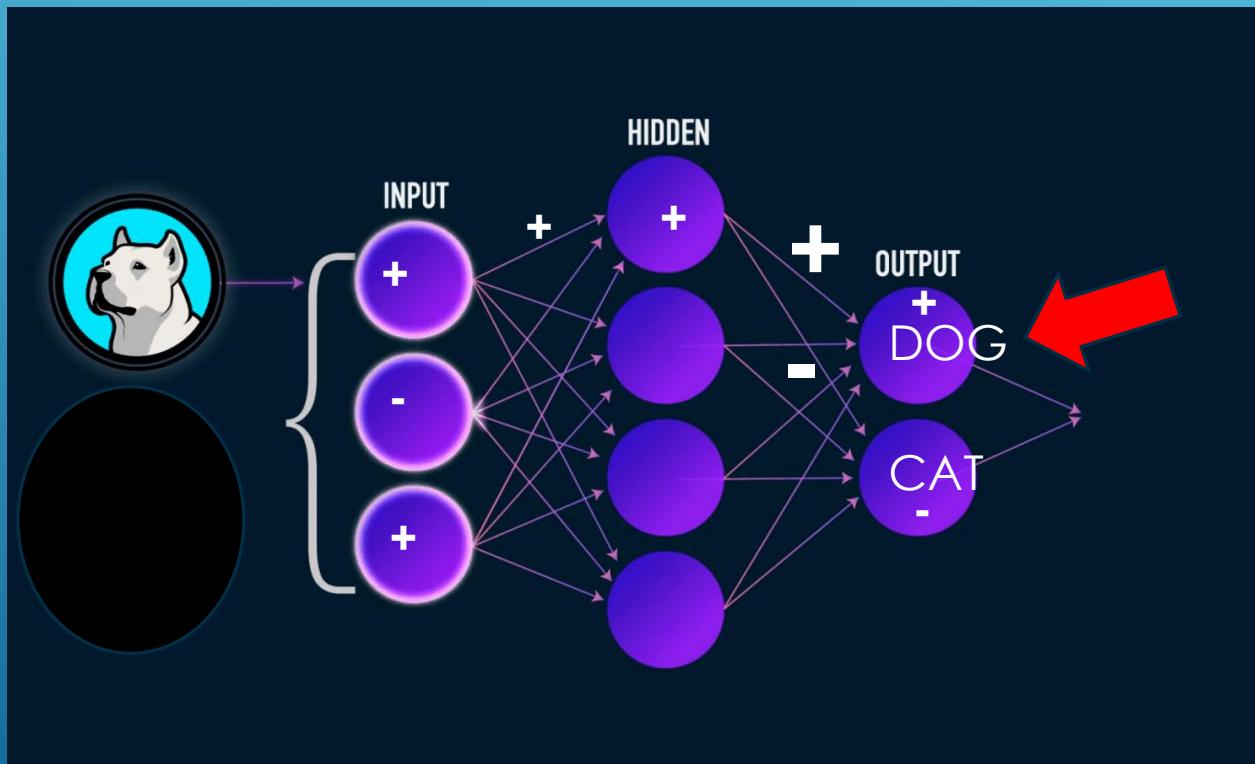
HOW TO FIX THIS AUTOMATICALLY?
(WELL....SEMI-AUTOMATICALLY SINCE NEED HUMAN
TO HAVE ALREADY FIGURED OUT THIS IS A DOG)



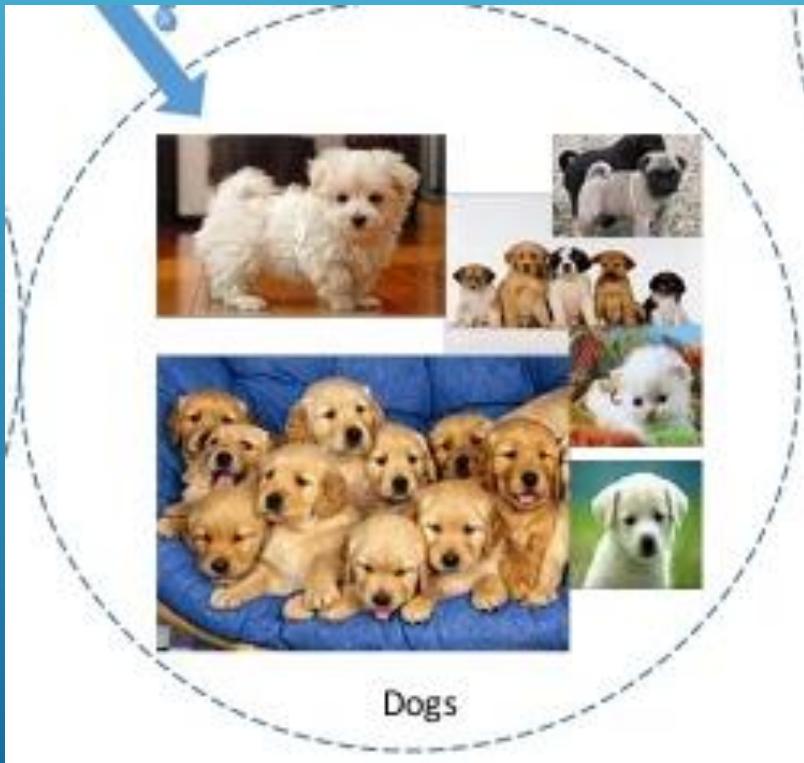
FIX AUTOMATICALLY WITH FEEDBACK



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

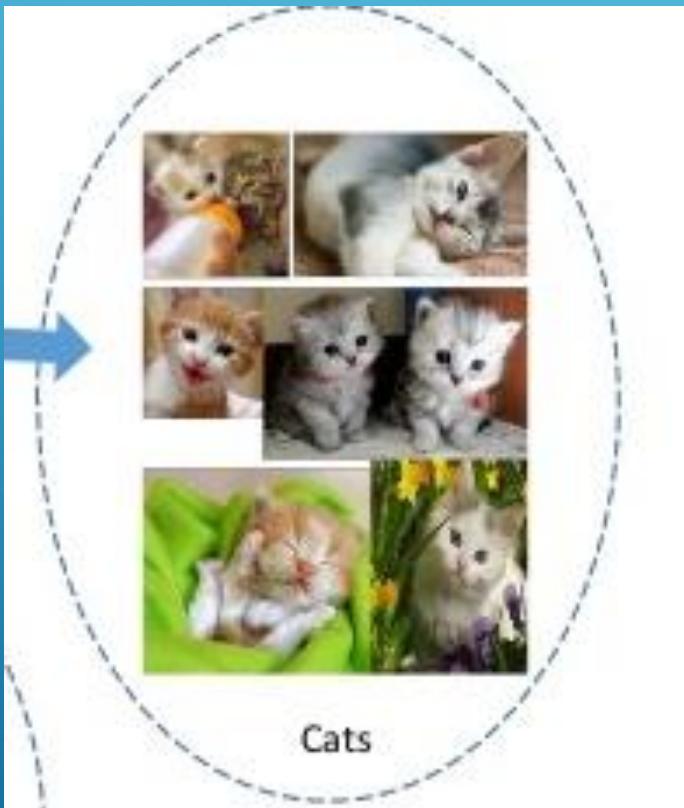


WE TRAIN OUR NETWORK ON A VARIETY OF DIFFERENT DOGS



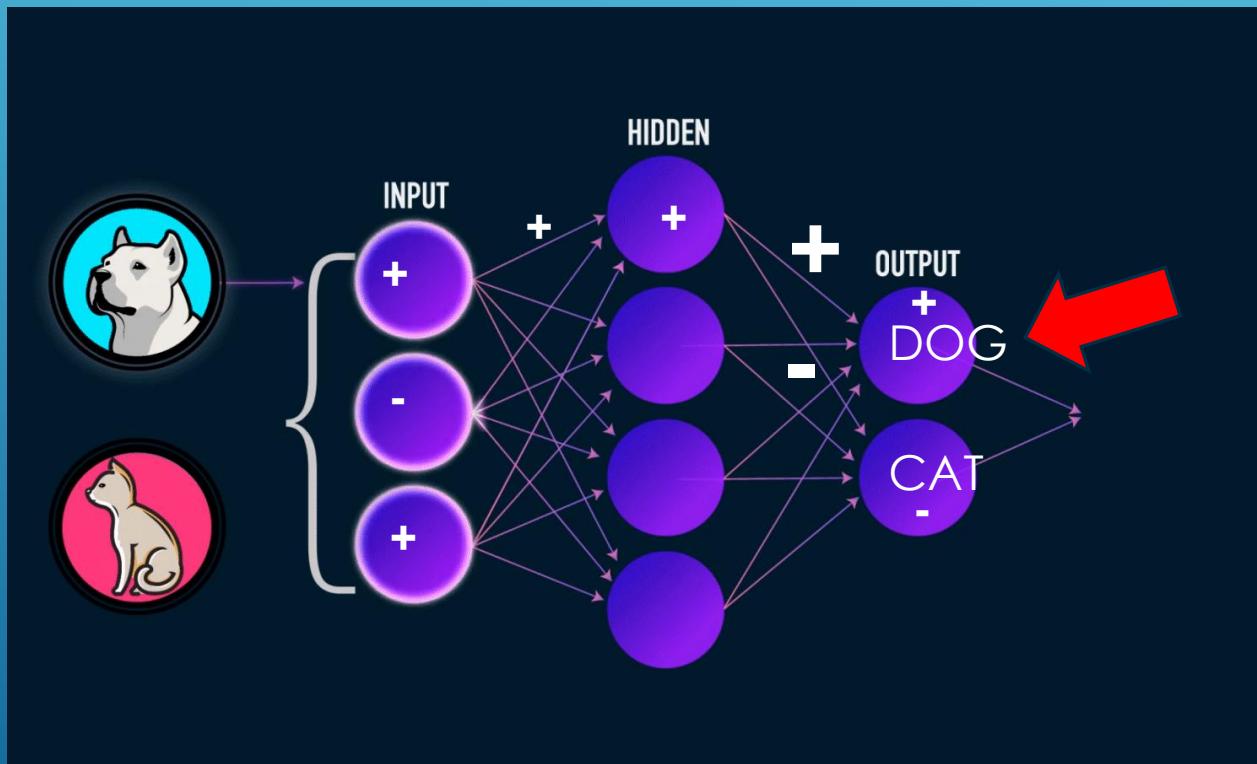
Pass in a file with pictures of many different types of dogs, and all these pictures are labeled “dog” so the neural network will know that the correct answer is to classify as a dog

WE TRAIN OUR NETWORK ON A VARIETY OF DIFFERENT CATS

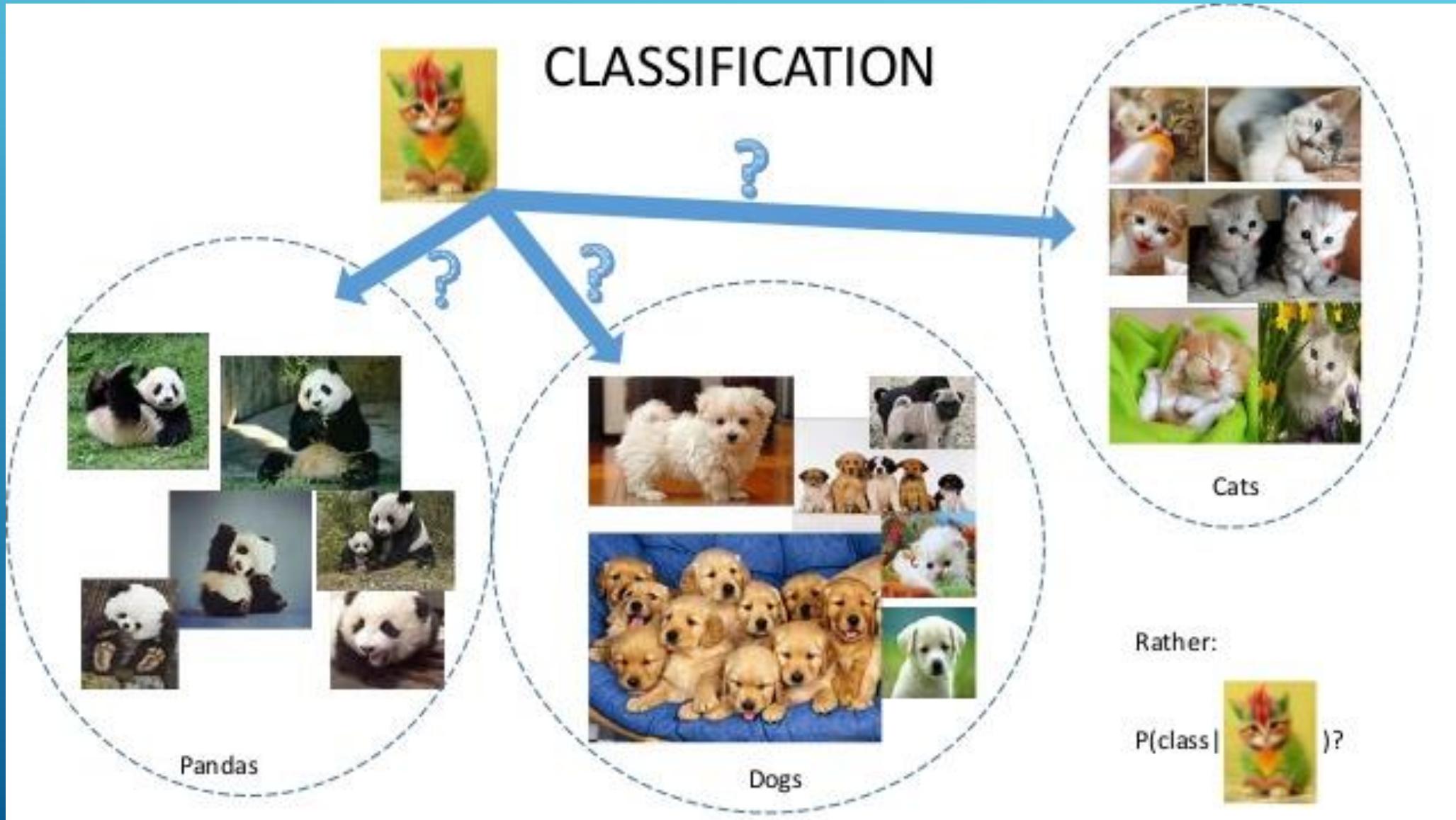


Pass in a file with pictures of many different types of cats, and all these pictures are labeled “cat” so the neural network will know that the correct answer is to classify as a cat

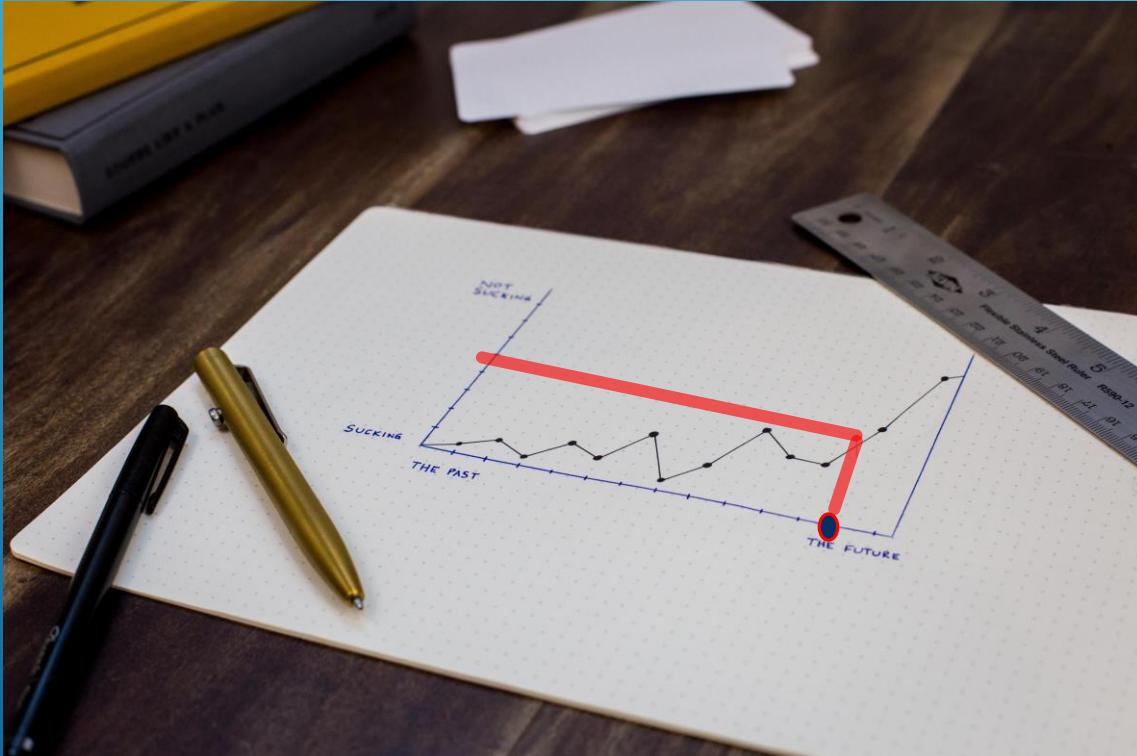
AFTER ENOUGH TRAINING CYCLES, ON DIFFERENT TYPES OF DOGS AND CATS, THE NEURAL NETWORK CAN CLASSIFY DIFFERENT IMAGES AS A DOG VERSUS CAT



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

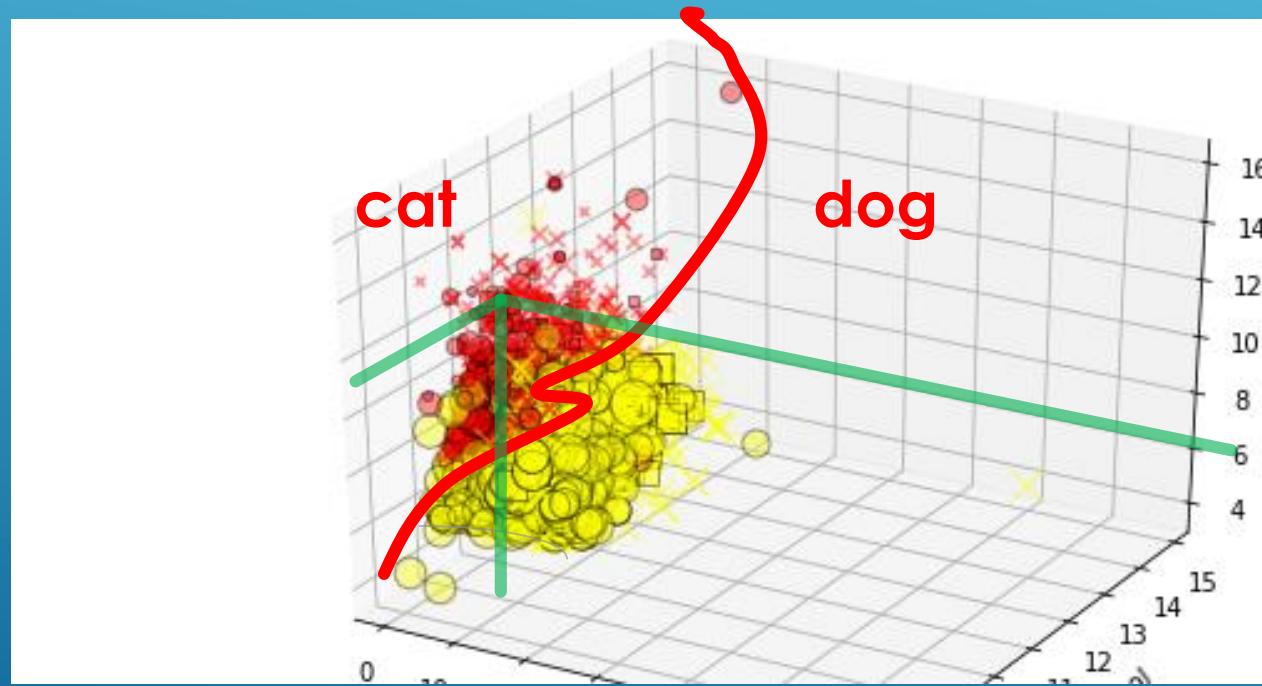


YOU WERE ABLE TO CLASSIFY A DATA POINT YOU NEVER SAW BEFORE ALSO ON YOUR GRAPH



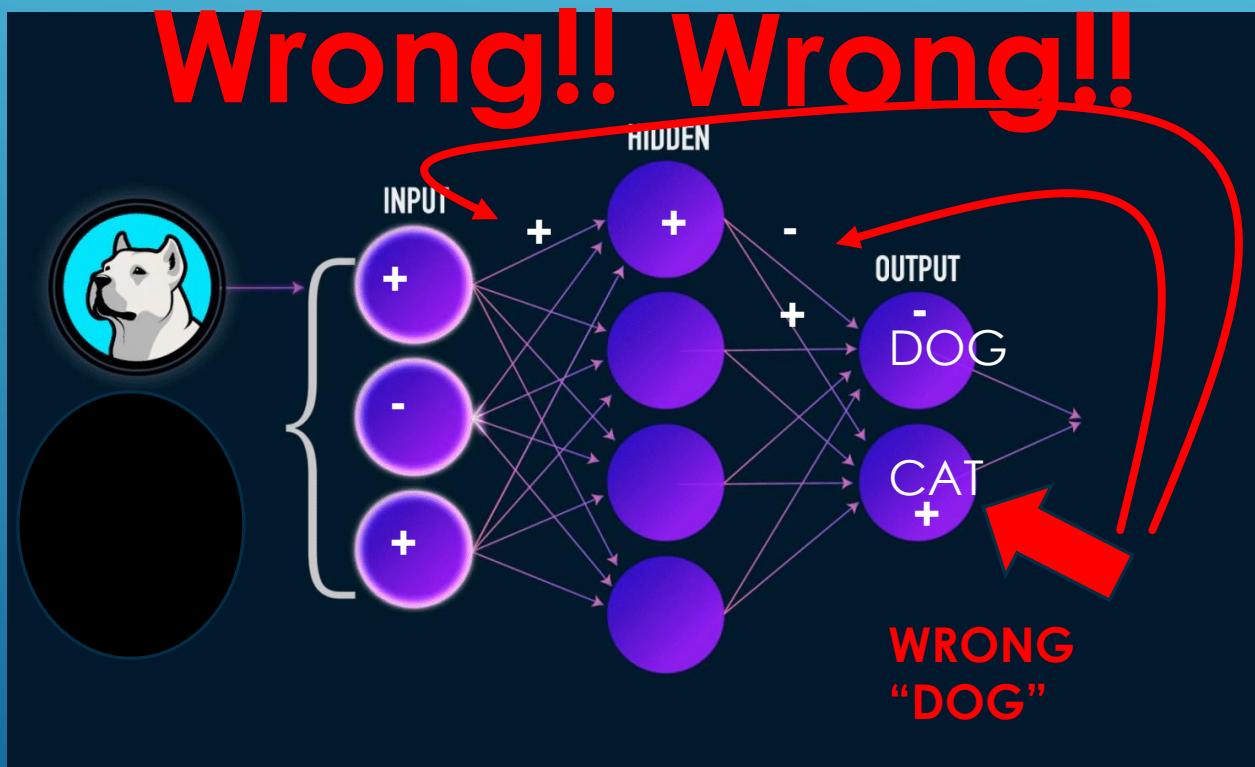
New X value never seen before, you can predict the Y value

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

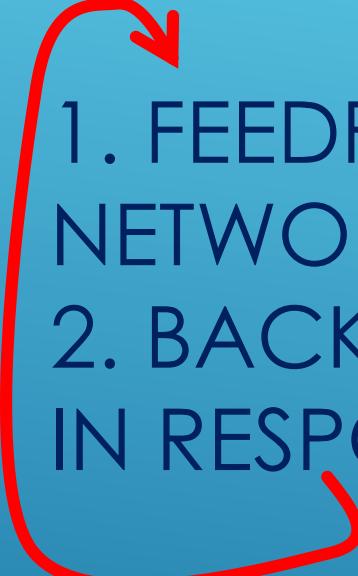


“BACKPROPAGATION”

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

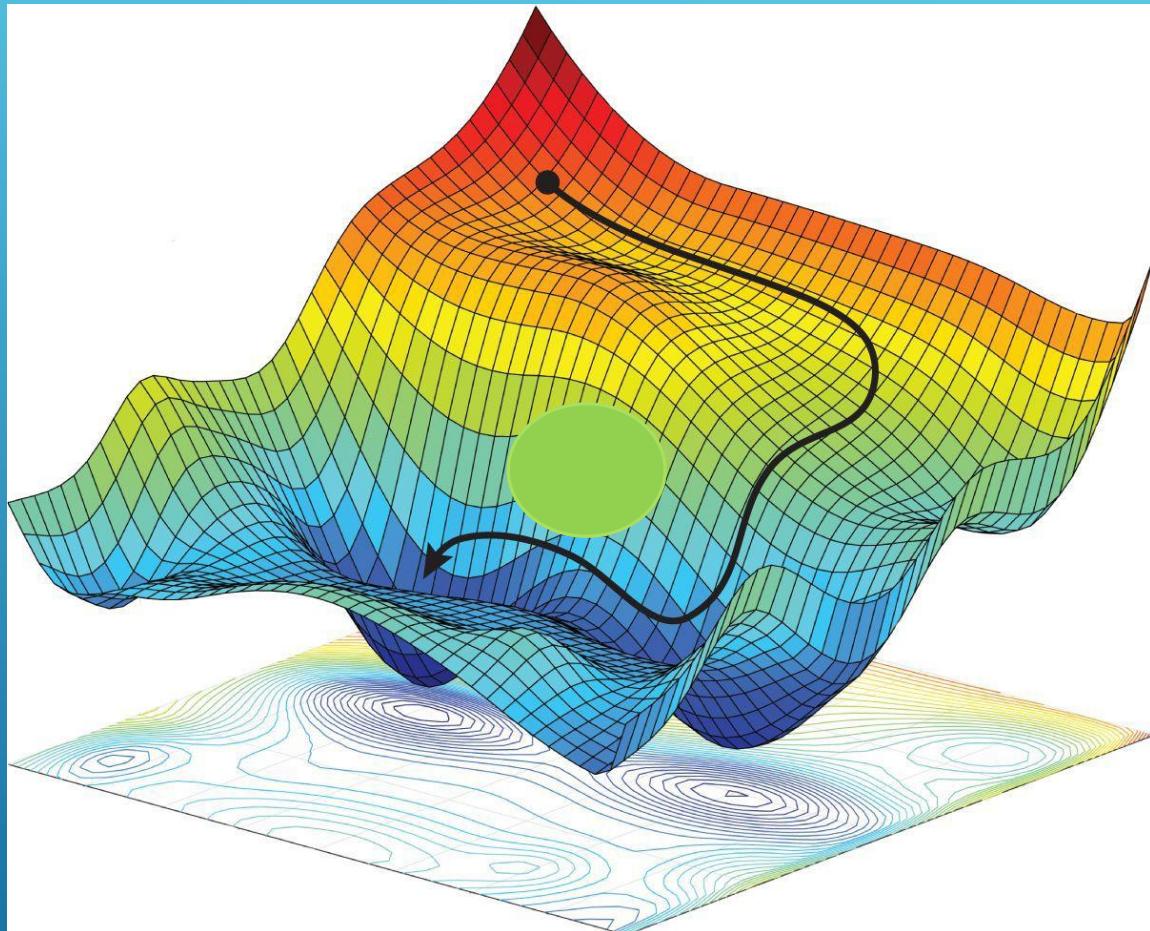
STOCHASTIC GRADIENT DESCENT (SGD)

'Stochastic' – single random sample each iteration

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

'Gradient Descent' – iterative optimization method

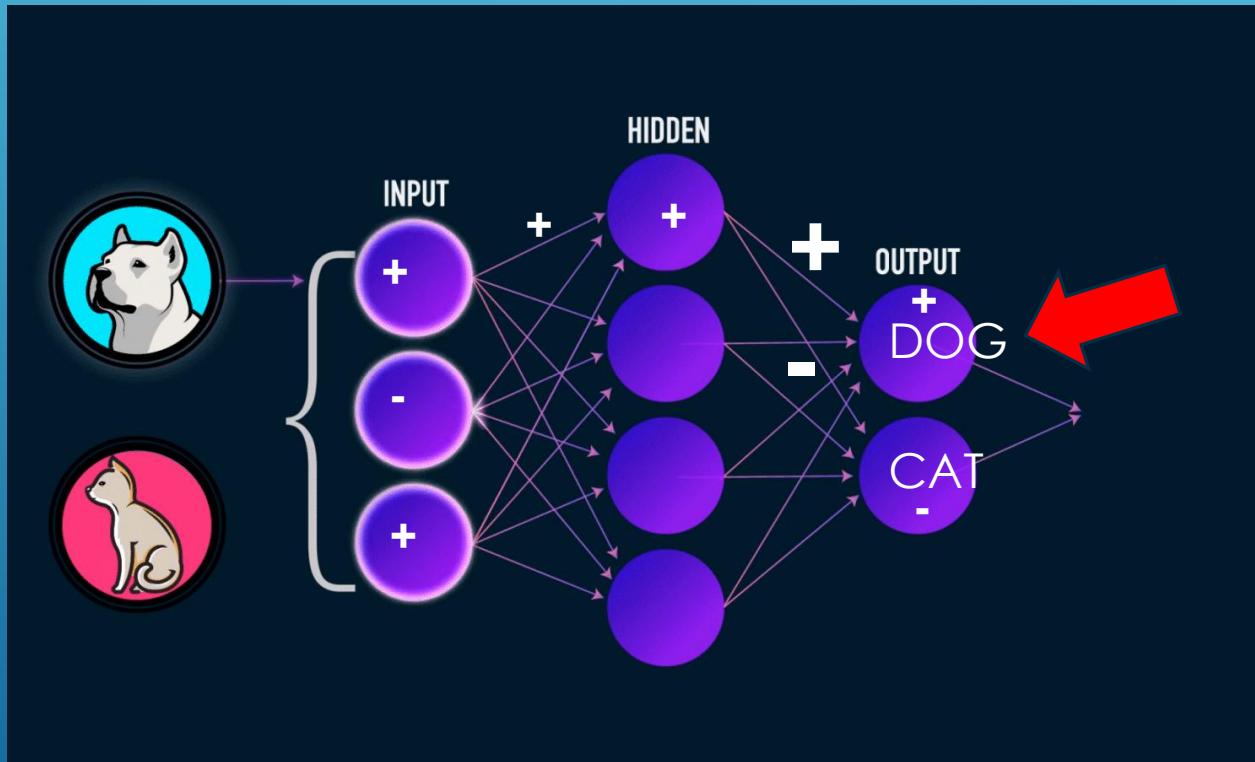
Can apply to 1000's of dimensions, not just 3-D shown in figure



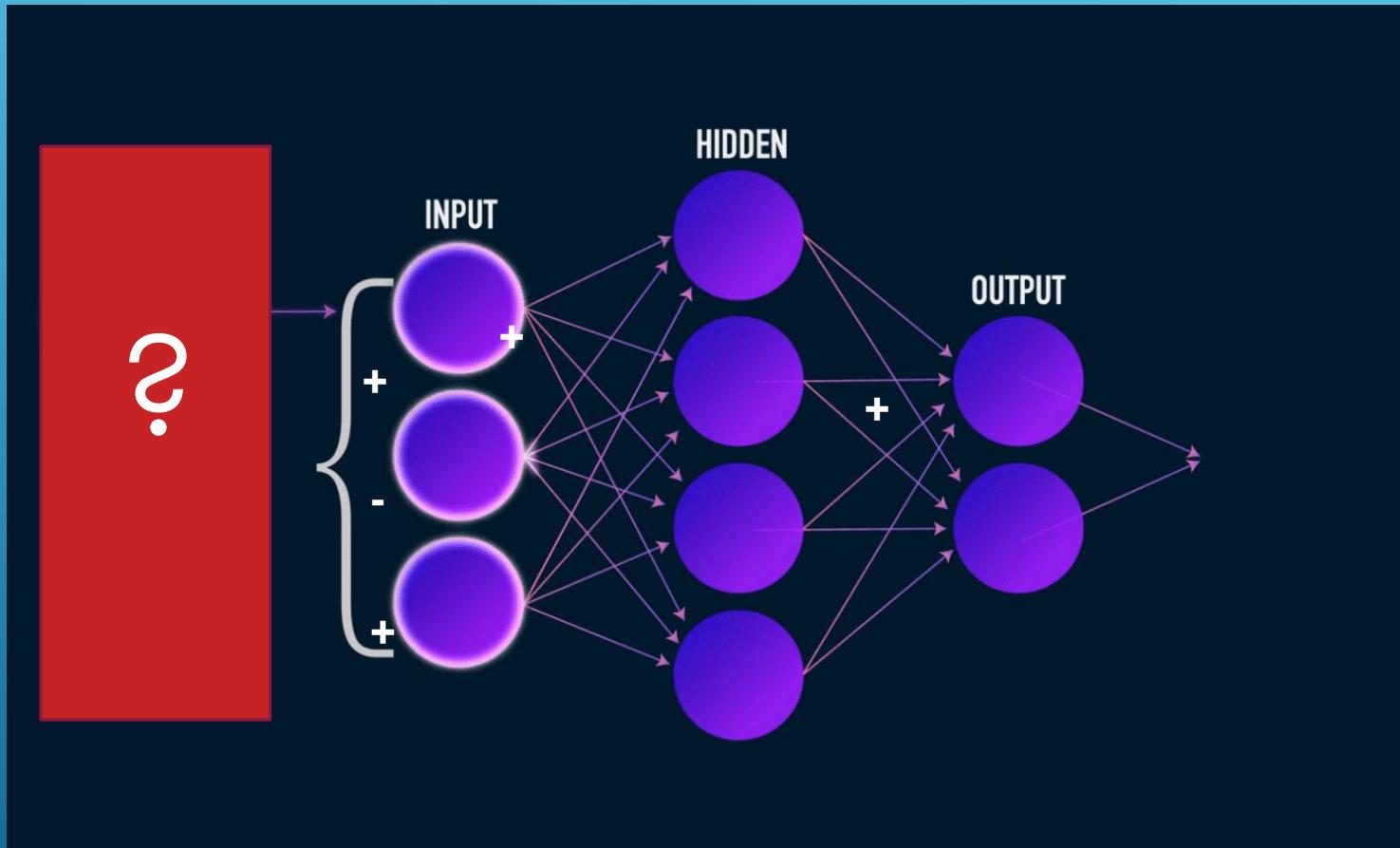
A wide-angle photograph of a tropical beach at sunset. The sky is filled with large, billowing clouds colored in shades of orange, yellow, and blue. The ocean waves are a vibrant turquoise color, crashing onto the light-colored sand. In the distance, a strip of land with palm trees and buildings is visible under the setting sun.

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

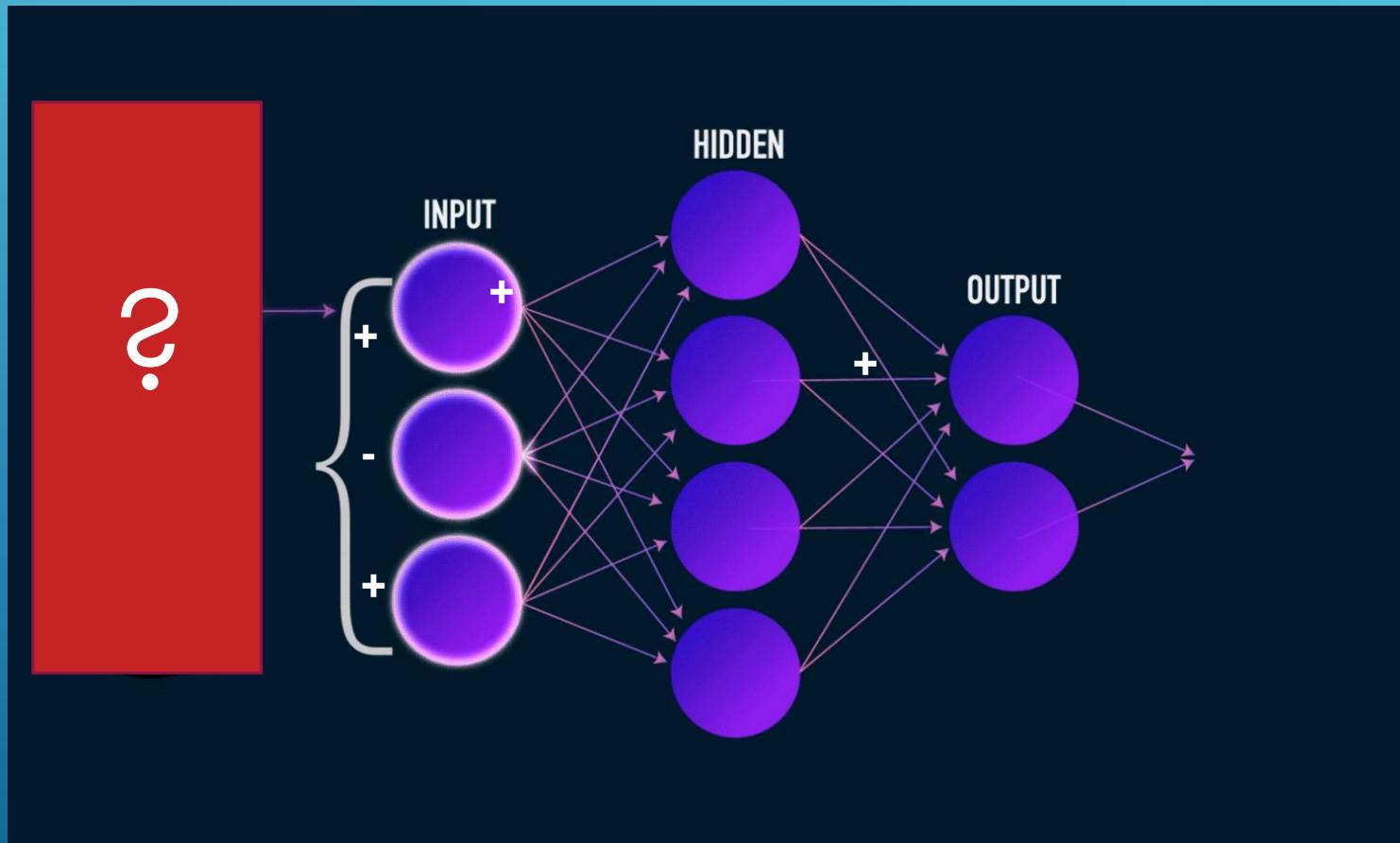
OUR NEURAL NETWORK CAN RECOGNIZE DOGS FROM CATS.....



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



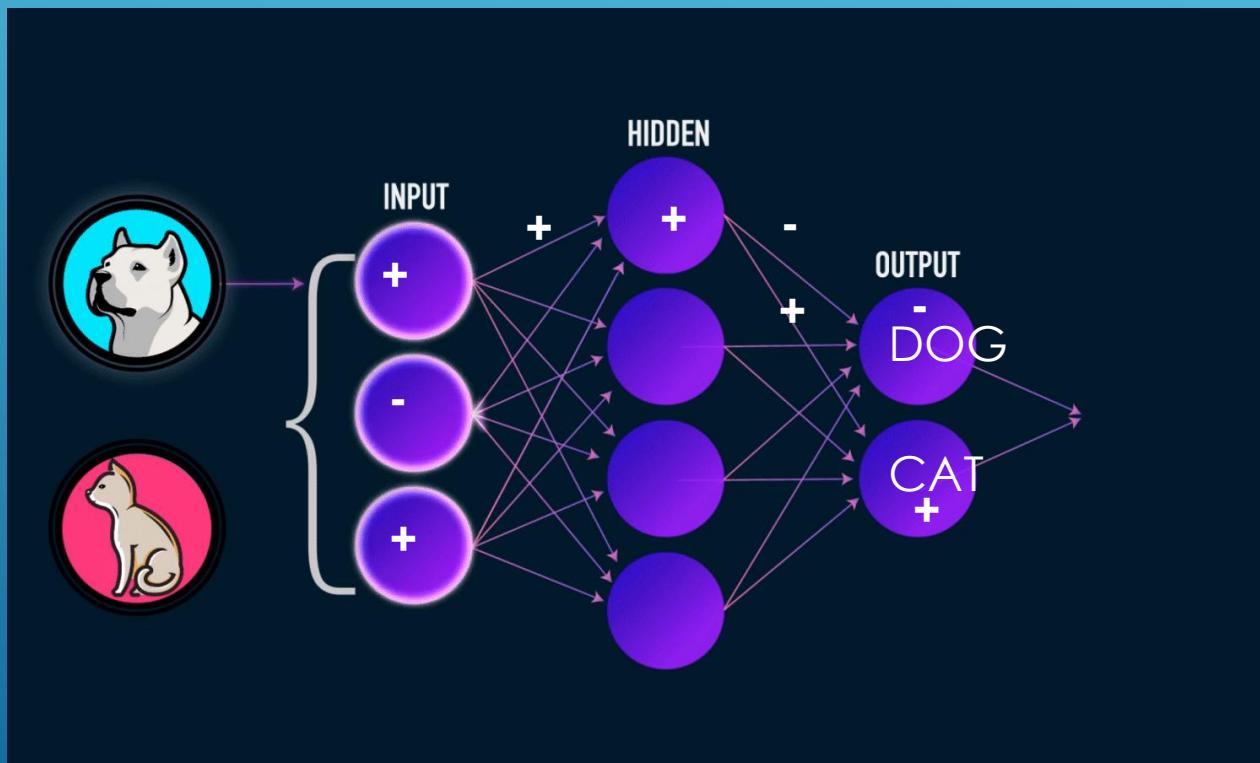
WITH SMALL CHANGES TO THE WAY WE ORGANIZE THE LAYERS, THE NEURAL NETWORK CAN CLASSIFY SOUNDS AND SPEECH AND MARKETING DATA AND.....



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....)

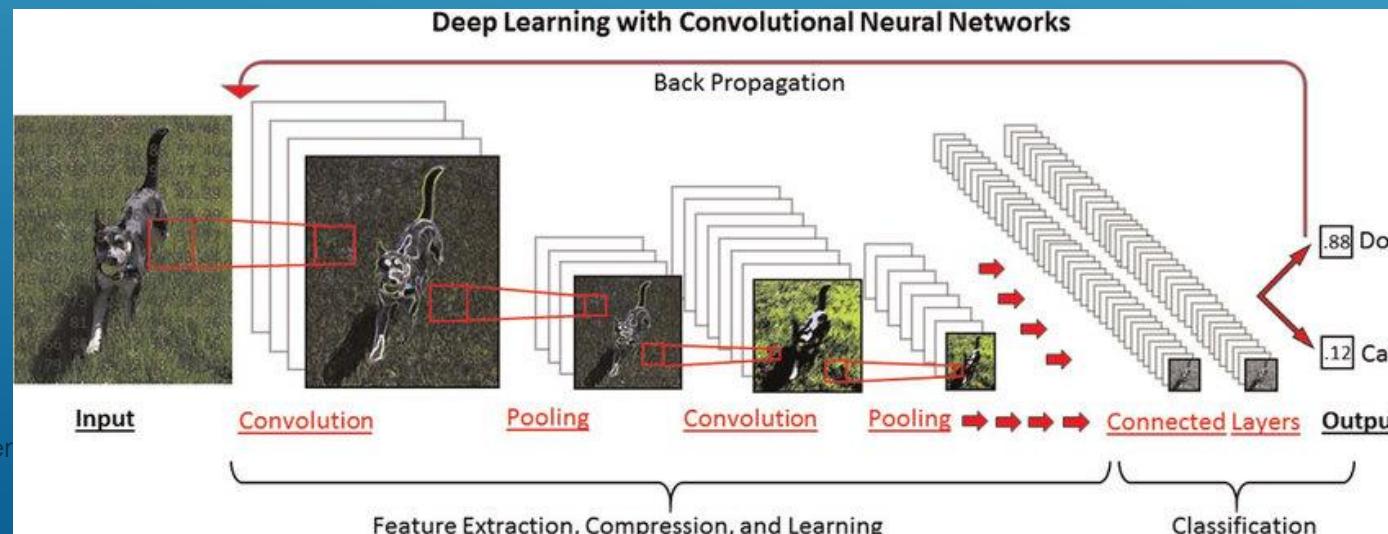


1980's

62

March 2020

- 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

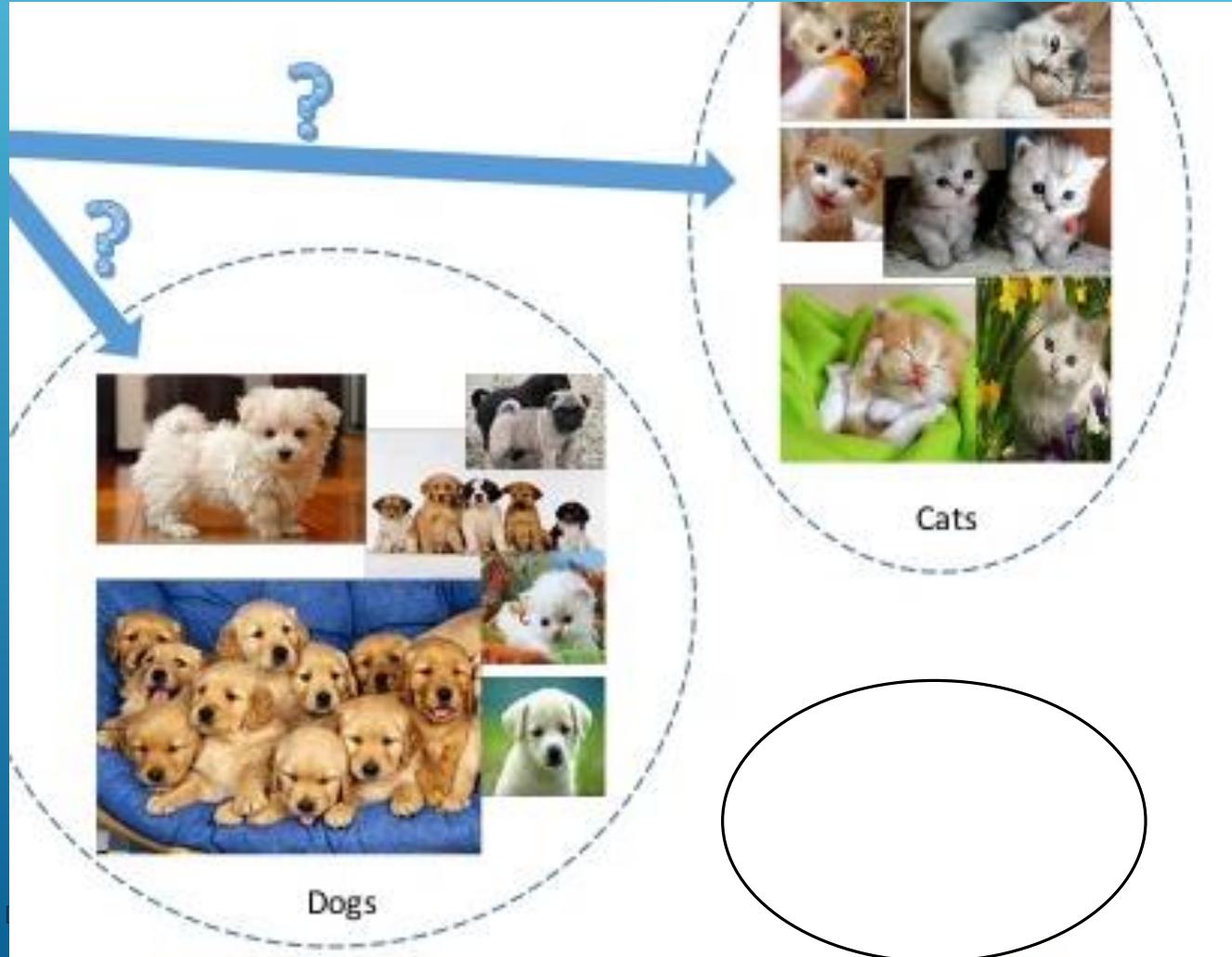


2. GET A COMPUTER FAST ENOUGH TO DO TRILLIONS AND TRILLIONS AND TRILLIONS OF OPERATIONS AND CALCULATIONS



'COMPUTE'
2010'S

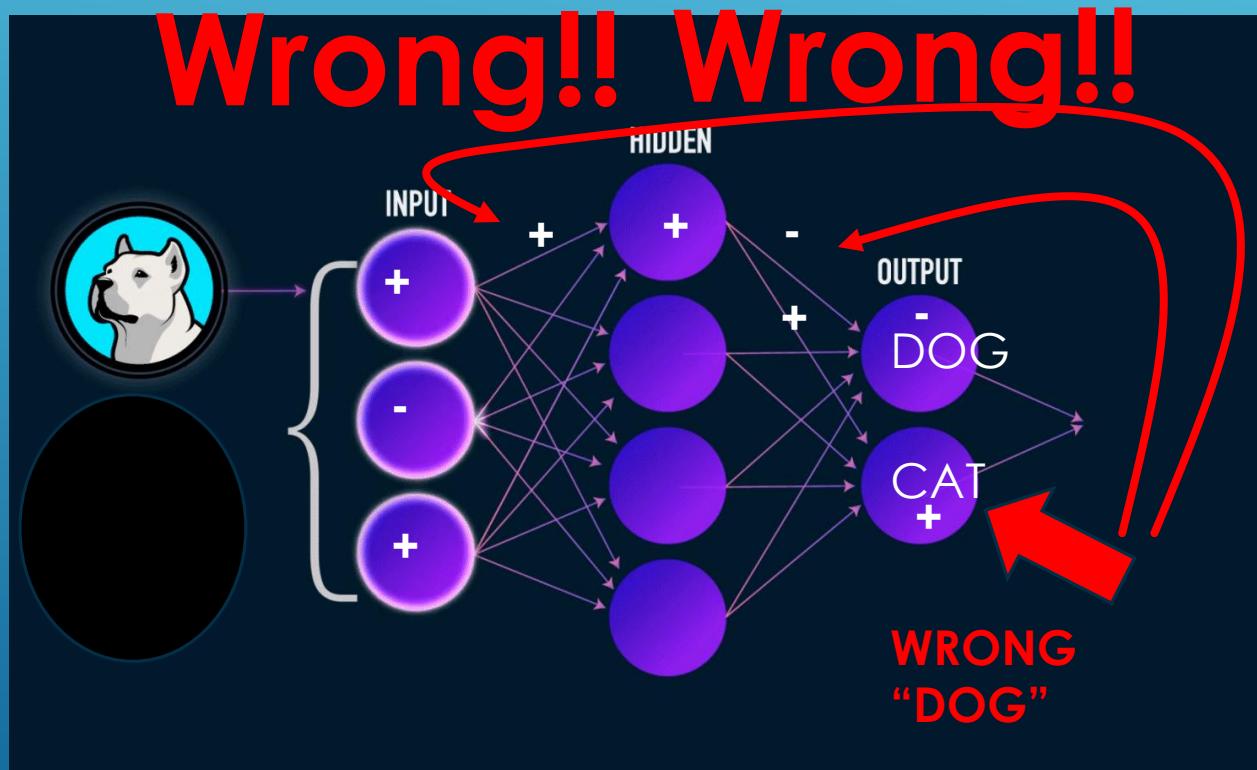
3. GET LOTS AND LOTS OF TRAINING DATA (ACTUALLY – THOUSANDS OR MILLIONS OF IMAGES!!)



'BIG DATA'
2000'S

G**

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

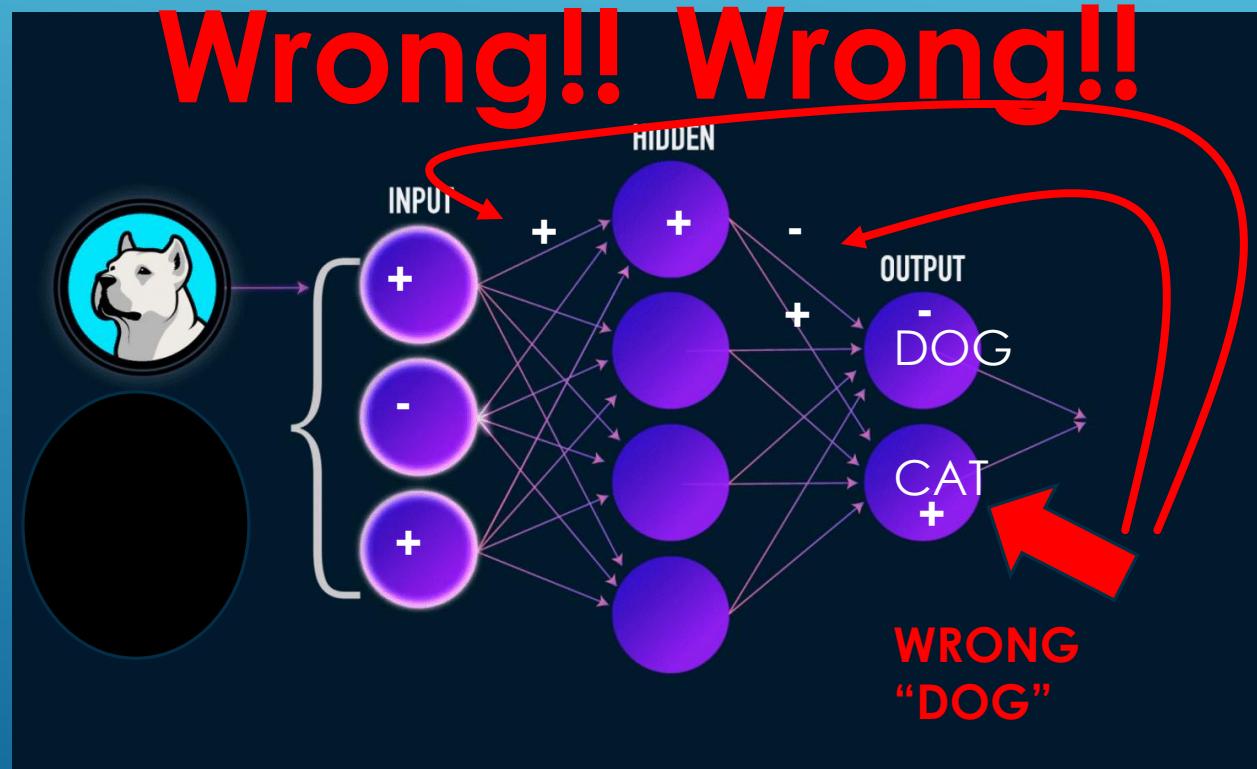


5. REPEAT #4

67

March 2020

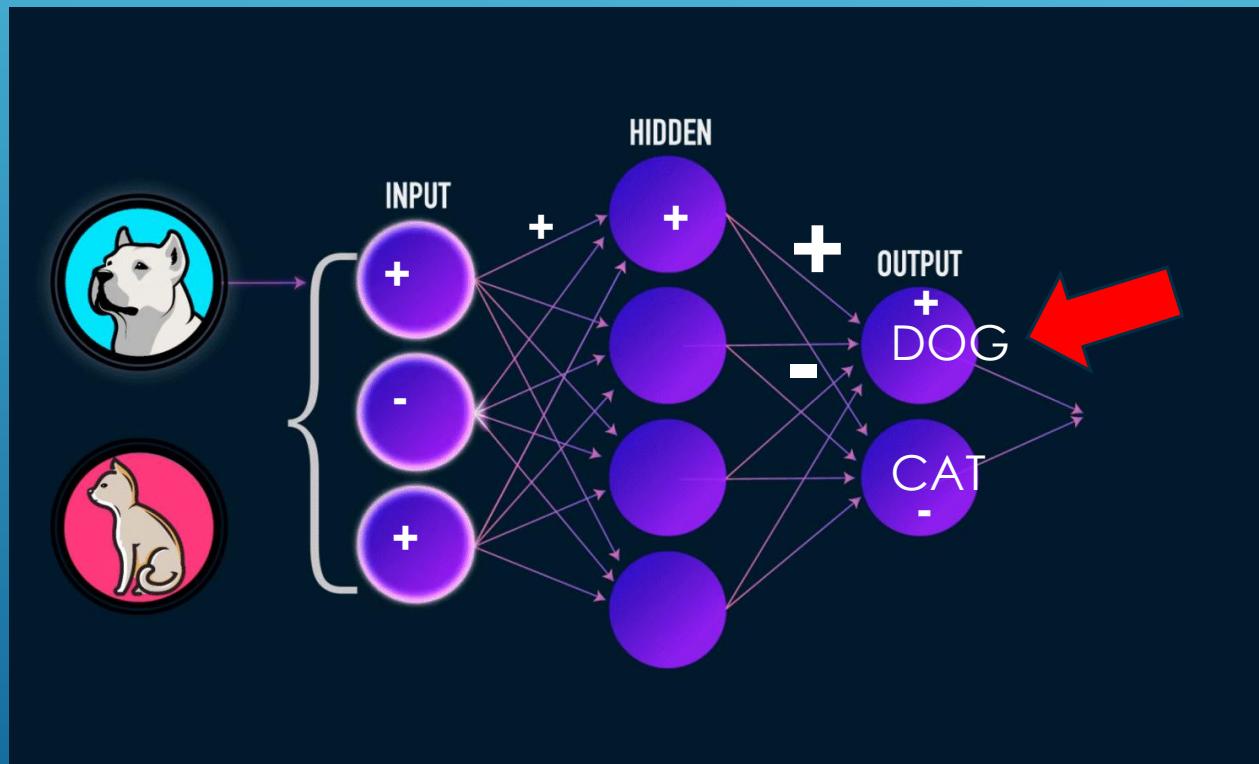
4. FEED DATA INTO THE NETWORK 'BACKPROPAGATION' – USE FEEDBACK TO AUTOMATICALLY ADJUST SYNAPSES



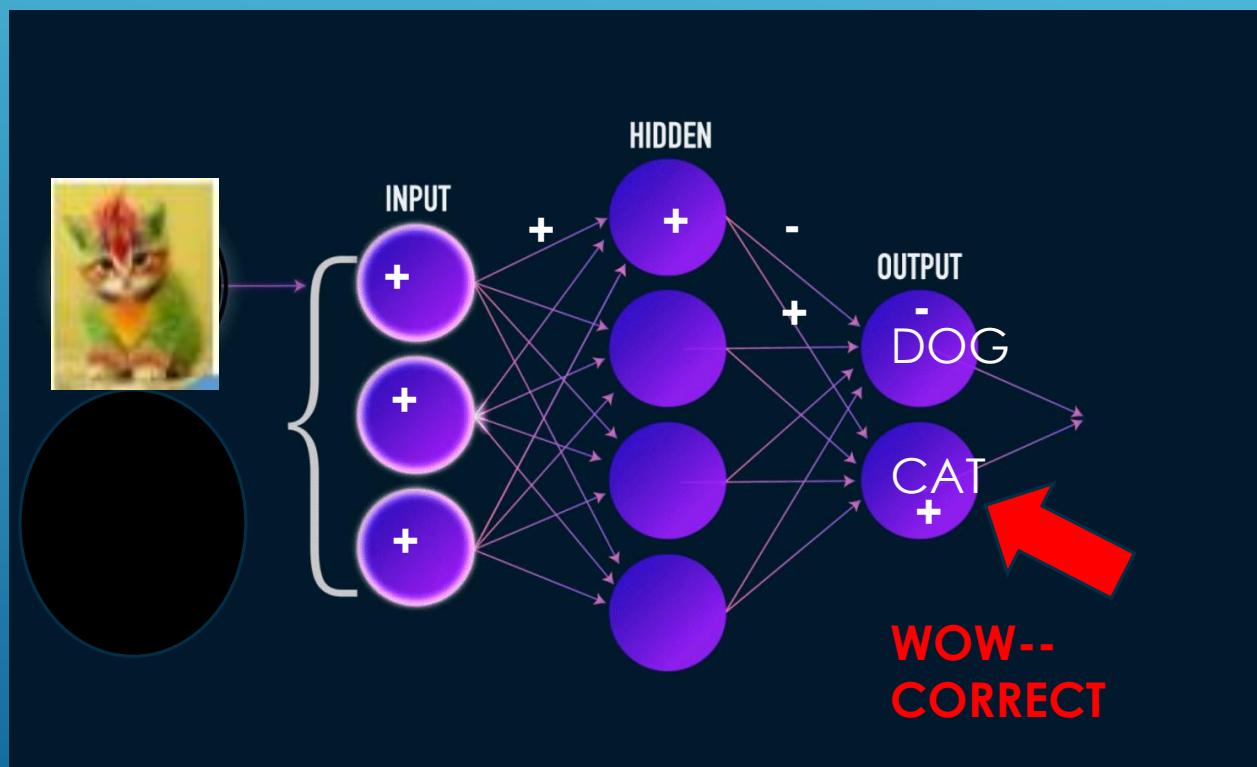
5. REPEAT #4

(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.....

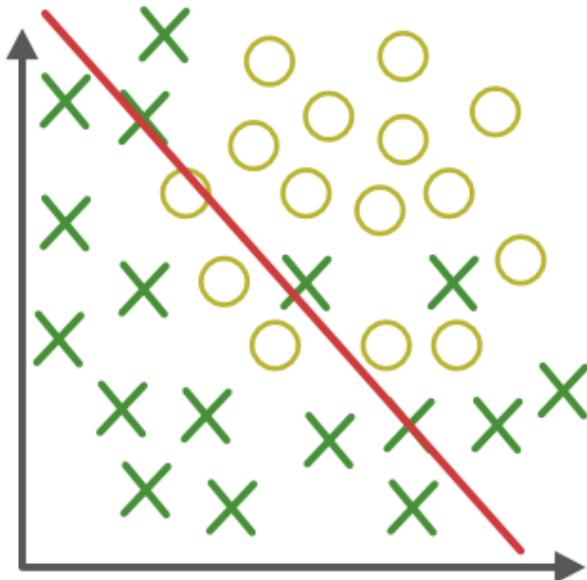


A wide-angle photograph of a tropical beach at sunset. The sky is filled with large, billowing clouds colored in shades of orange, yellow, and blue. The ocean in the foreground has small, white-capped waves crashing onto the light-colored sand. In the distance, a few palm trees and some low buildings are visible on the shore.

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

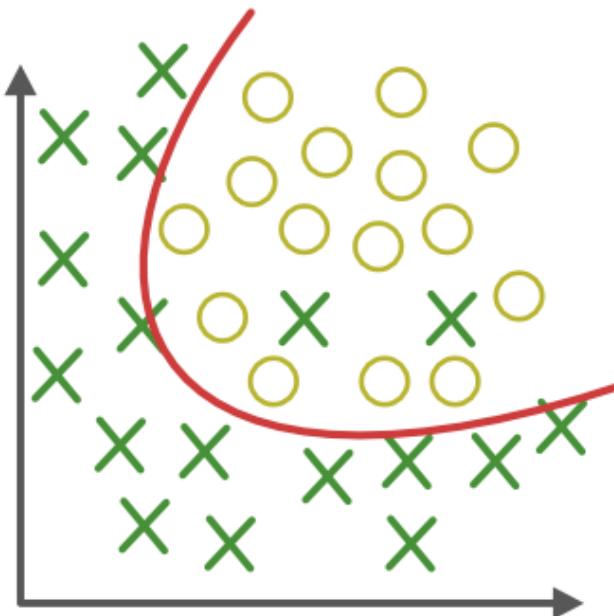
DEEP LEARNING EXPERTS SPEND MUCH TIME ON
'ALCHEMY' – TWEAKING THIS AND TWEAKING THAT
– TRYING TO AVOID OVERFITTING AND AVOID
UNDERFITTING...



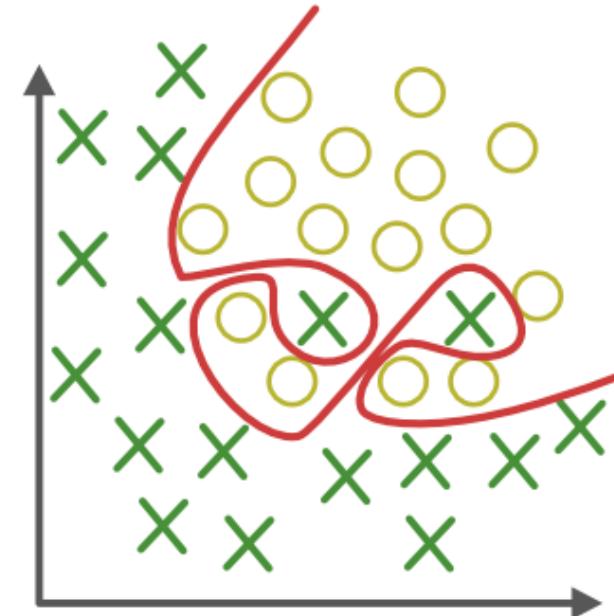


Under-fitting

(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*

API'S (APPLICATION PROGRAMMING INTERFACES) – MACHINE LEARNING LIBRARIES ALREADY WRITTEN, EASY TO INCORPORATE INTO SOFTWARE

ML APIs

Image Recognition

Image content analysis, Image classification, detects individual objects and faces, detects labels and logos from the images, etc.

Language Translation

Text translation, Language identification, etc.

Speech Recognition

Chatbots for basic questions and answers. Speech to text APIs, to convert call center voice calls into text.

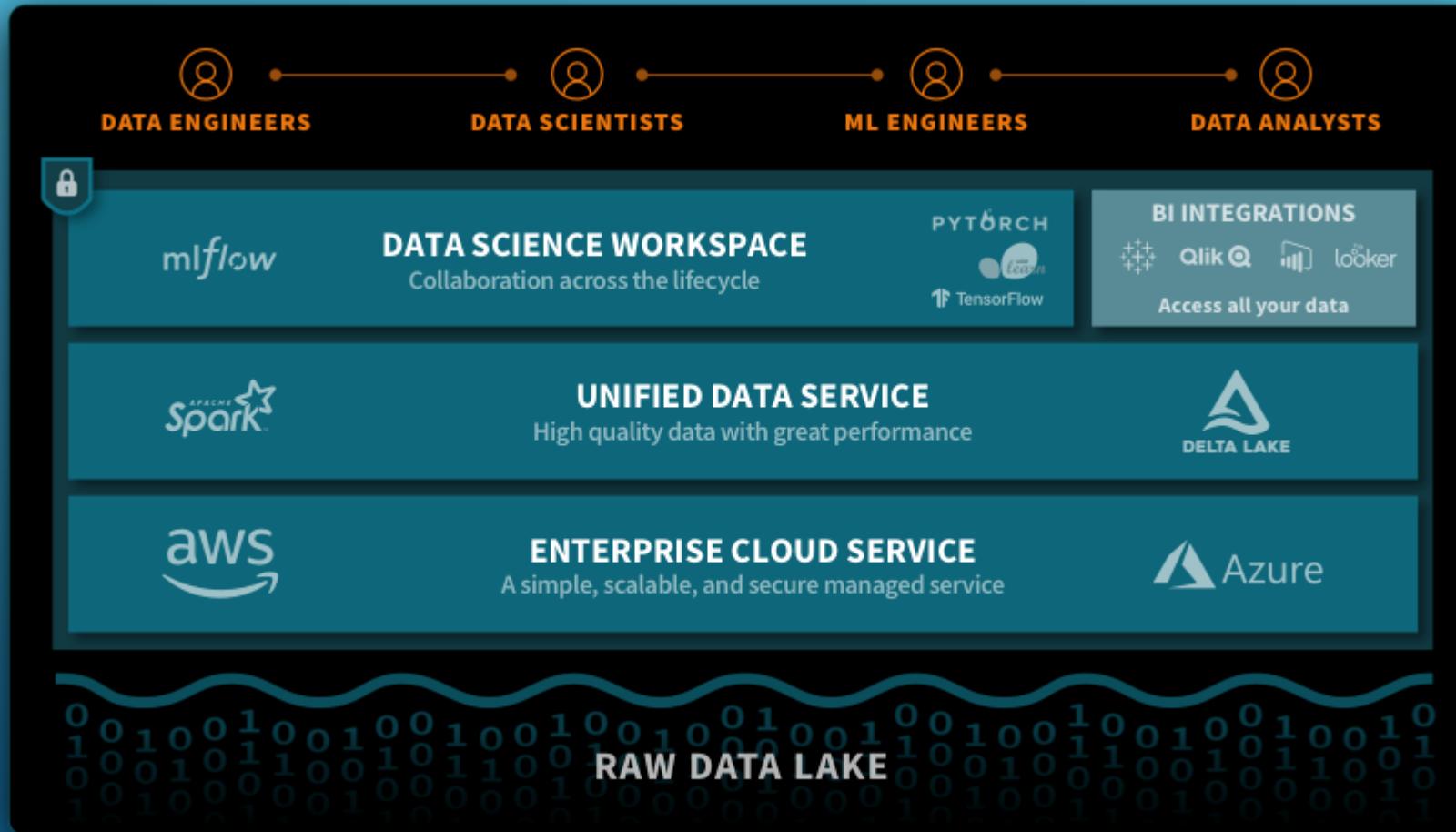
Text /Sentiment Analytics (NLP)

Social media monitoring/analysis, sentiment analysis, key phrase extraction, language detection, spam and topic detection.

Prediction

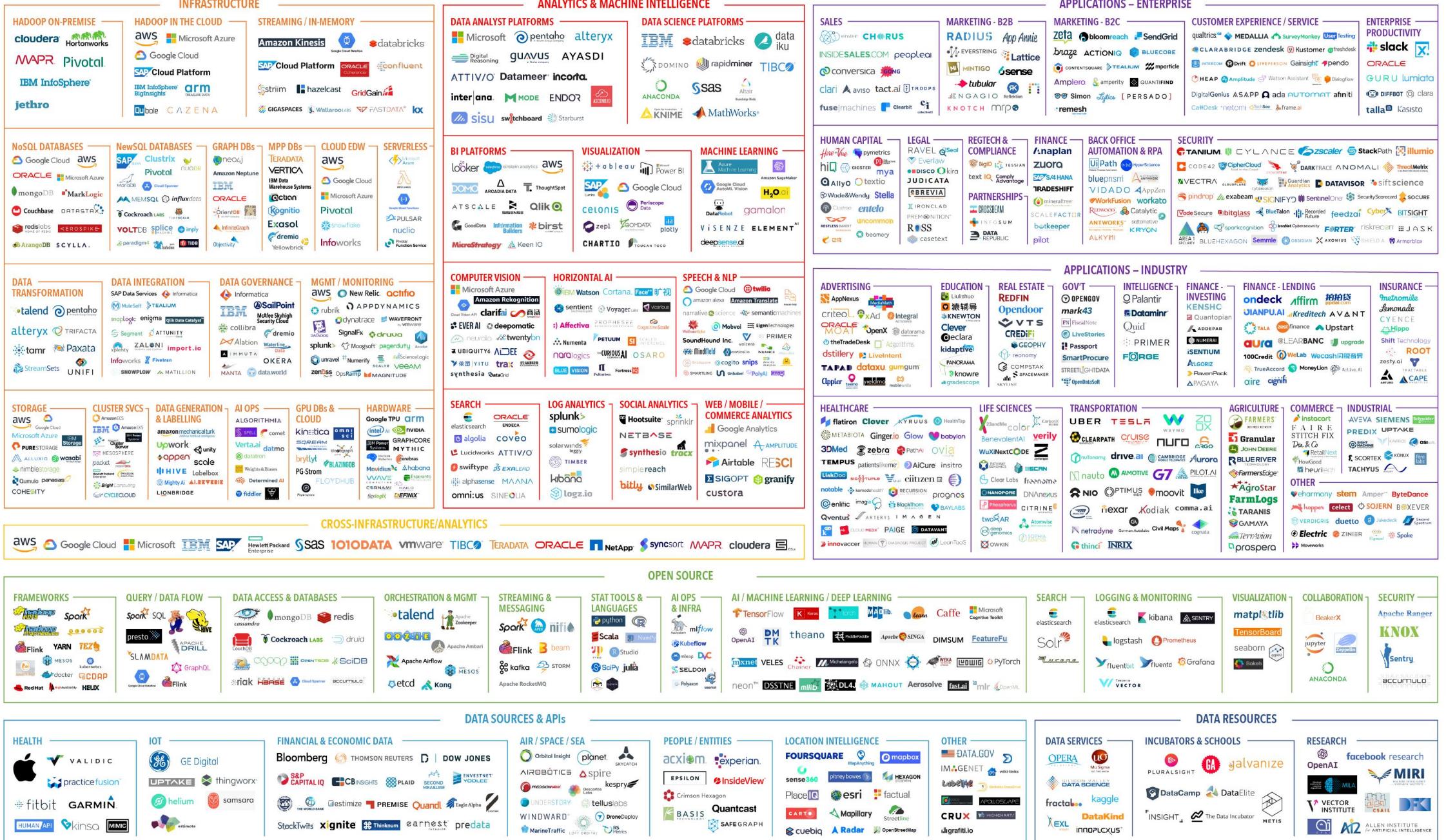
Fraud detection, customer churn, predictive maintenance, recommender systems and forecasting etc.

TOOLS TO LET USERS EASILY CREATE AND USE NEURAL NETWORKS

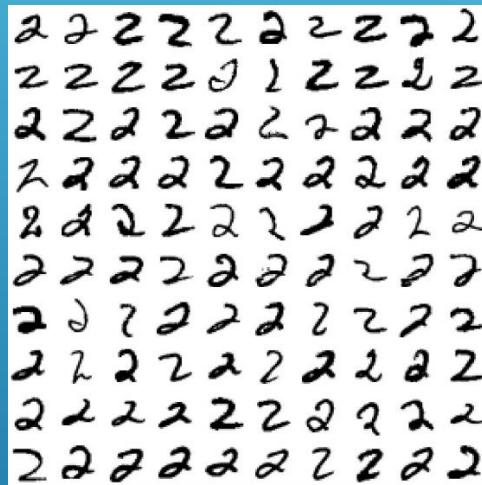


Too many tools??

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'?)

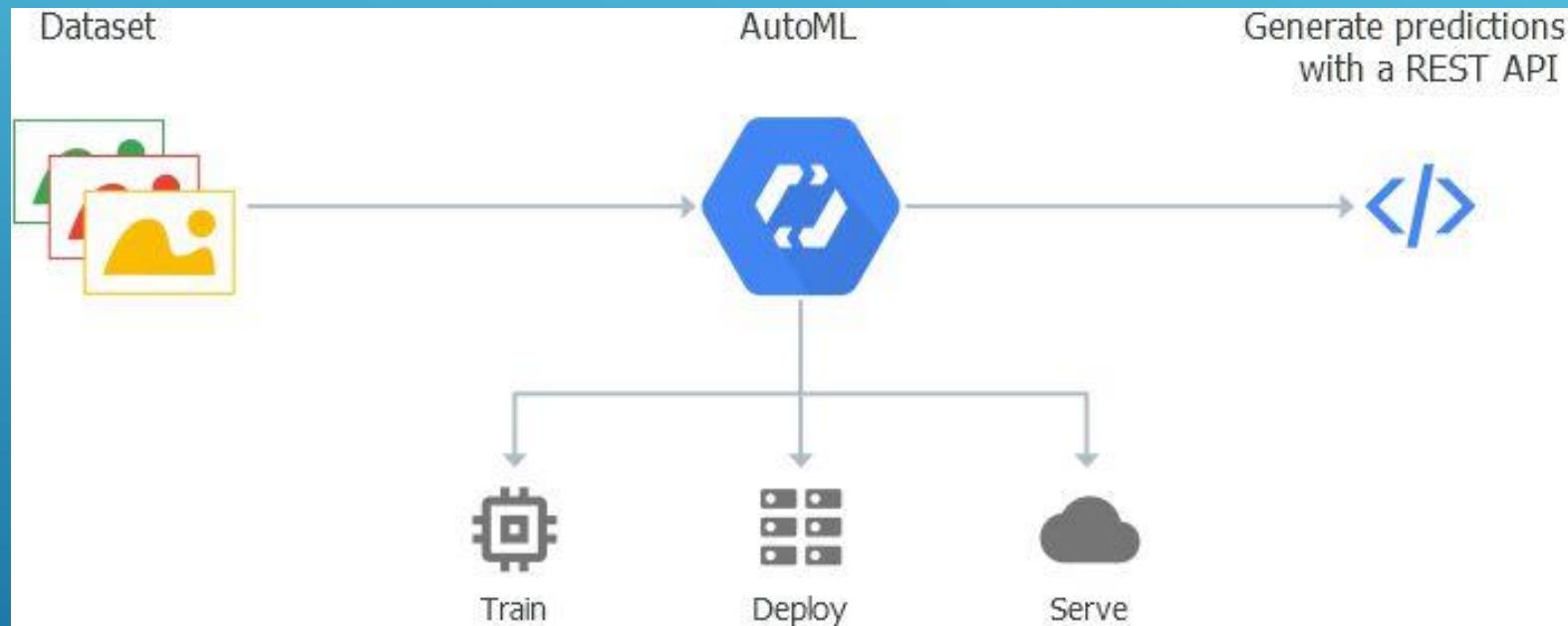


"Labeled data is the key bottleneck to the growth of the machine learning industry. In fact, labeled data is even more essential than algorithms."

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

81

'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



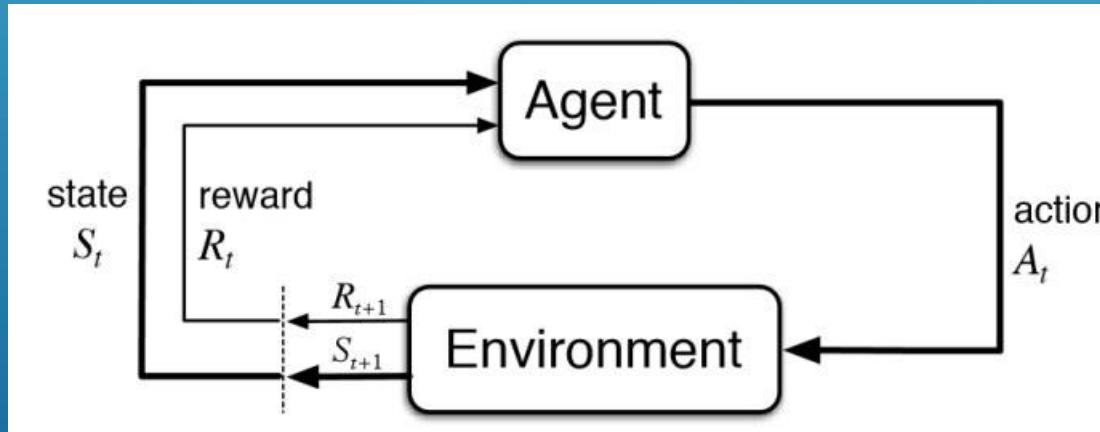
DEEP LEARNING ALL AROUND US NOW: ALL AROUND US NOW: SELF DRIVING CARS....



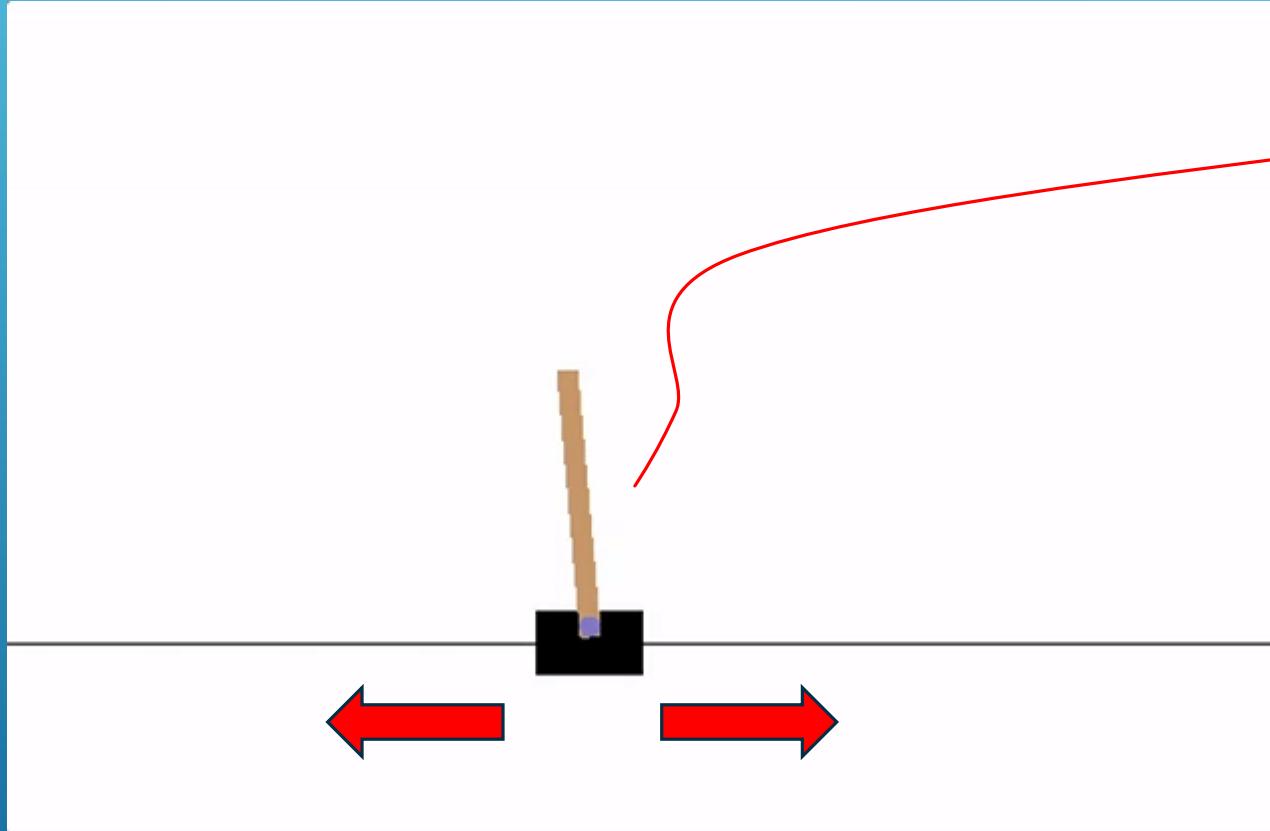
84

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)

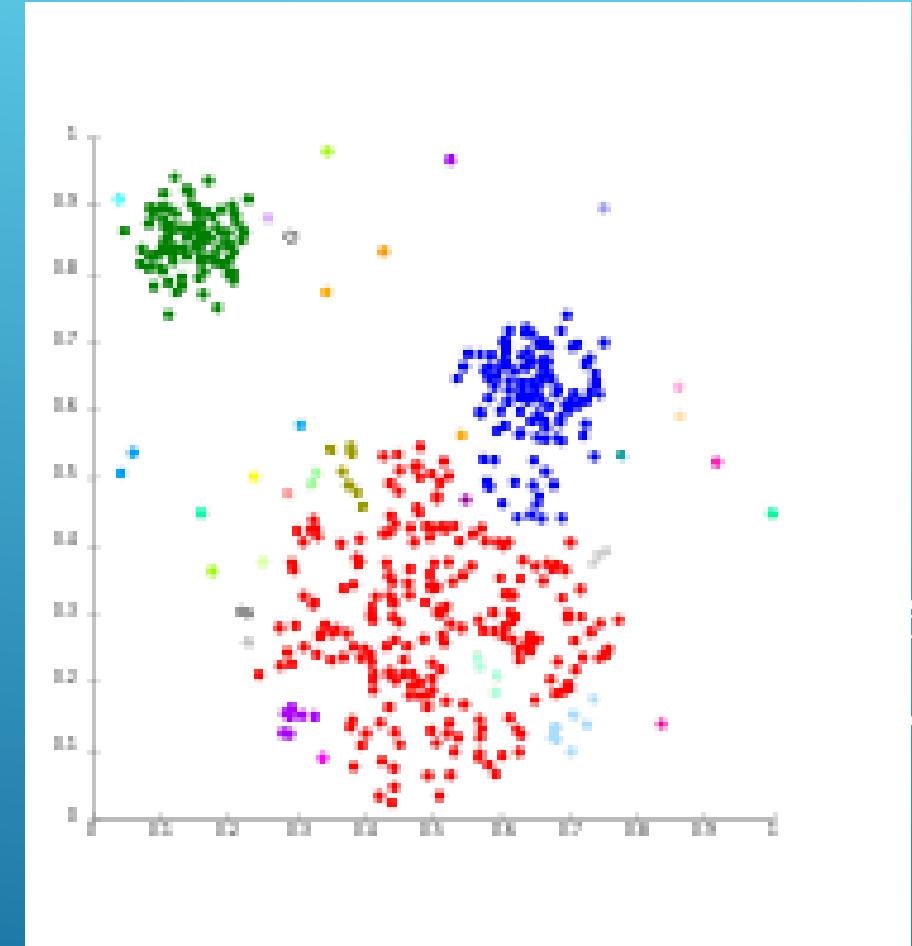


TYPES OF MACHINE LEARNING

- 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



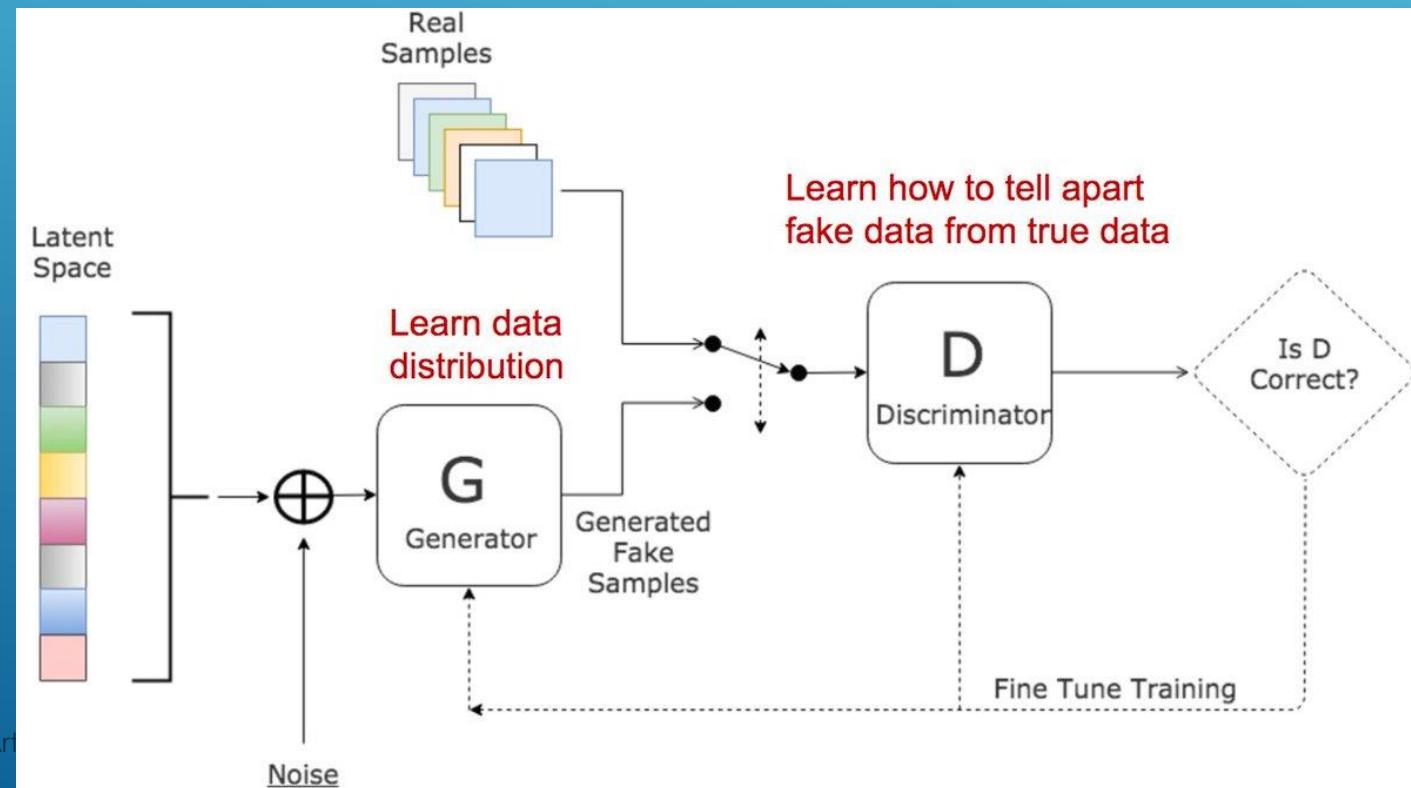
90

March 2020

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

(all of these people created by the computer – none have ever existed!!)

- '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, EG, TF-QUANTUM)
- 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)?

99

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?

100

March 2020

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
- ▶ 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



← **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** – Université de Montréal
- Ian Goodfellow** – Univ de Montréal, inventor of **GANs** (then Google Brain and then Apple)
- University of Waterloo** -- **TensorFlow Quantum** (future??)

105



← **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.

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

OR....



108
March 2020

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?

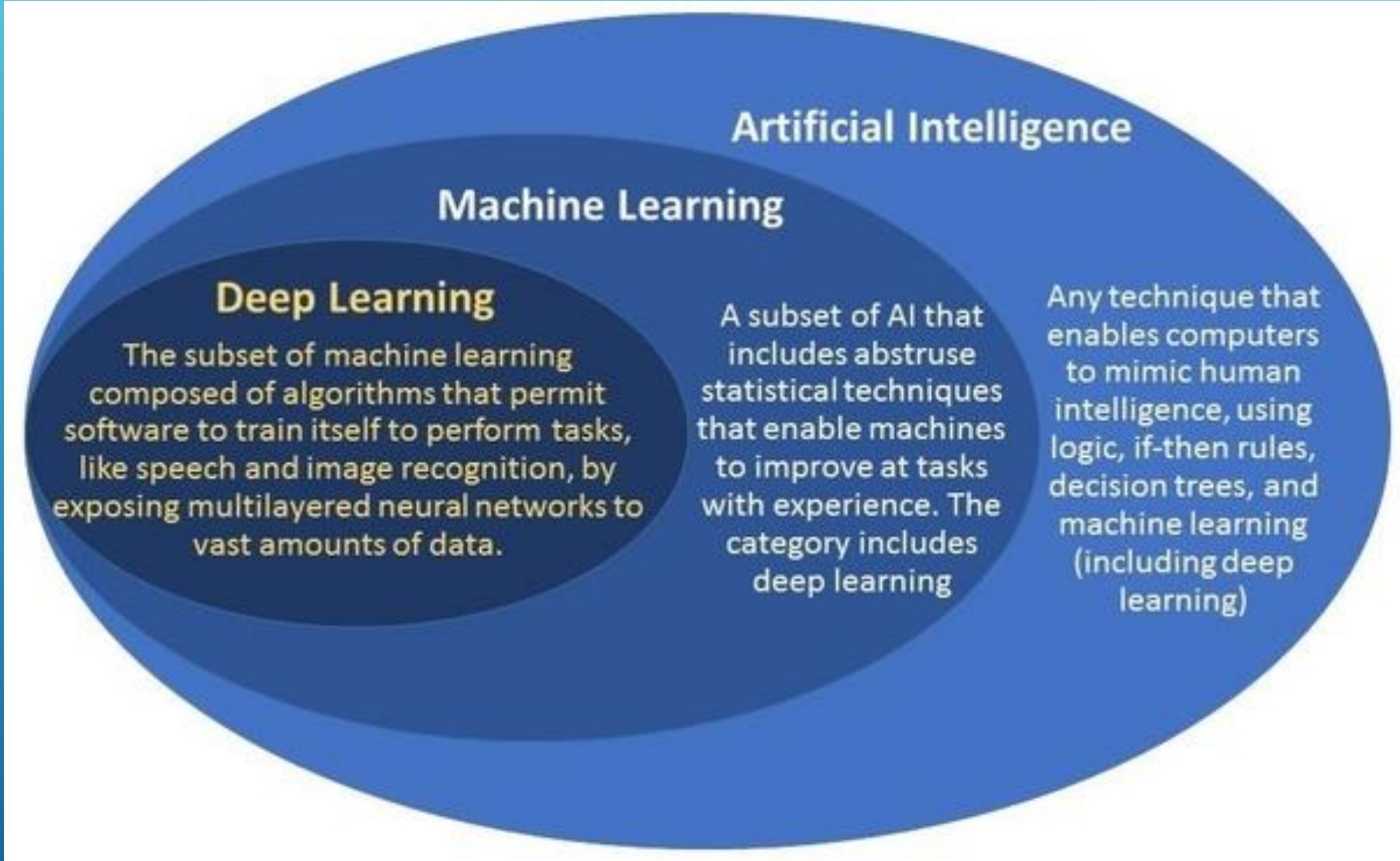
Wozniak Test – AI/machine must go into a typical home and figure out on its own how to make a cup of coffee

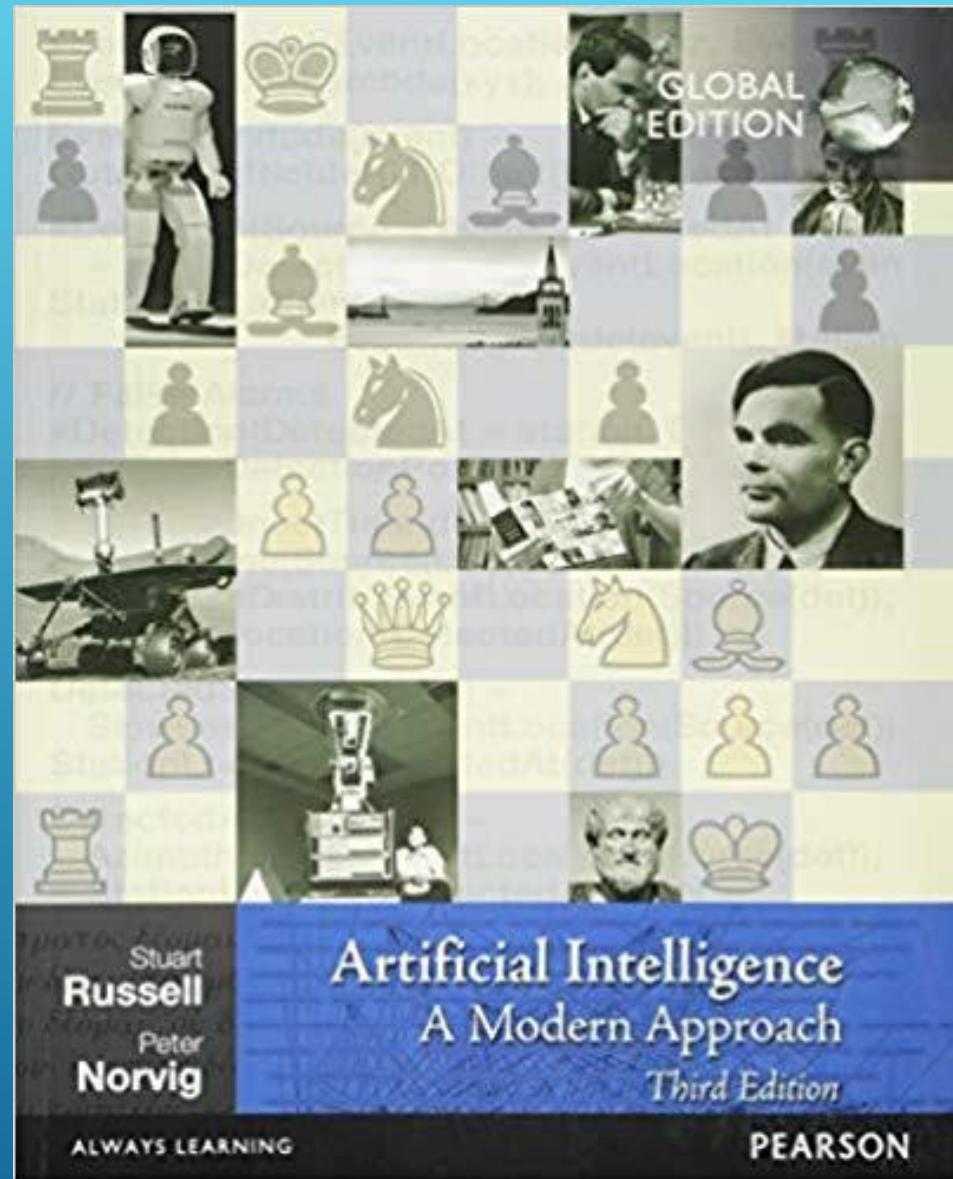
Legg & Hutter – Universal Intelligence (2007)



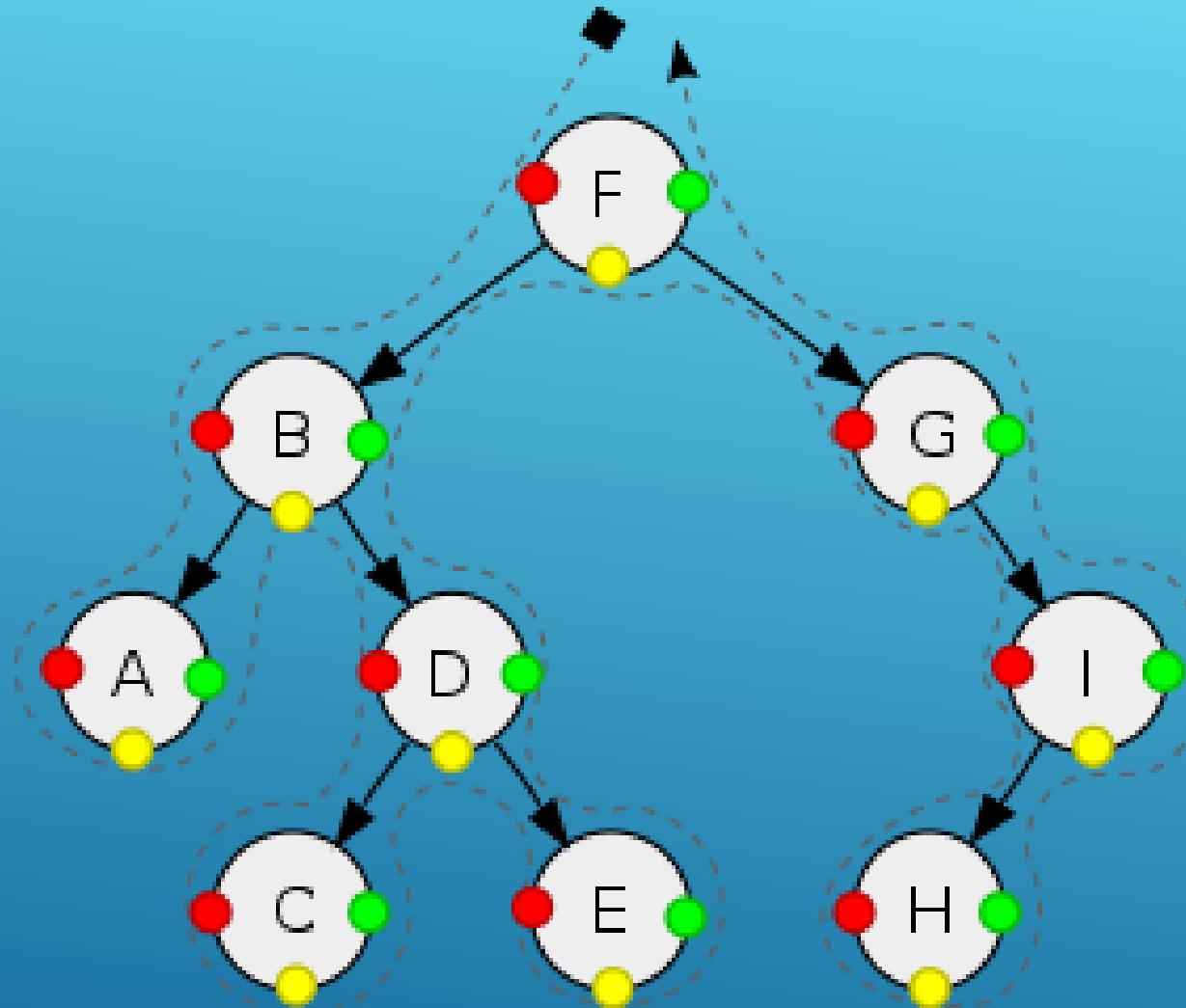
← Let's quickly try to make
senses of where Deep
Learning fits into all of this

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





SEARCH



113

March 2020

LOGIC

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

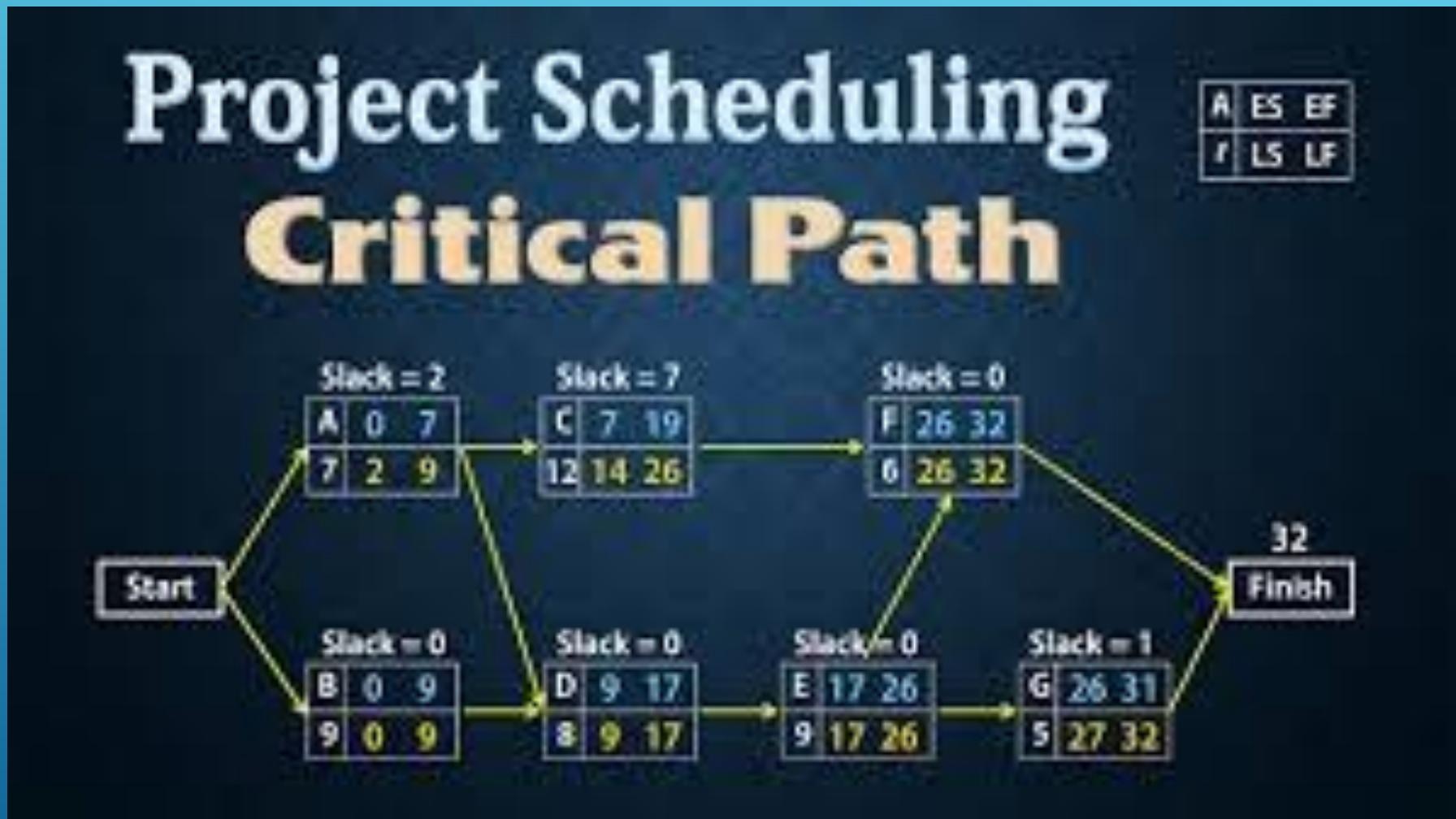
Given any x where it is a king and greedy this implies x is evil

(“All greedy kings are evil”)

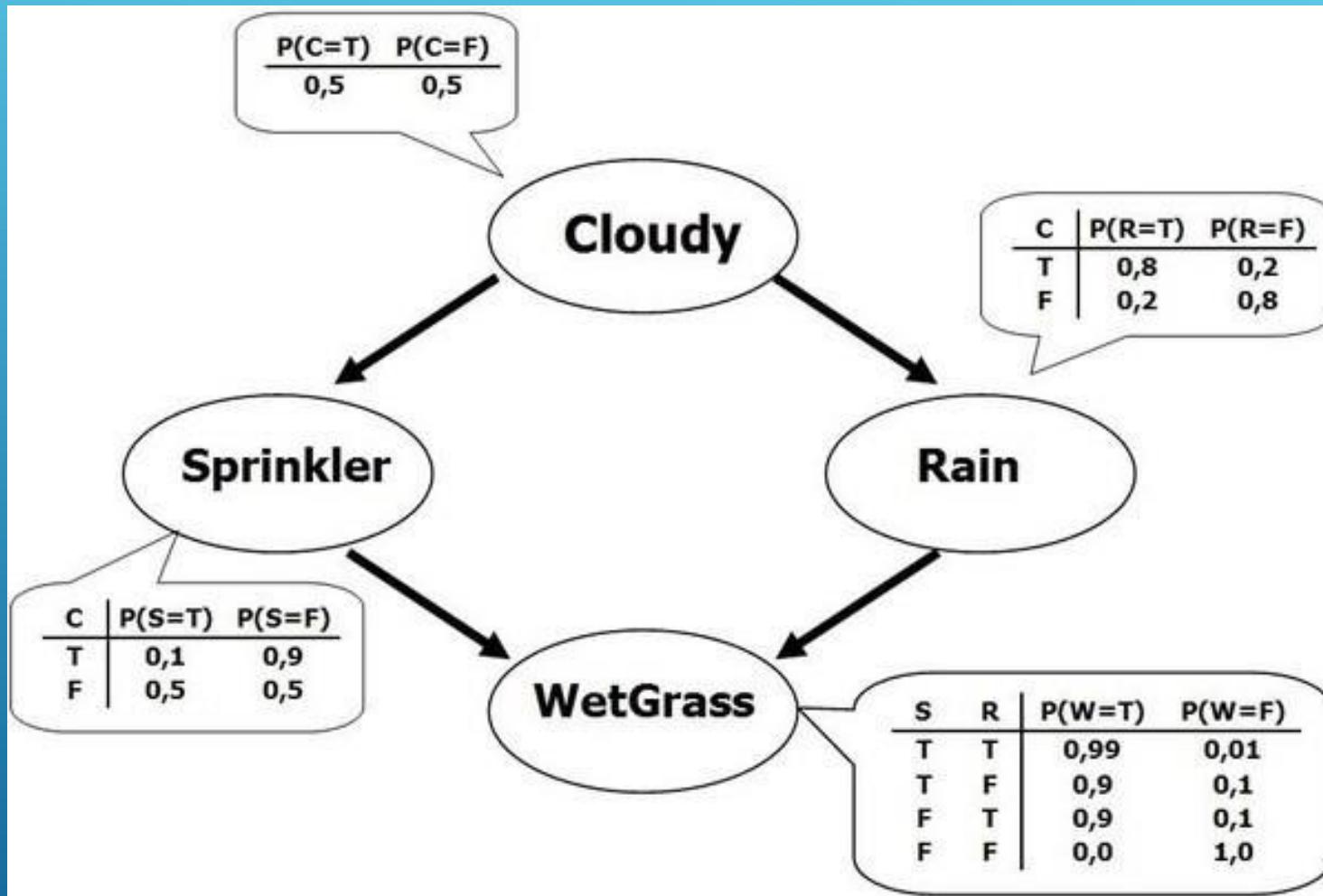
Therefore can infer:

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

PLANNING



PROBABILISTIC REASONING

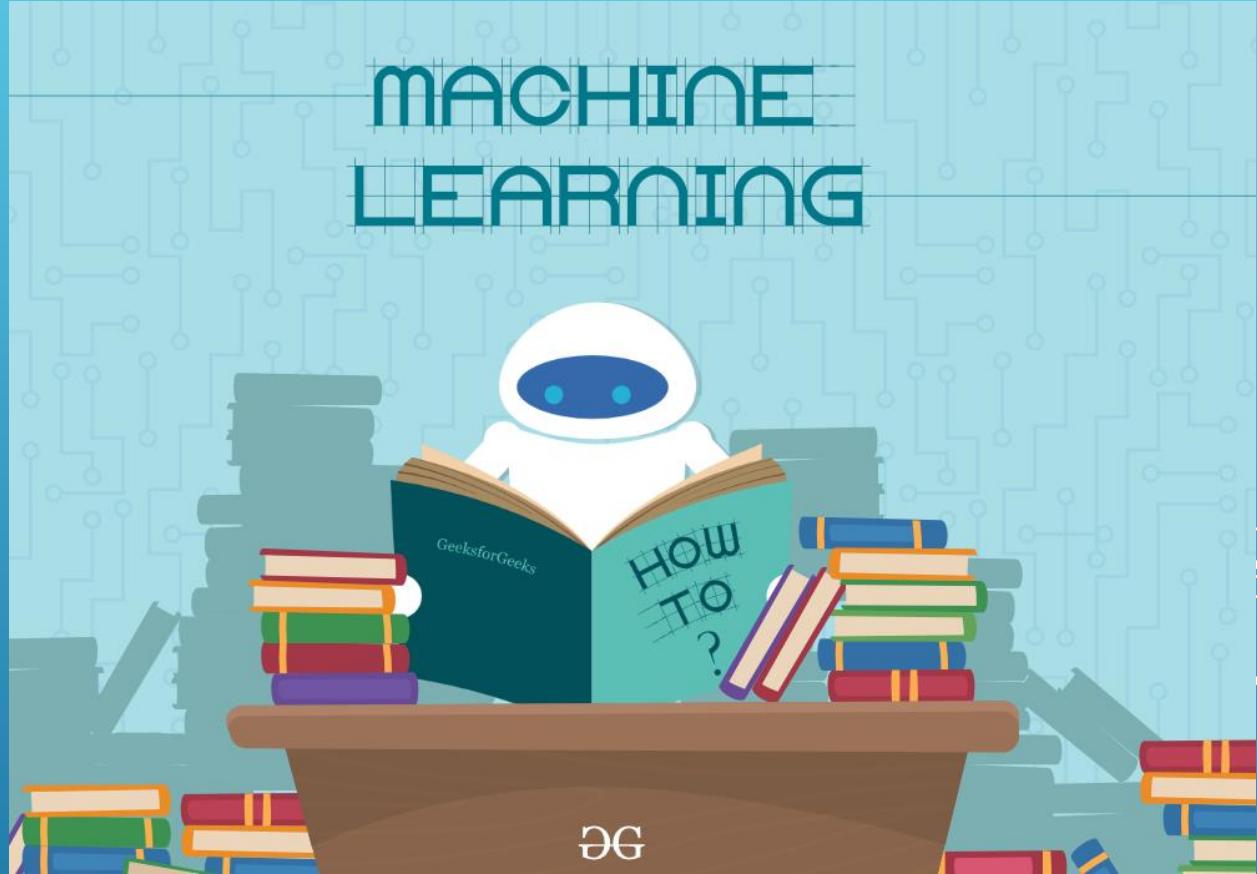


LEARNING

Learn from examples
Forms of learning
Knowledge in learning
Inductive learning

.....

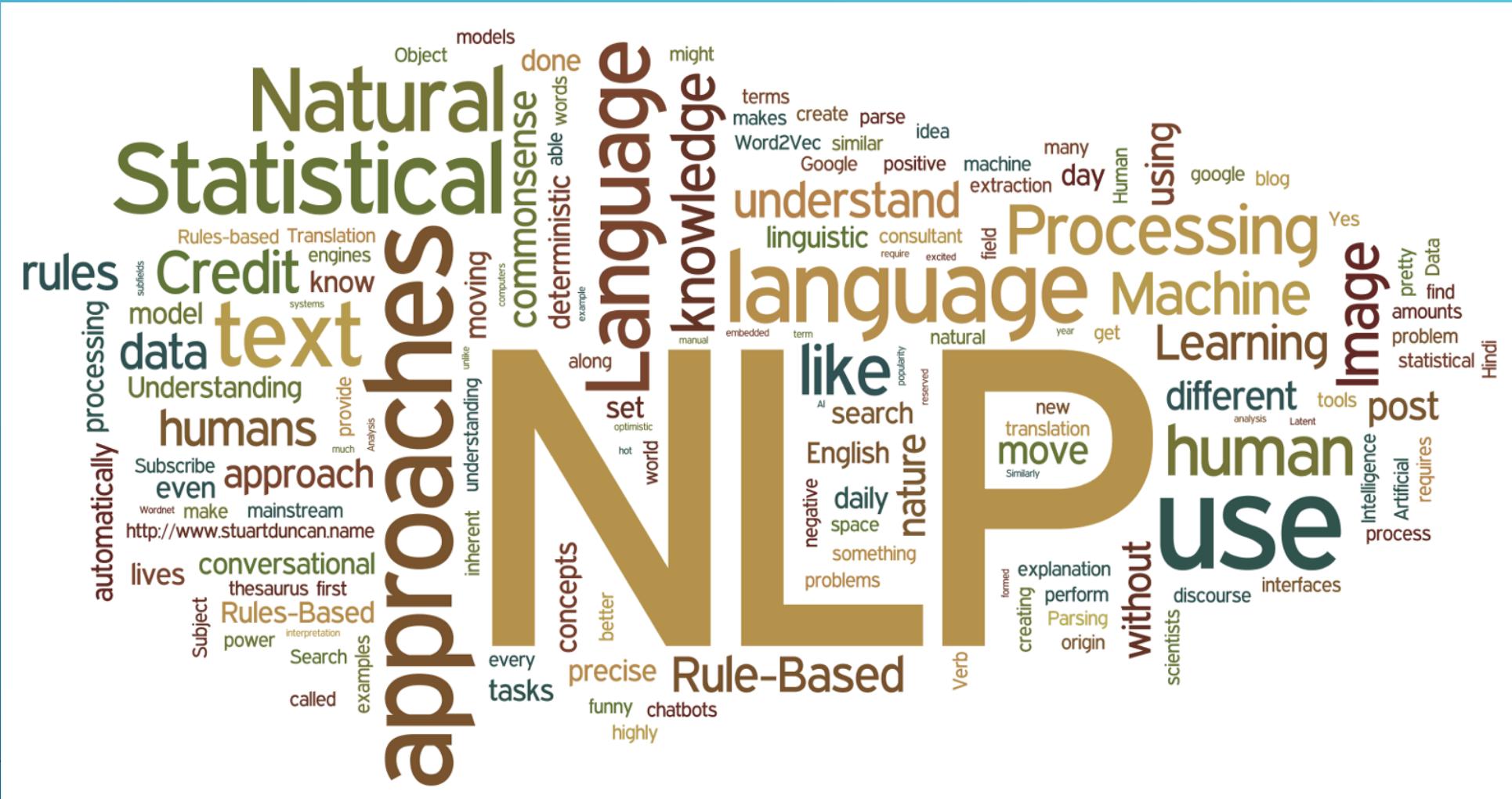
.....



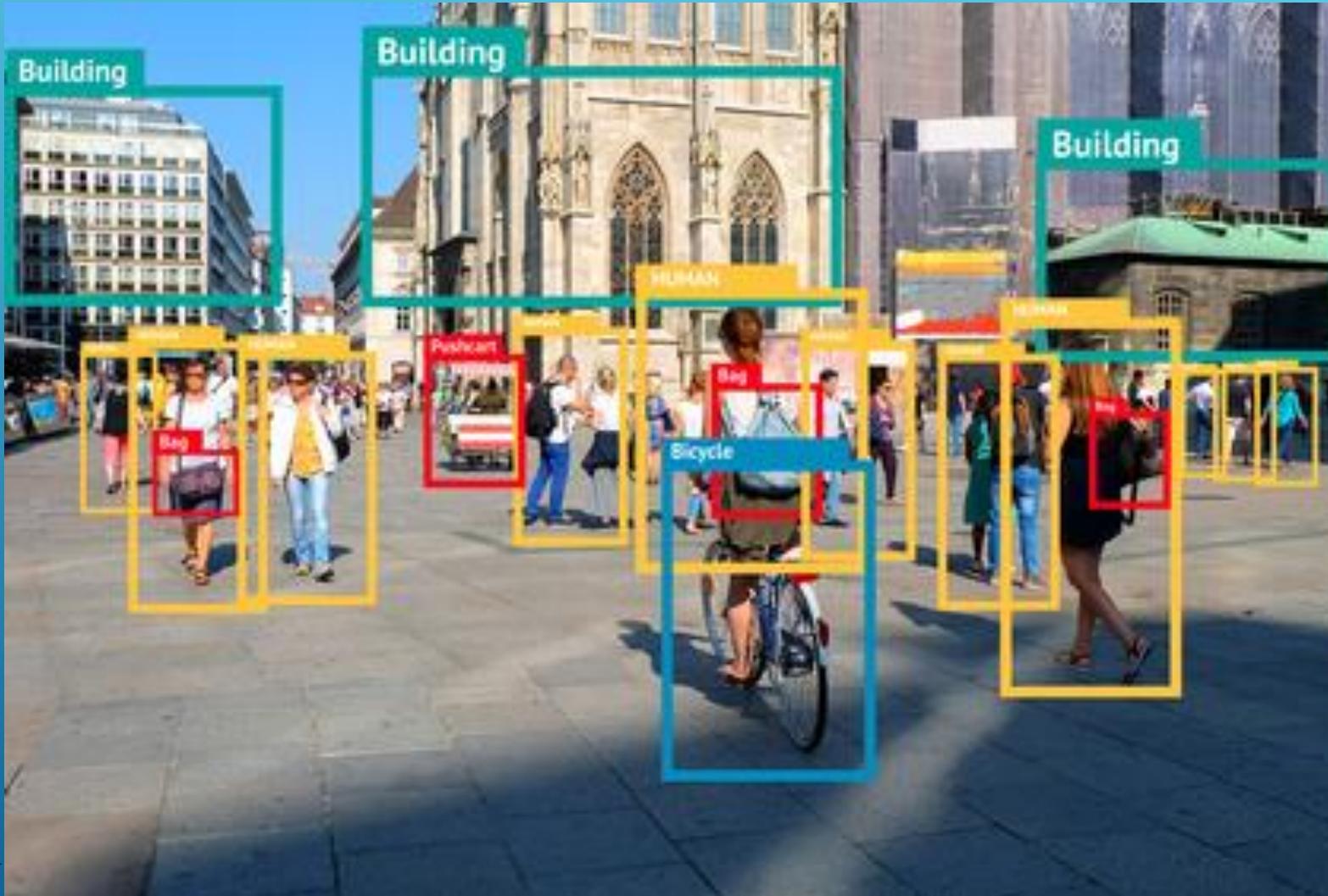
117

March 2020

NATURAL LANGUAGE PROCESSING

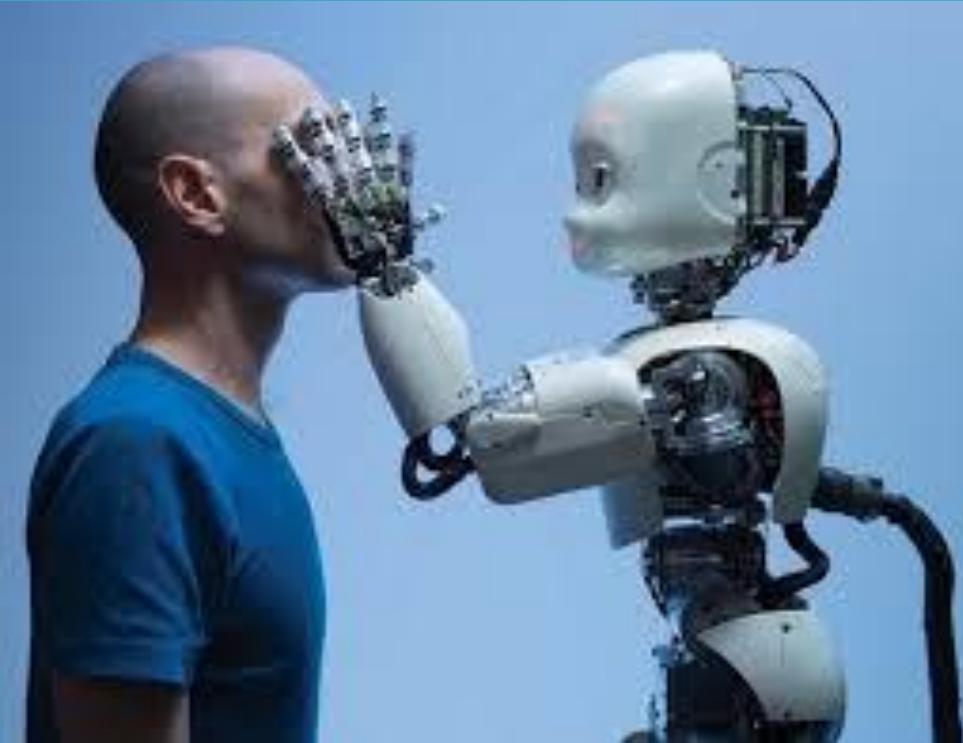


VISION, PERCEPTION



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
5th 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

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:

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

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
5th 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

QUIZ – QUESTION 1.

WHAT IS REINFORCEMENT LEARNING?

124

March 2020

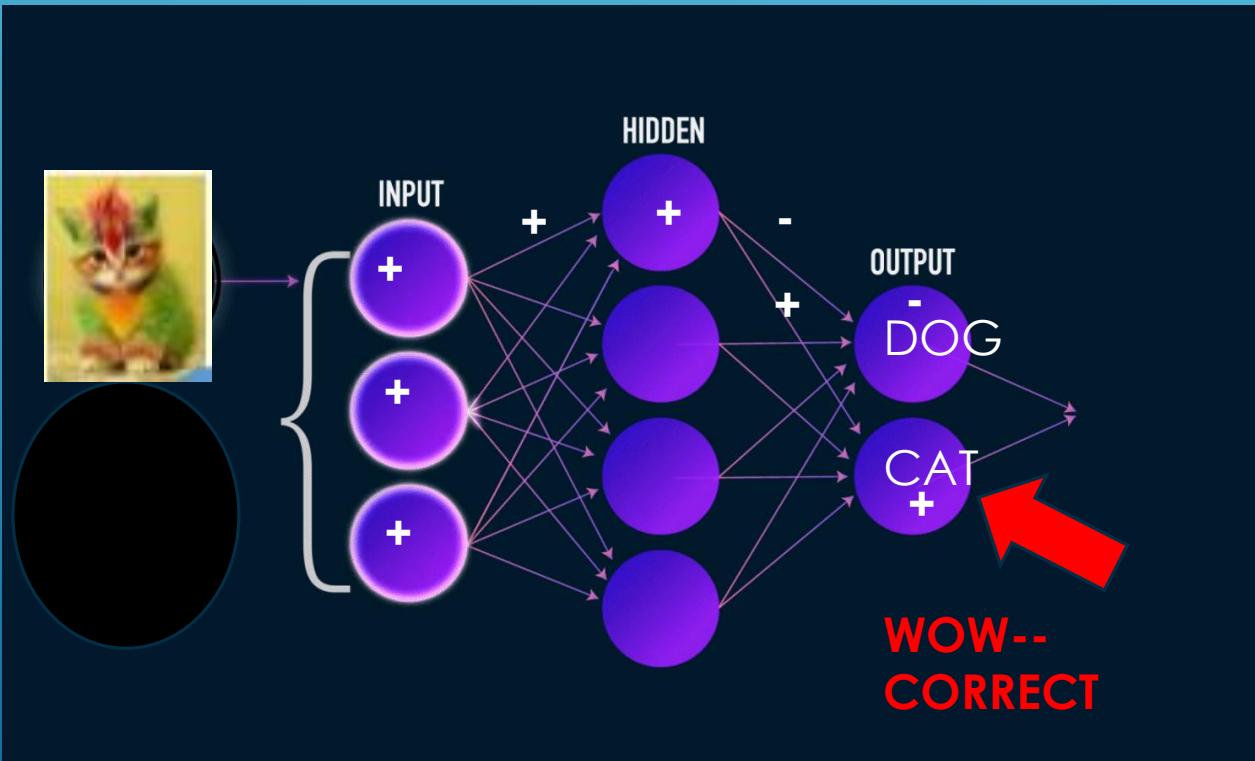
REINFORCEMENT LEARNING

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

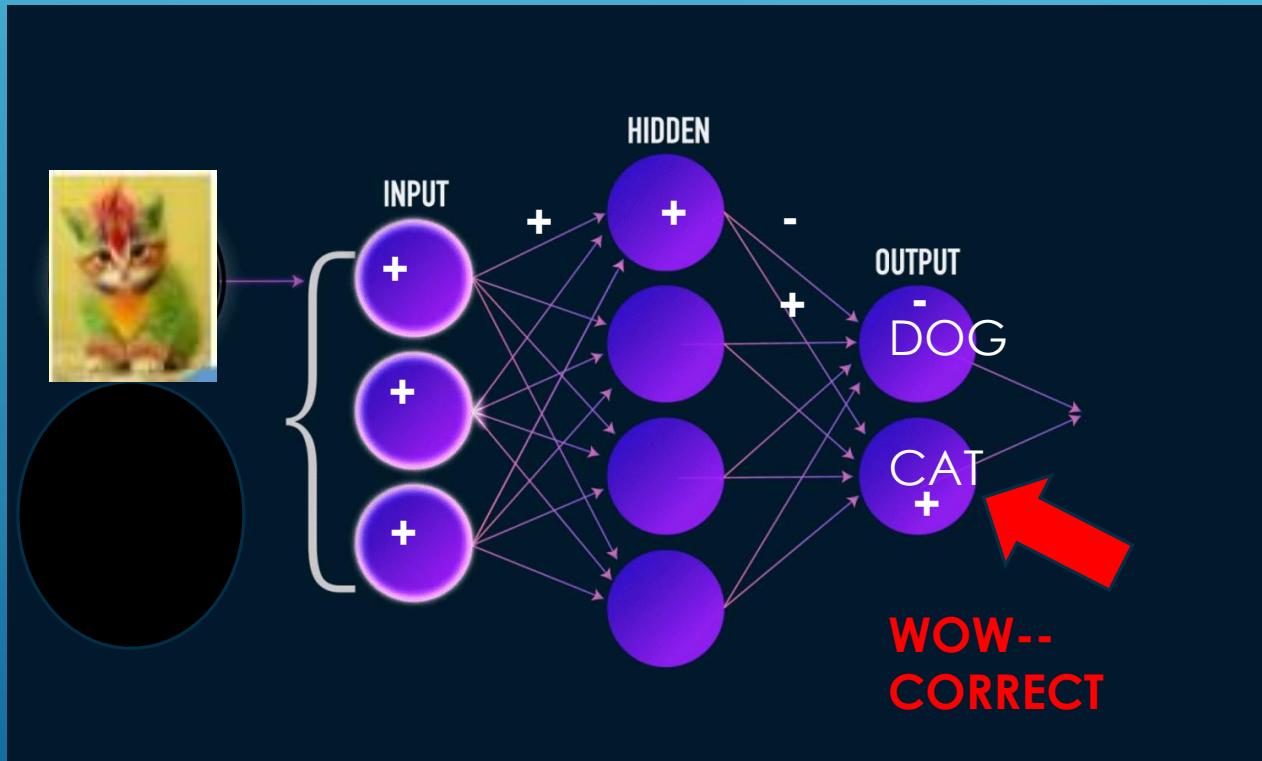


Deepmind 2017: Alphazero –
superhuman performance in
chess, shogi & go

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:

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

129

March 2020

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:

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

130

March 2020

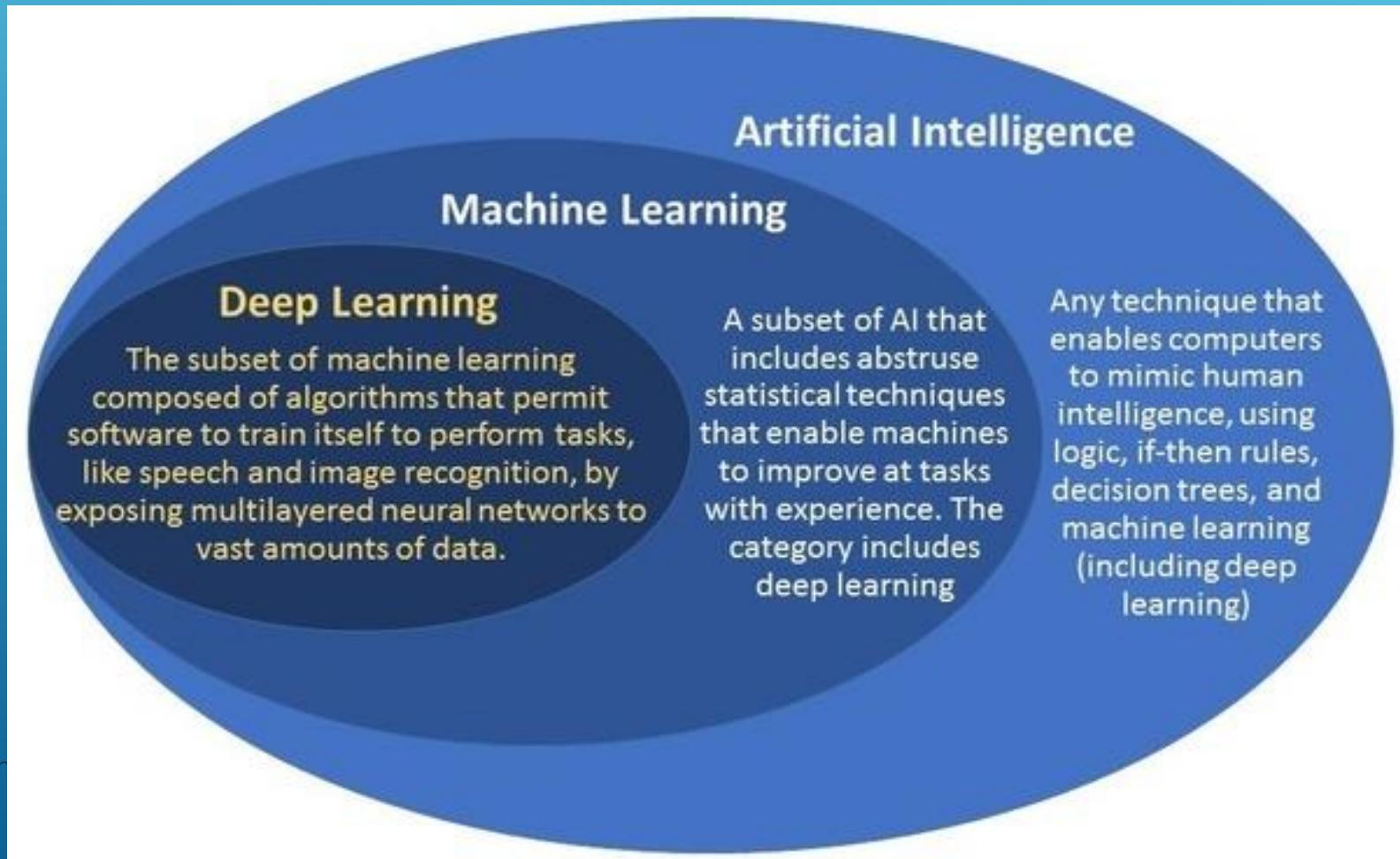
GOOD OLD FASHIONED ARTIFICIAL INTELLIGENCE “GOFAI” == “SYMBOLIC AI”

```
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
```

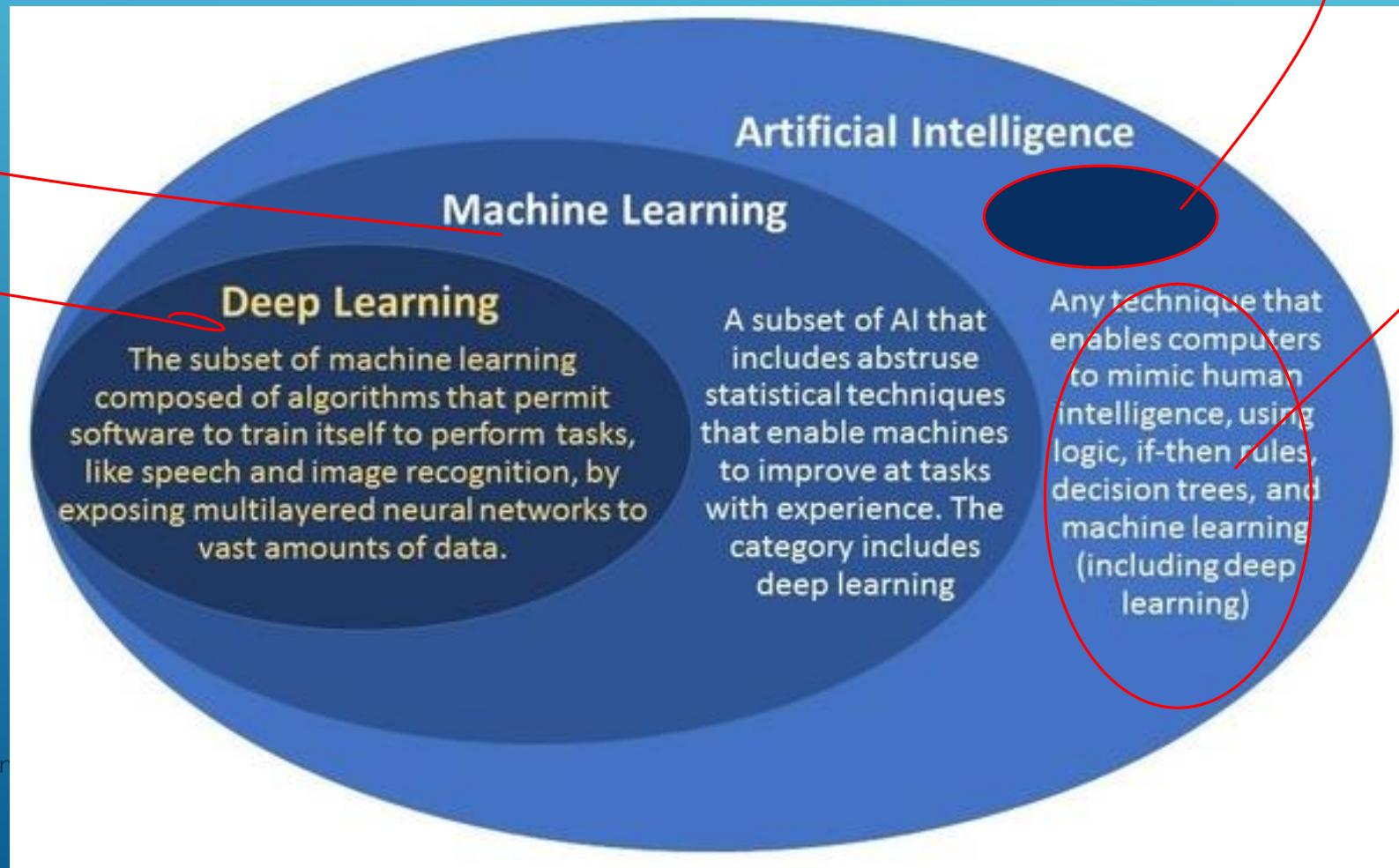
Quiz – question 4

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
- ▶ 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

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 136 few examples (eg, Gopnik)



“panda”
57.7% confidence

+



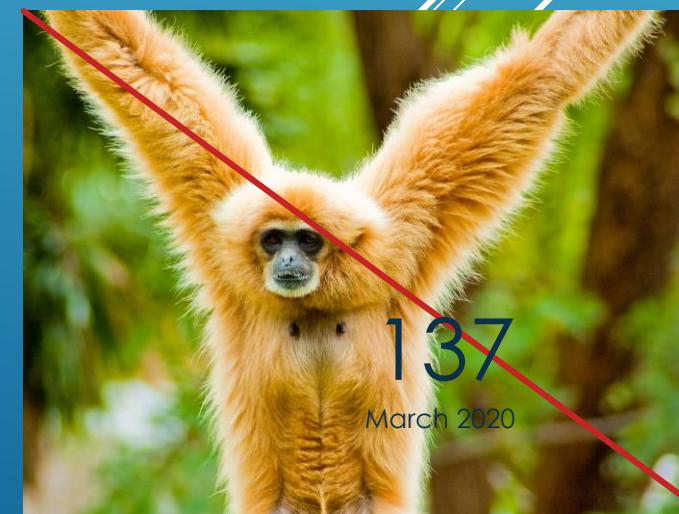
=



“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

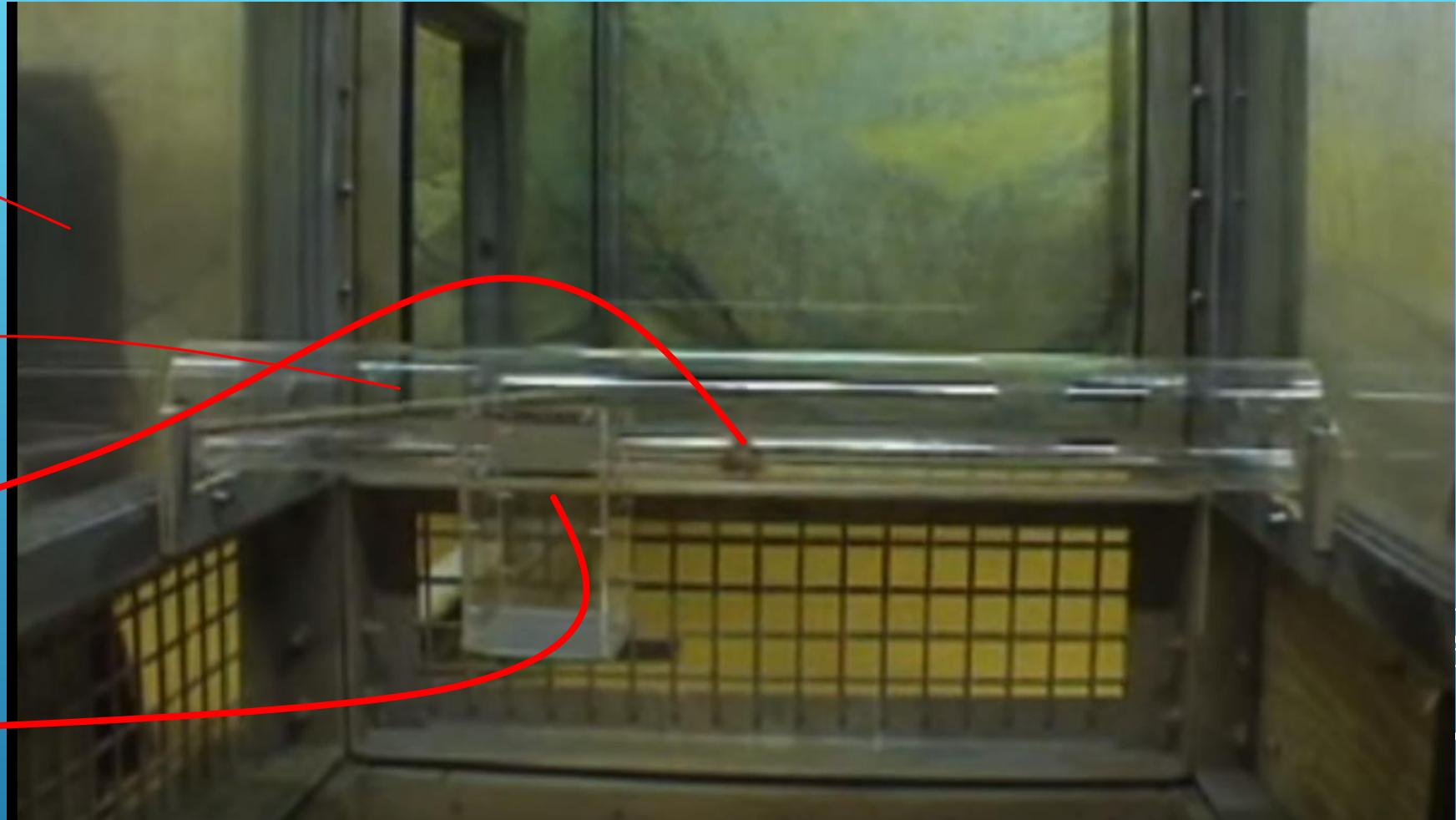
138

Chimpanzee (behind plexiglass)

Stick to push or pull food

Food

Gravity trap



Chimpanzees **do not** have full causality

139

March 2020

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

140

March 2020

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**

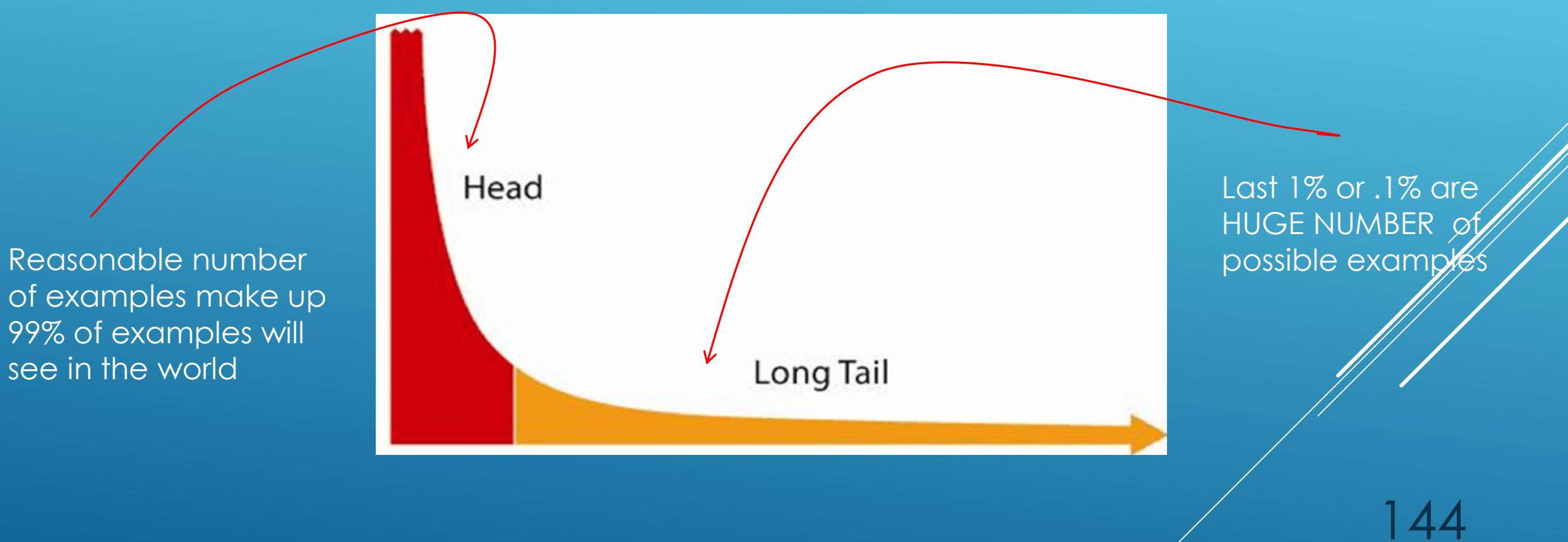
Eg, Tesla has about a billion miles of driving experience of its cars as training data now.

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

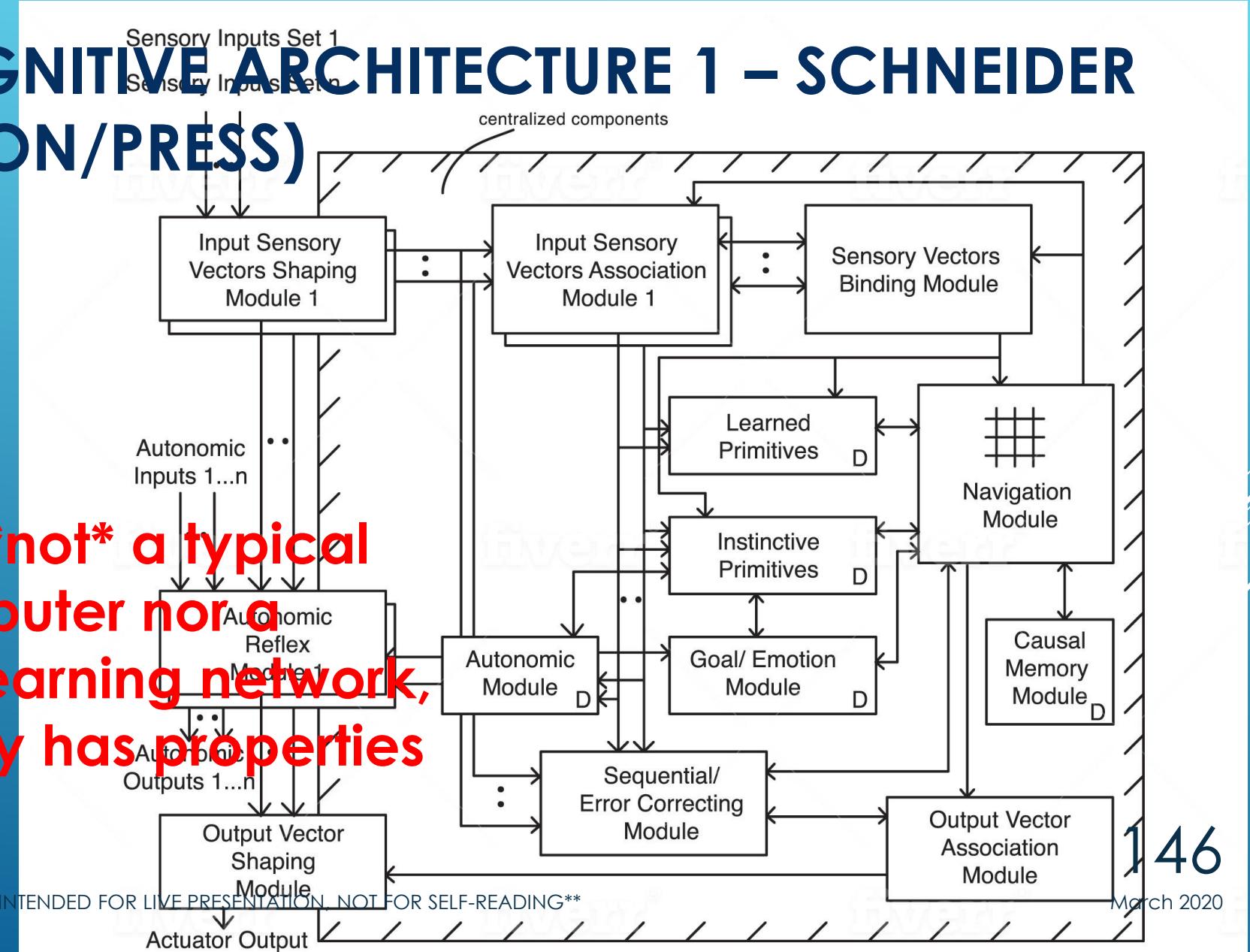
-Uber's system never had training with image of pedestrian pushing bike across the middle of the street
-Volvo normal system: did detect (6secs) but ignored



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

- ▶ 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**

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”**

150

March 2020

- 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**

AI -- NEXT DECADE

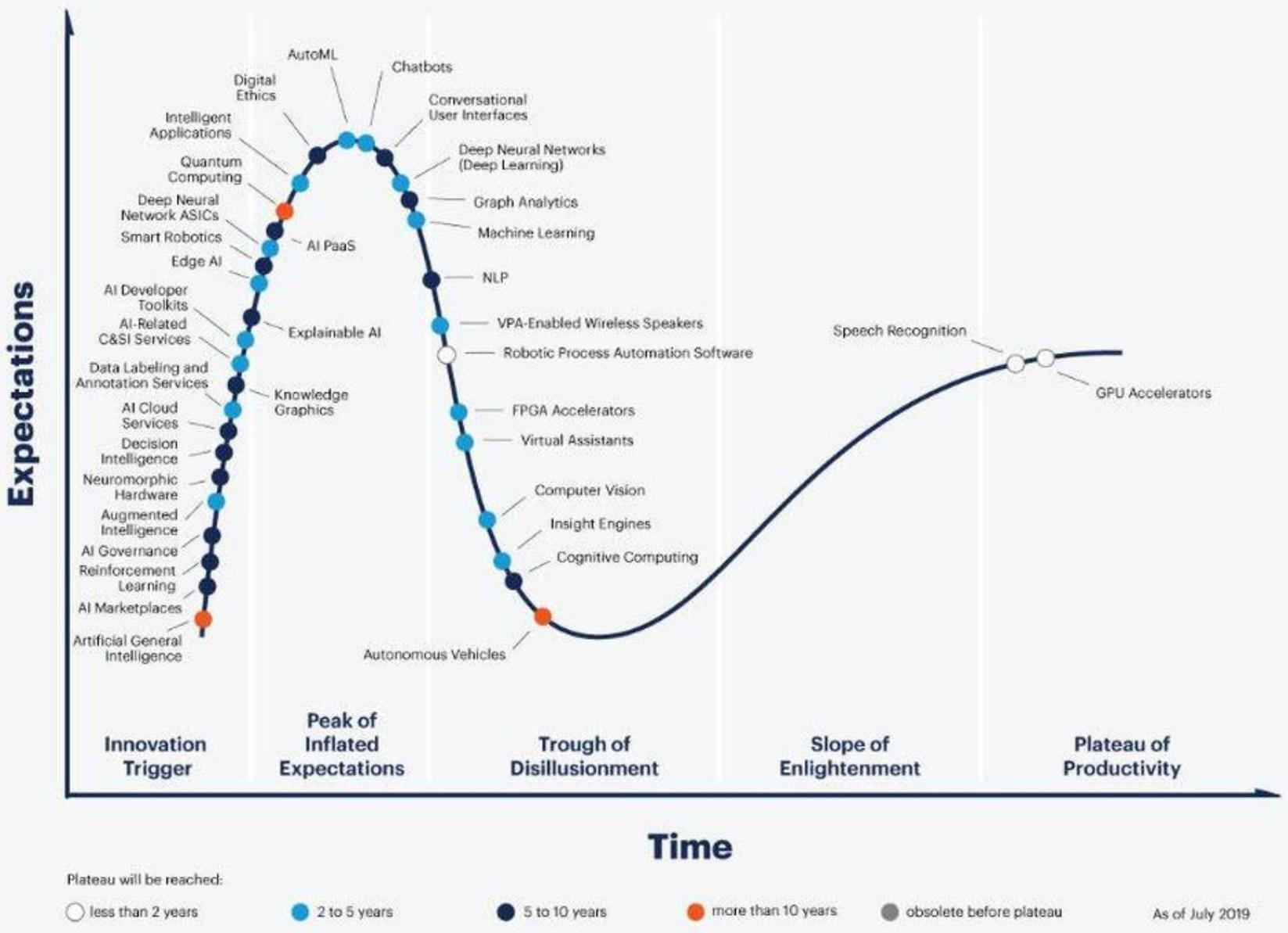
*“It's tough to make predictions,
especially about the future”*

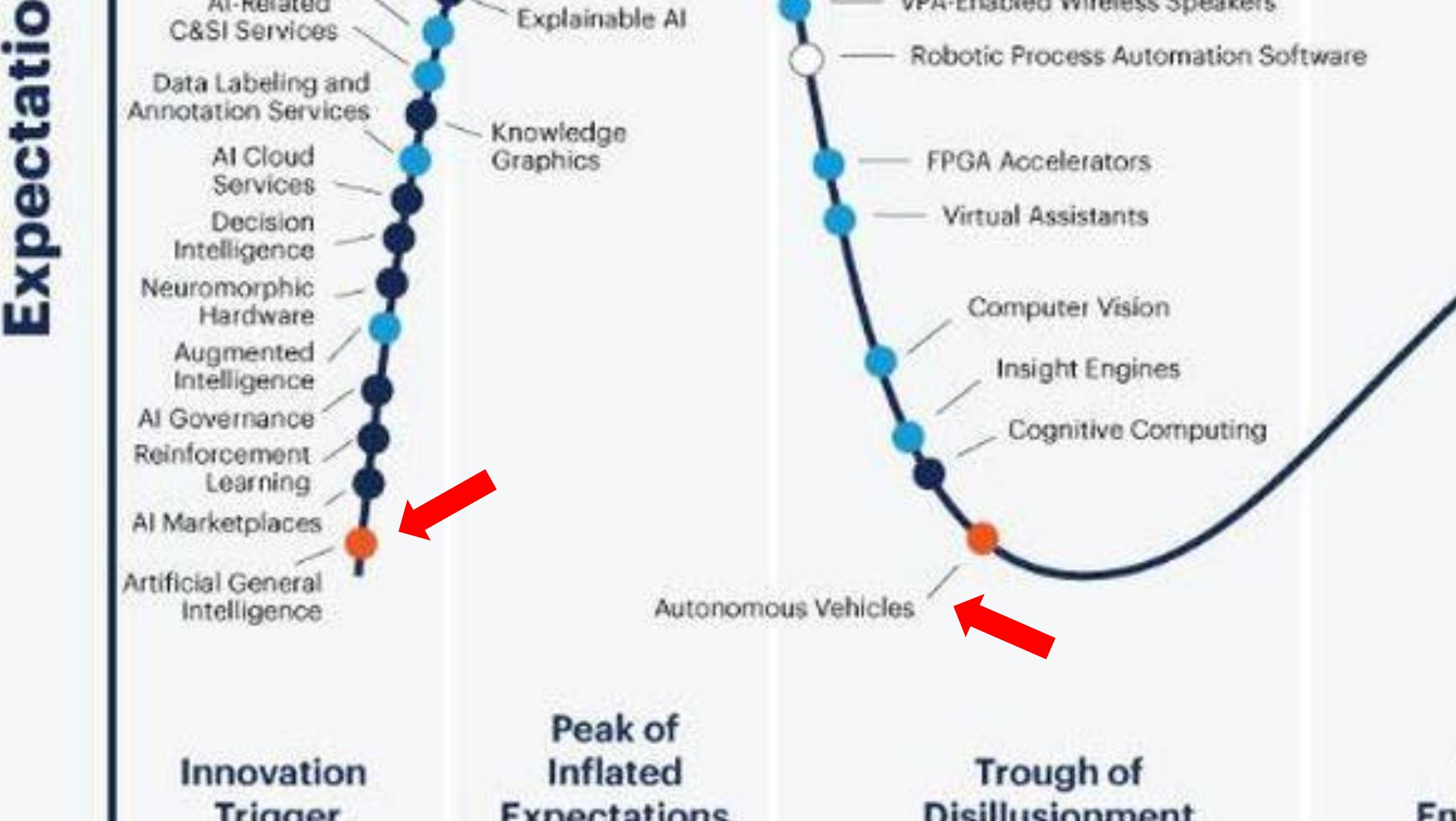
--Yogi Berra

152

March 2020

Gartner Hype Cycle for Artificial Intelligence, 2019





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

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

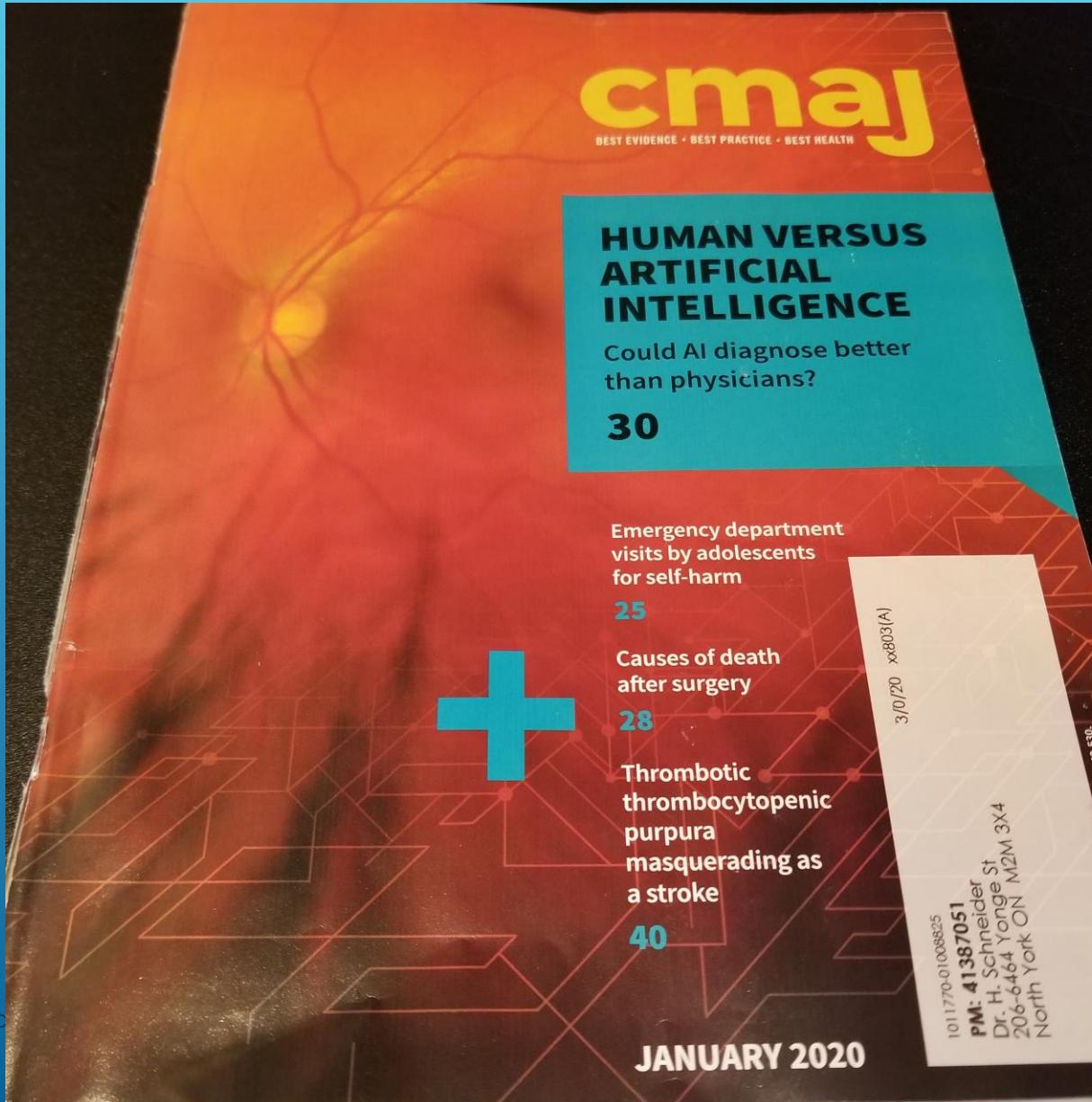
LEARNING OBJECTIVES

- ▶ 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

MEDICAL AI SYSTEMS

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

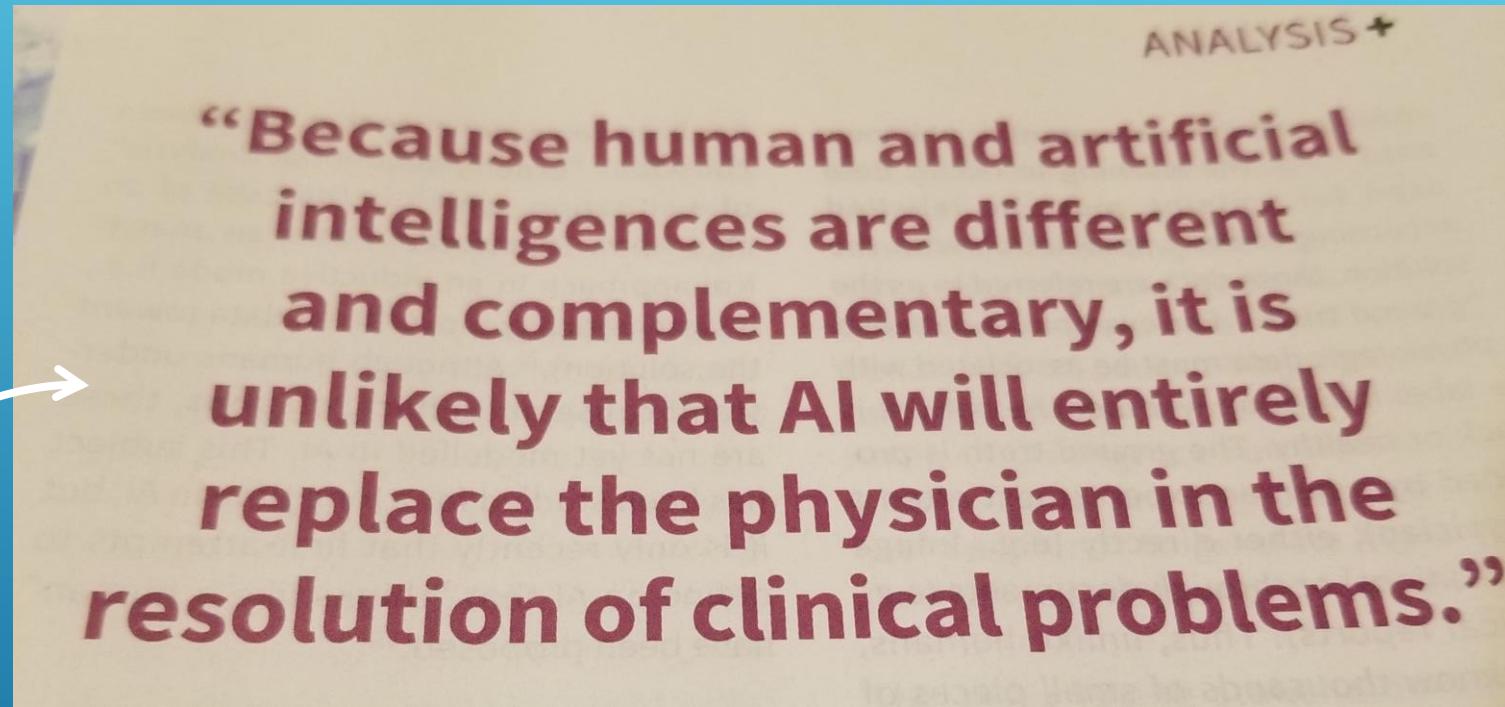
COVER STORY OF JANUARY 2020 PRINT CMAJ



Dr Howard Schneider - Artificial

159
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

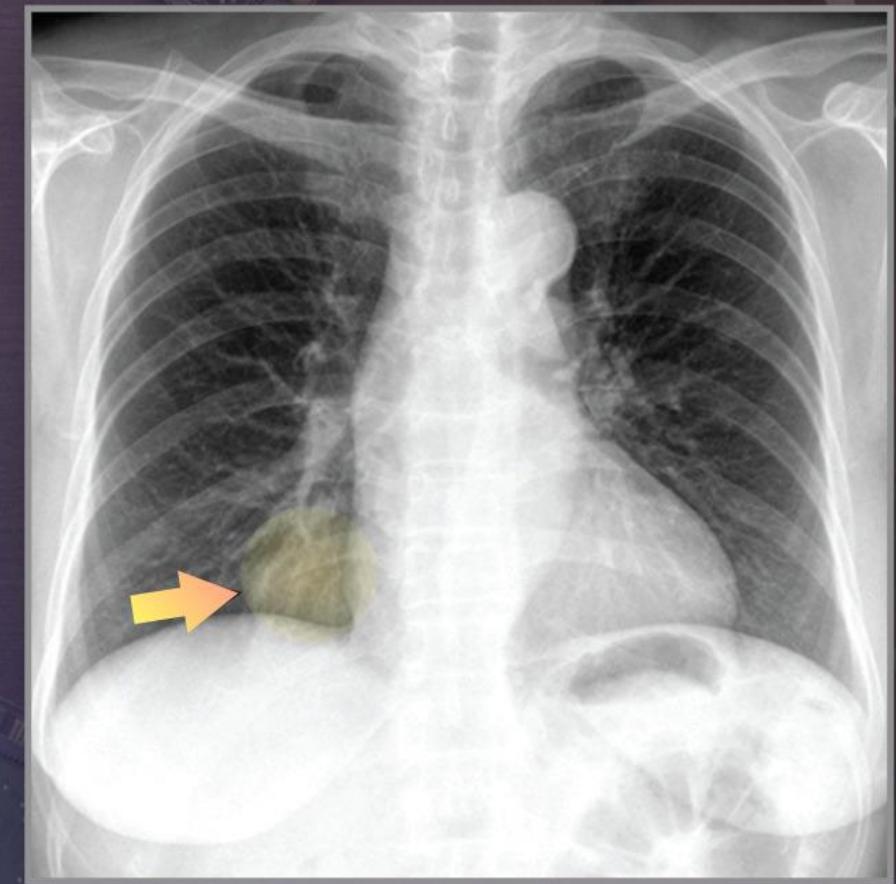
Human vs Machine: Lung Tumor

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

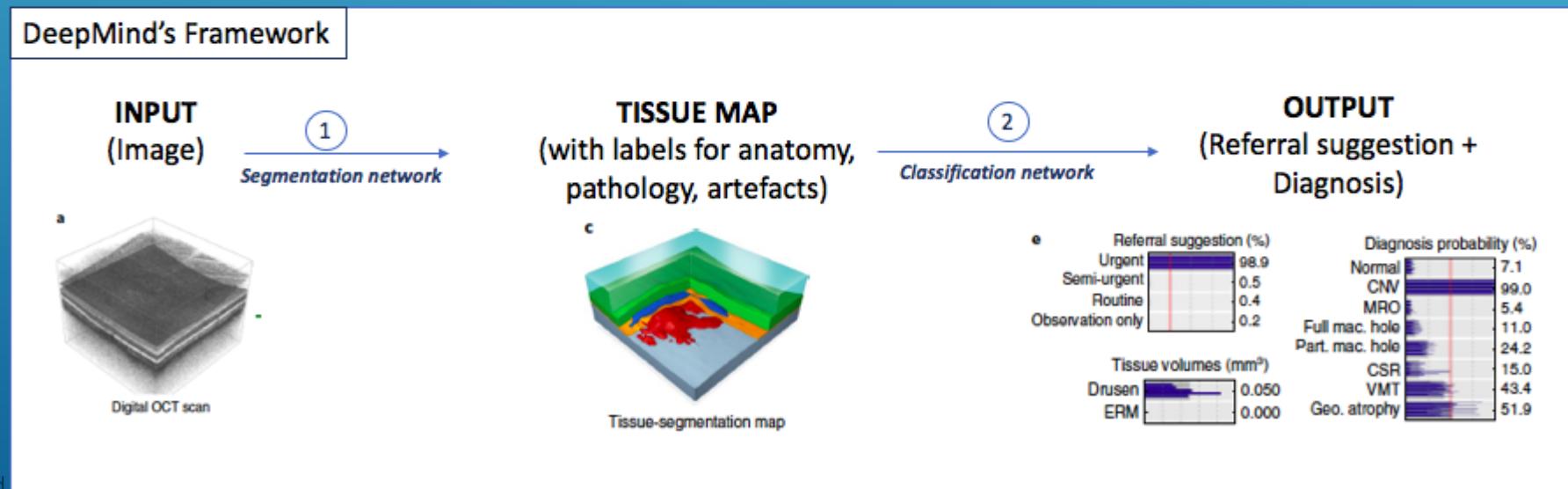
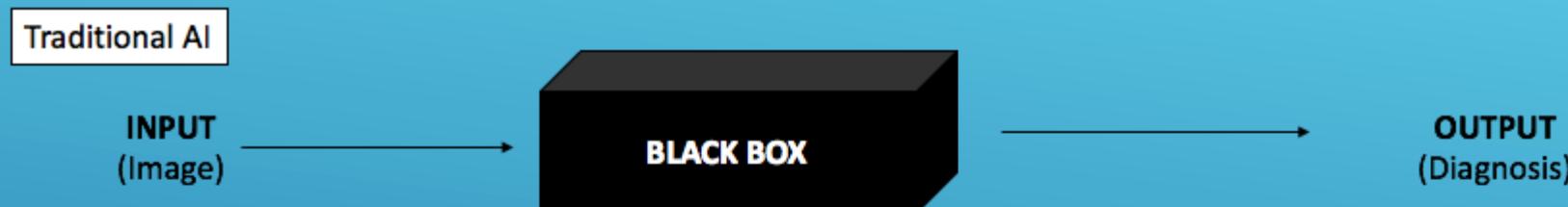
Example:
Lung Tumor

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

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.”

164

March 2020

Dr Sidney Kennedy, University of Toronto

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

165

March 2020

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



167

March 2020

Computer-Assisted CBT ('CCBT') for Depression

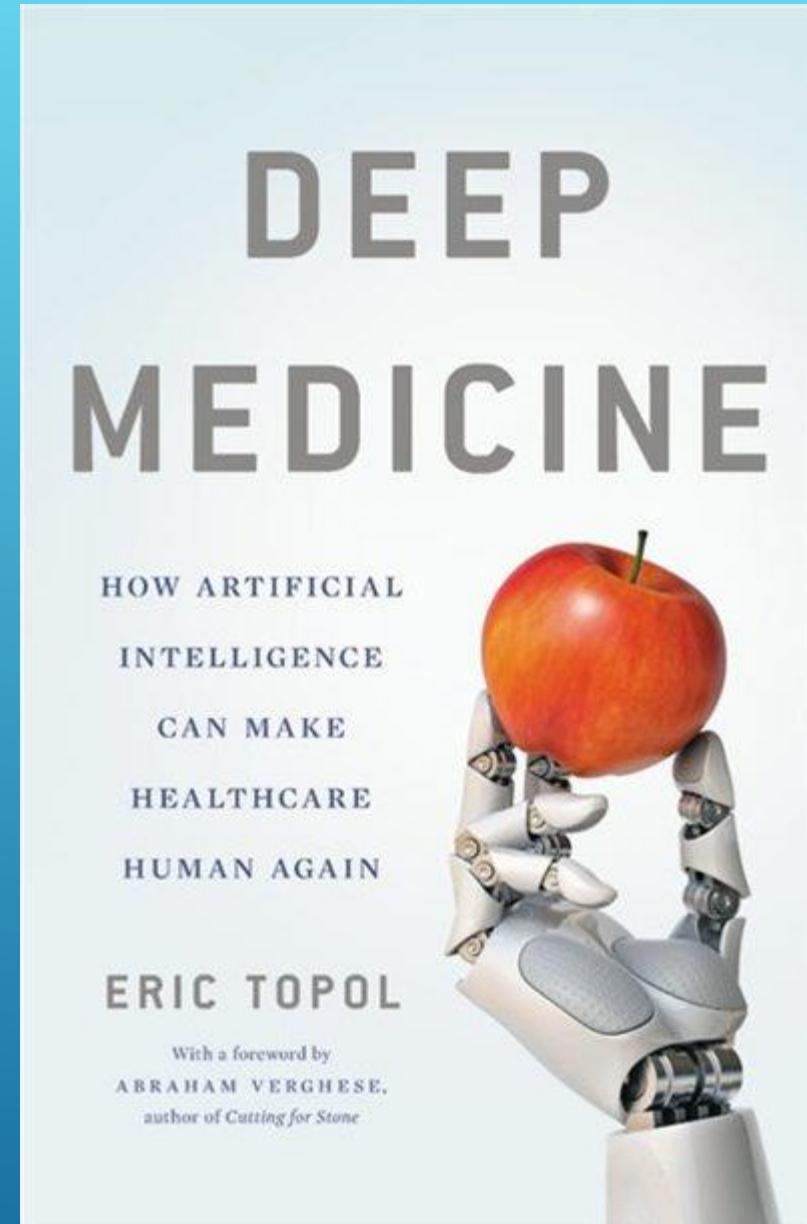
- JESSE WRIGHT ET AL, 2019, J CLIN PSYCHIATRY
- META-ANALYSIS 40 RCT STUDIES CCBT FOR DEPRESSION
- CCBT WITH MODEST SUPPORT FROM CLINICIAN EFFECTIVE
- CCBT FULLY SELF-GUIDED MUCH LESS EFFECTIVE
(TYPES, AMOUNT AI IN CCBT STUDIED??)

→ 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

172

March 2020

LEARNING OBJECTIVES

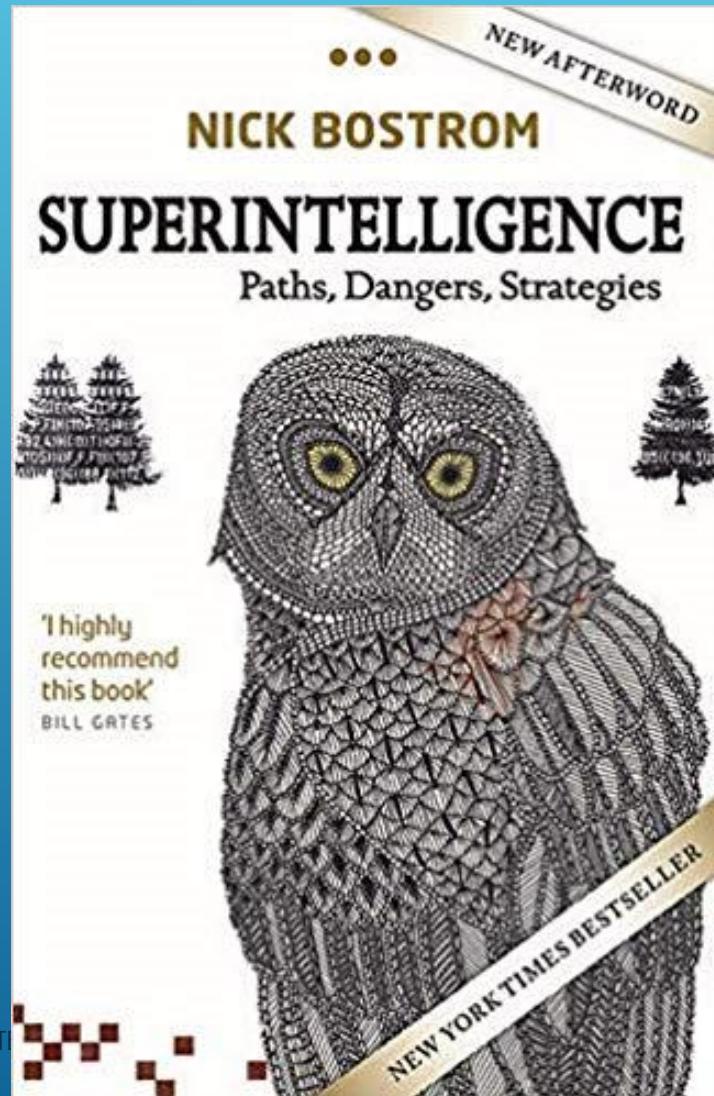
- ▶ 1. Real understanding of what AI is:
- ▶ 1a. Deep Learning and Reinforcement Learning
- ▶ 1b. Field of Artificial Intelligence (AI)
- ▶ 1c. Neuro-Symbolic Gap
- ▶ 2. How will AI in next decade (or two) affect my patients' lives?
- ▶ 3. How will AI affect my practice of medicine including psychotherapy?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

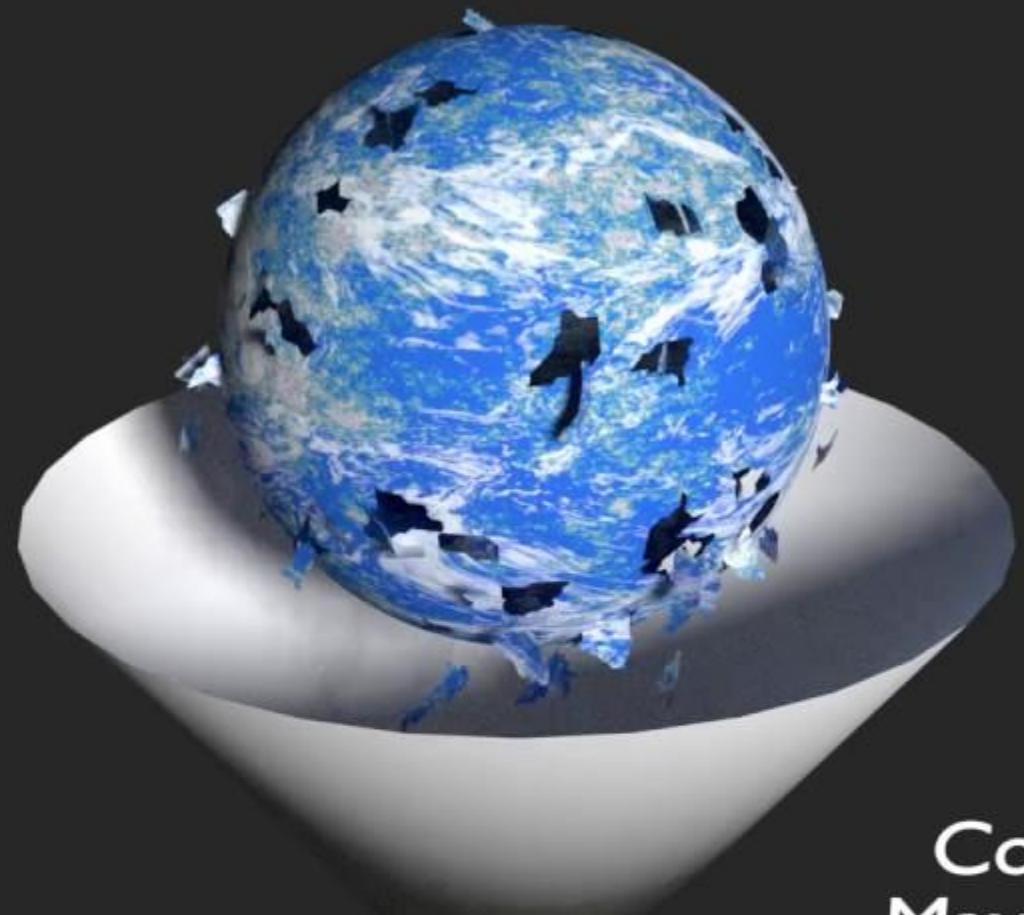
DEEP LEARNING ALL AROUND US NOW: LONDON POLICE SURVEILLANCE CAMERAS WITH FACIAL RECOGNITION

PSYCHOLOGY OF CONSTANT SURVEILLANCE??



Bostrom – SuperIntelligence



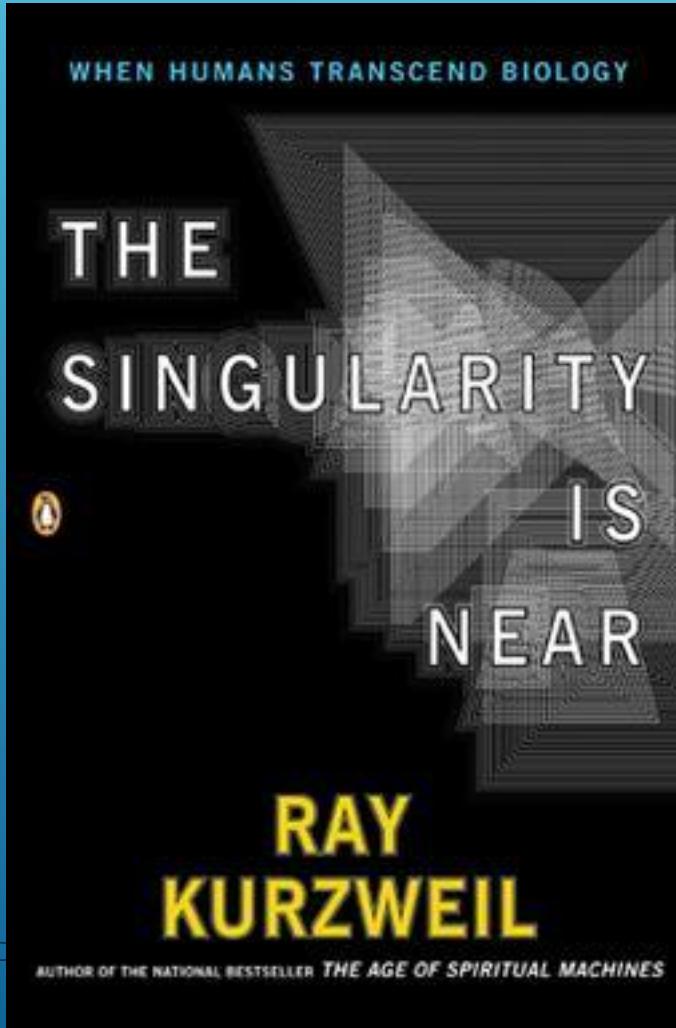


*Could an AI Paperclip
Maximizer machine turn
the earth into paperclips?*

176

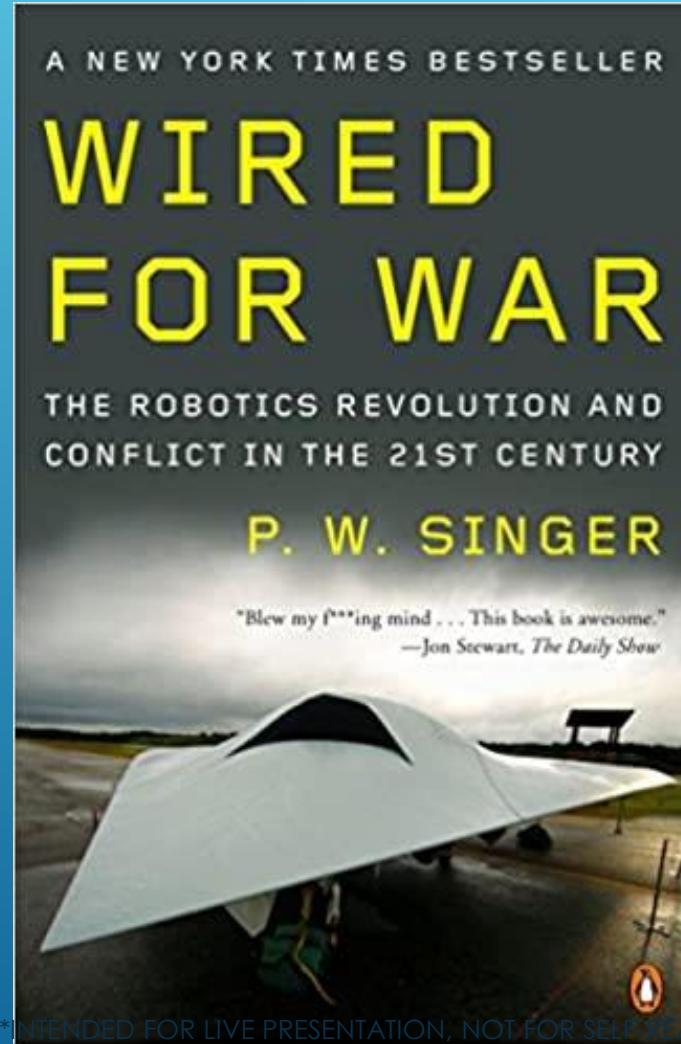
March 2020

Kurzweil – AI Exceeding Human Intelligence and Merging with Humans

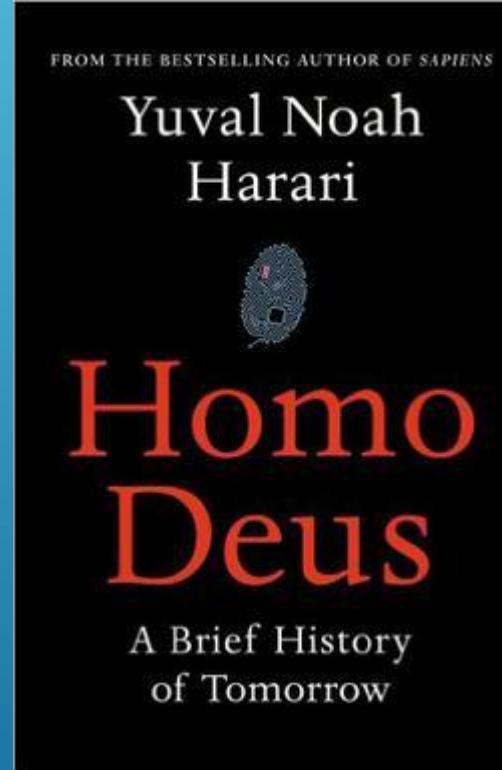
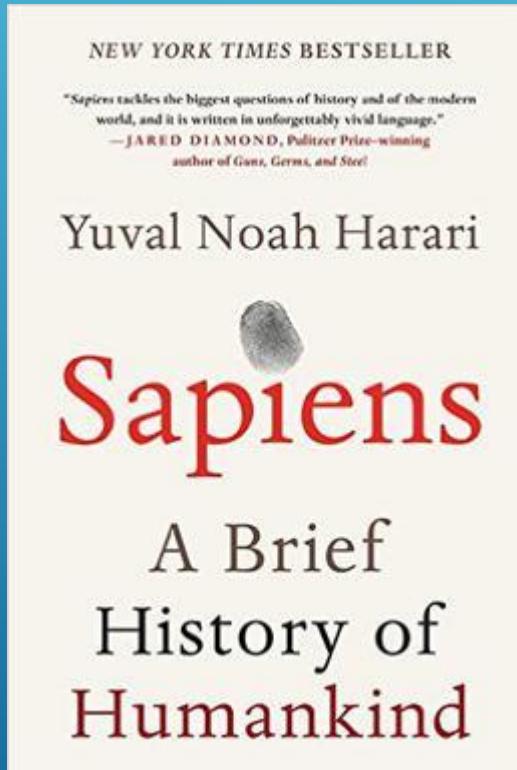




SINGER'S 2009 BOOK – WIRED FOR WAR



- 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

- ▶ 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

Artificial Intelligence and the Future of Medicine/Mankind

Thank You

howard.schneider@gmail.com