

Artificial Intelligence and the Future of Medicine/Mankind

Howard Schneider
Sheppard Clinic North, Toronto, Canada

OMA Section on Primary Care Mental Health
Toronto, March 21 2020

CONFLICTS OF INTEREST

- ▶ None

COMMERCIAL NAMES

- ▶ I will try to minimize use of commercial names, where feasible (but....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)

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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)



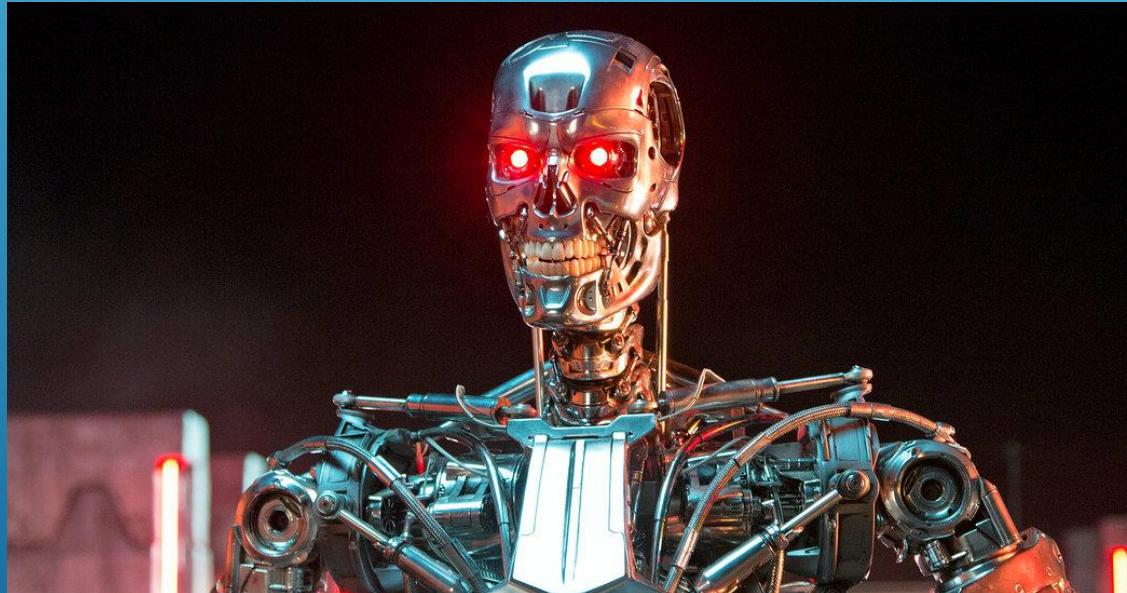
NOT REQUIRED.... BUT.....
CONSIDER MAKING NOTES IF THIS HELPS
YOU LEARN....



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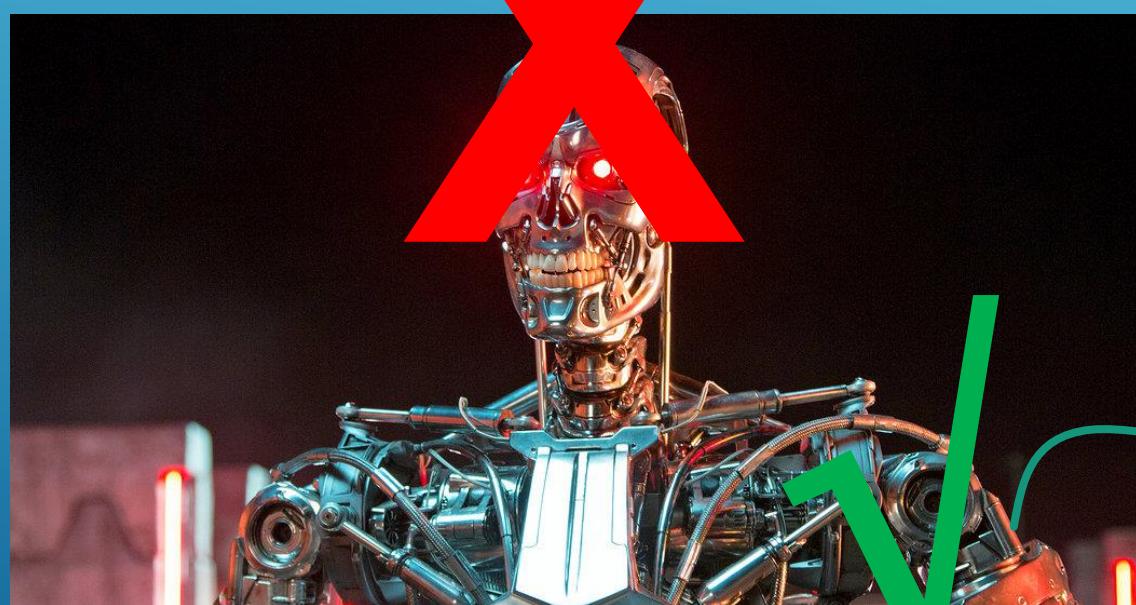
FORGET ABOUT CURRENT HYPE YOU SEE
ABOUT AI (ARTIFICIAL INTELLIGENCE) ALL
AROUND YOU IN THE MEDIA....



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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

Current technology: **AI** part
not possible, but android-like
walking (running, even
jumping) **robots exist**

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



Straightforward computer engineering can greatly improve EMRs (an almost magical AI would be nice to have.... but huge improvements are possible with normal computer engineering)

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



NOT
REALLY AI

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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

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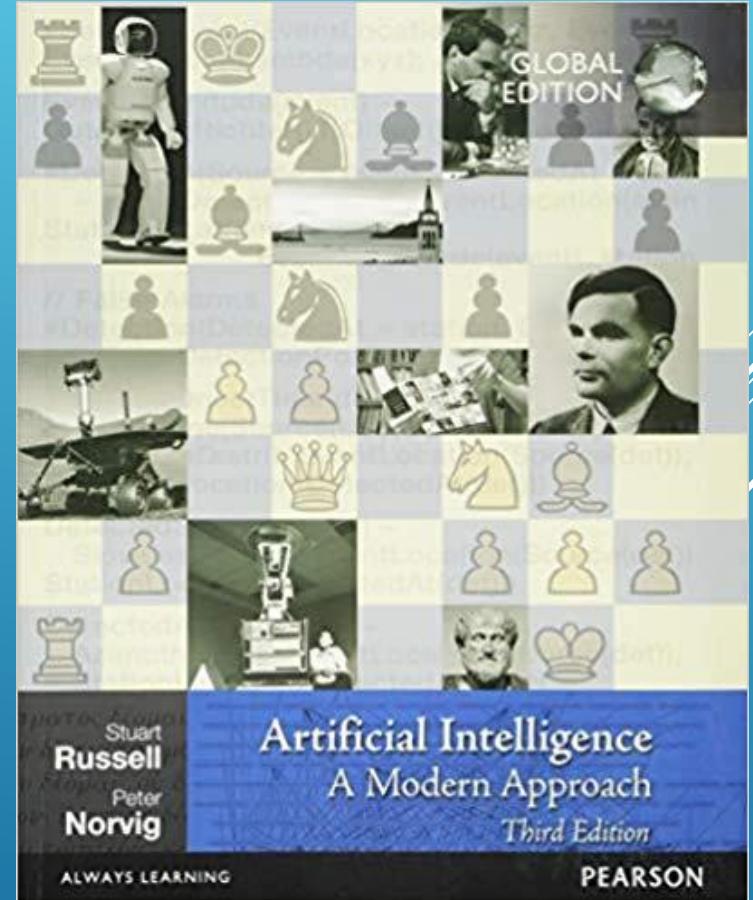
THESE DAYS, PEOPLE USE THE TERM “AI” TO REFER TO **DEEP LEARNING**

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

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

Deep Learning actually only tiny part of AI
AI a huge field – even an introduction to the subject
is massive

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



DEEP LEARNING.... LET'S JUST JUMP IN....



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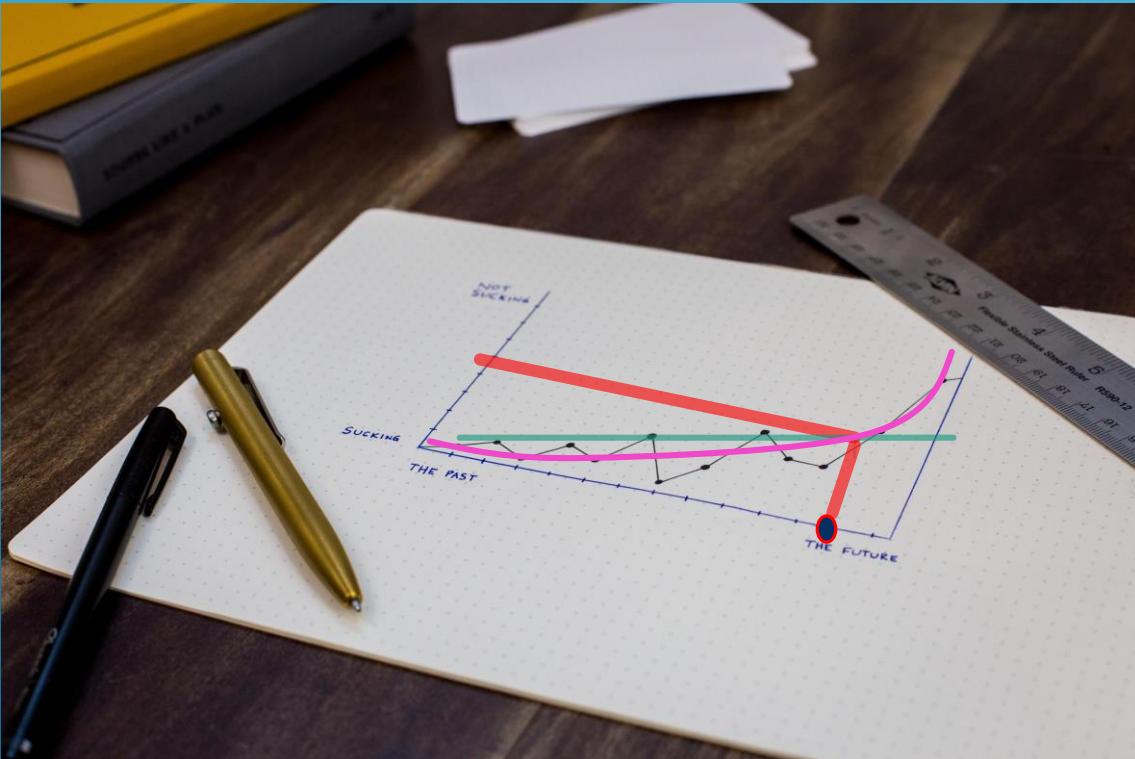
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OK.... WHAT IS DEEP LEARNING?

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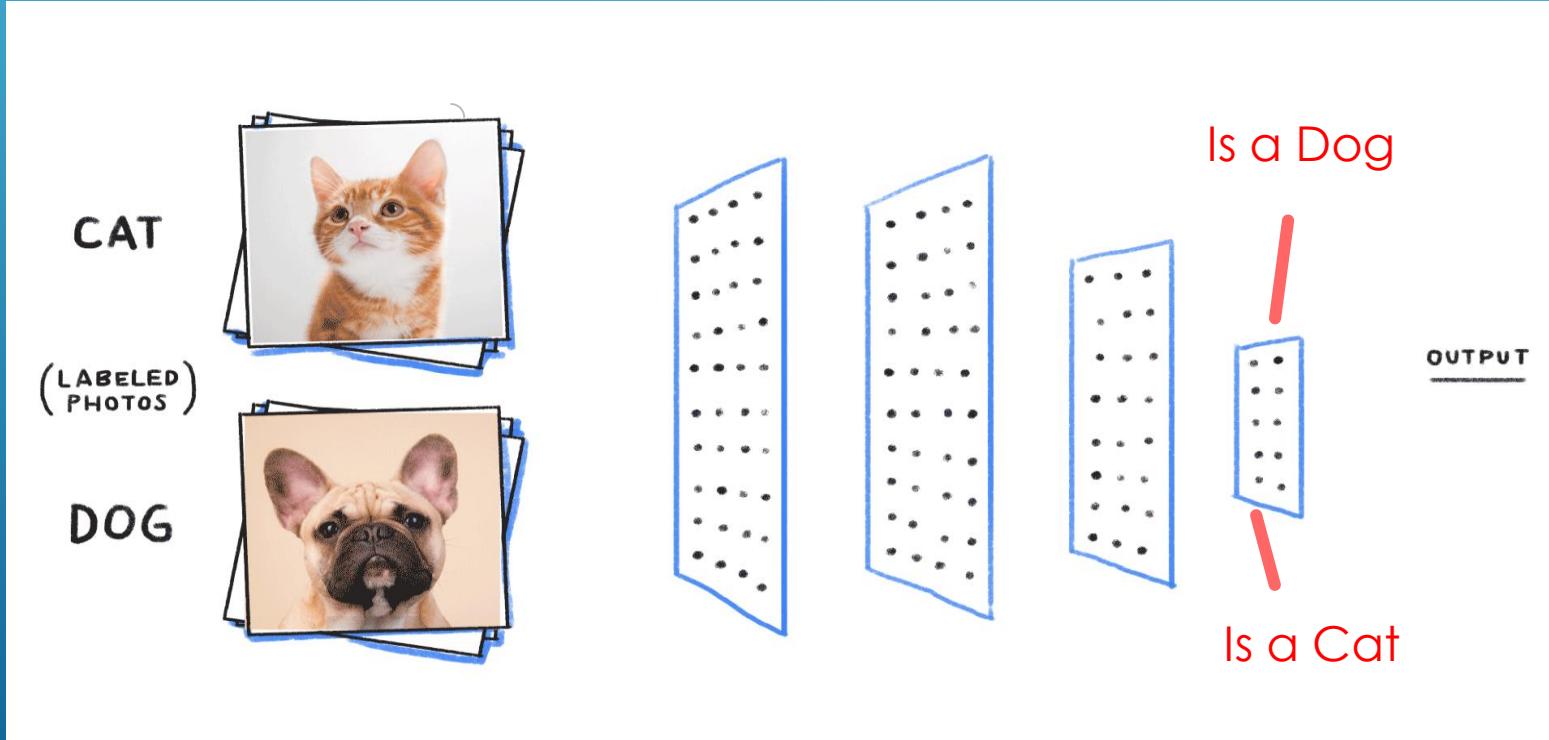
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THIS IS YOU – EG, PREMED CHEMISTRY – DOING SIMPLE “ARTIFICIAL INTELLIGENCE”, IE, DEEP LEARNING

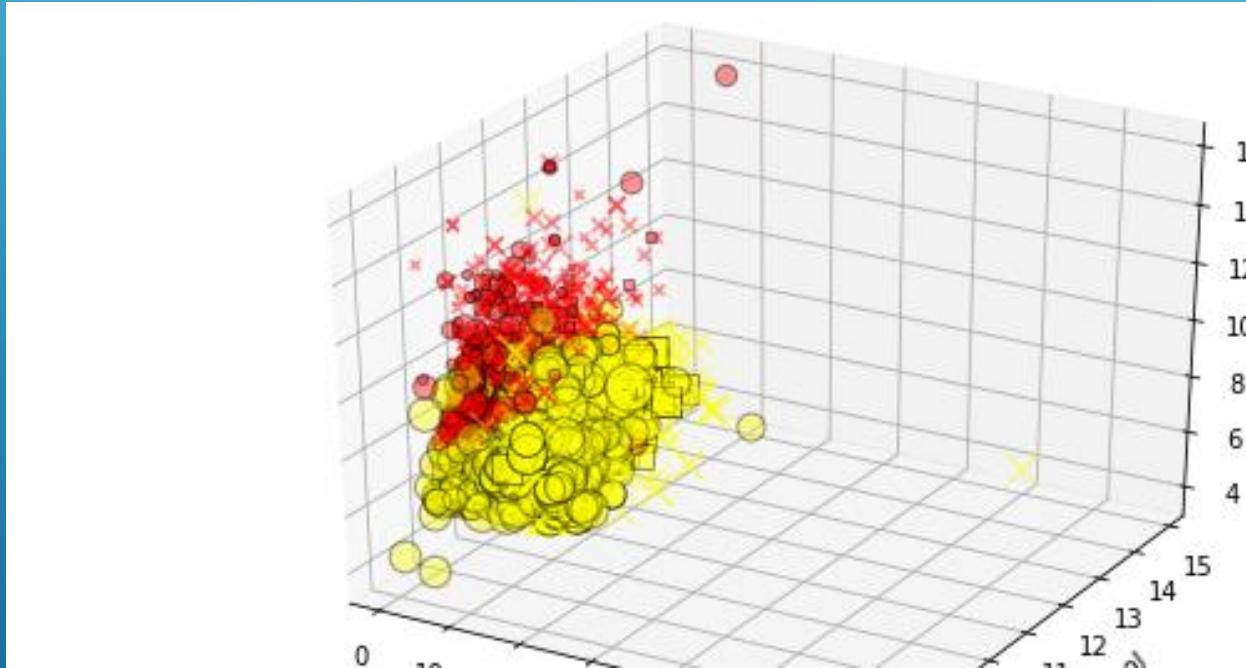


New X value never seen
before, you can predict
the Y value

NOW MAKE A GRAPH SO IF SEE A NEW ANIMAL (JAW SHAPE, NOSE SHAPE, ETC) JUST LIKE NEW X VALUE, YOU CAN PREDICT THE Y VALUE – IS IT A DOG OR A CAT??

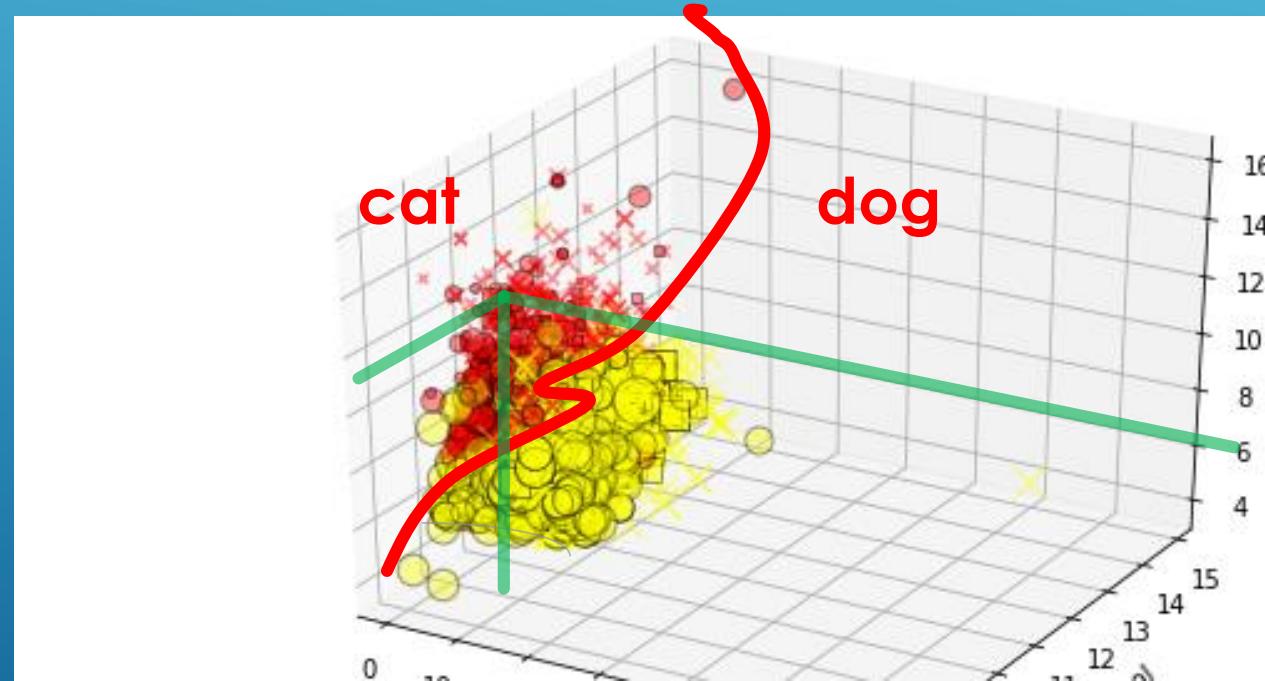


- CONSIDER DIFFERENT FEATURES OF DIFFERENT DOGS AND CATS
- PLOT THEM
- BELOW IS 3-D BUT MAYBE REALLY NEED 1000-D (OR 64,000 DIMENSIONS!!)



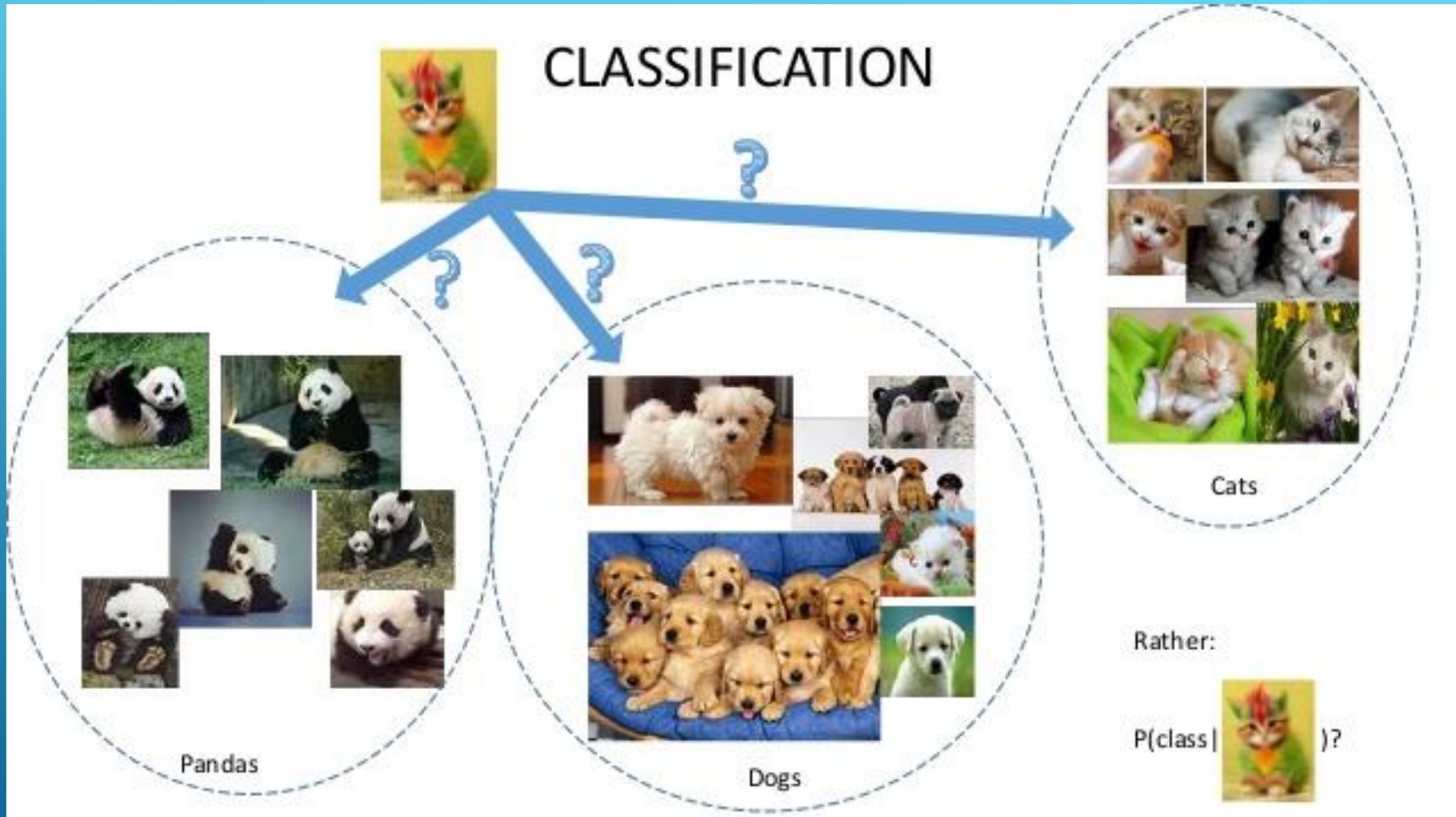
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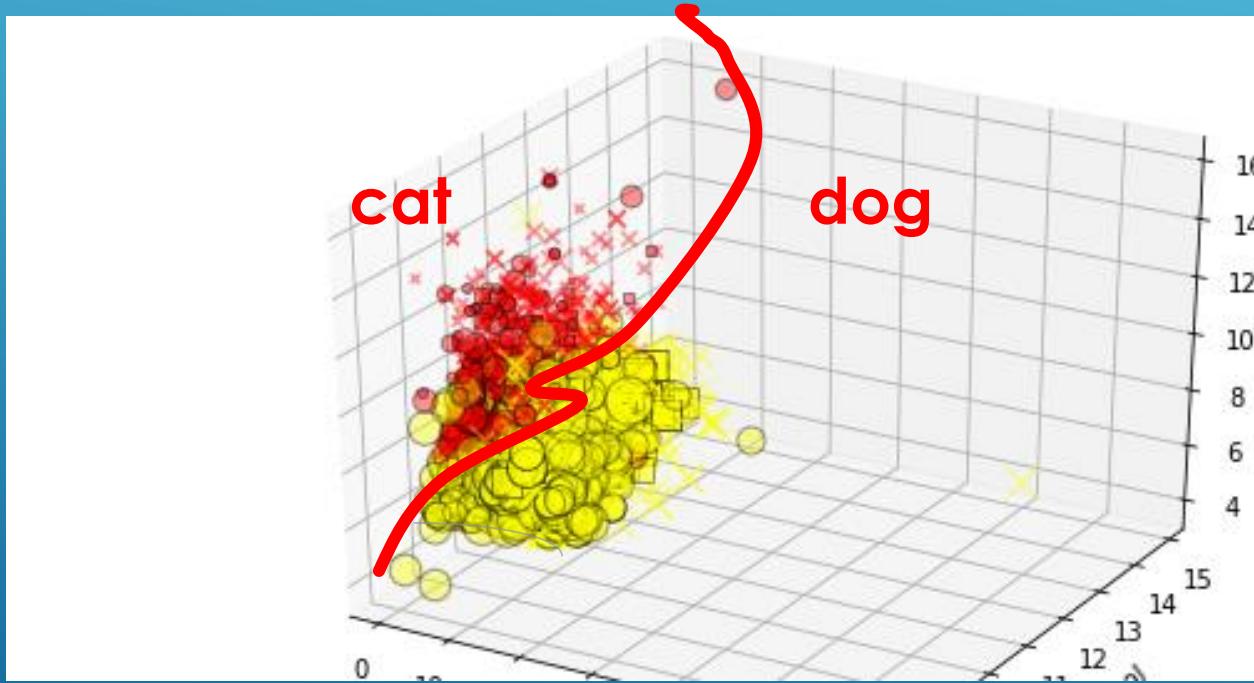


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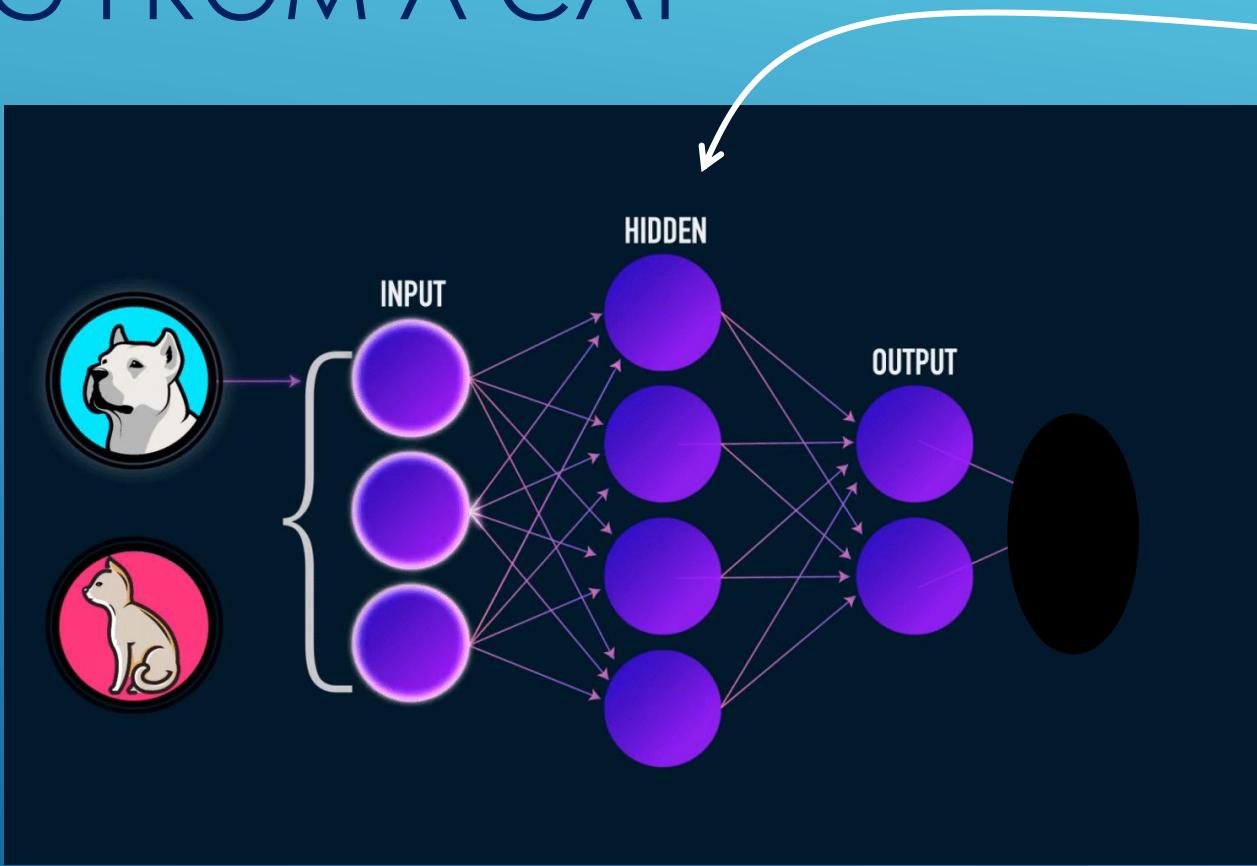
CLASSIFICATION



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

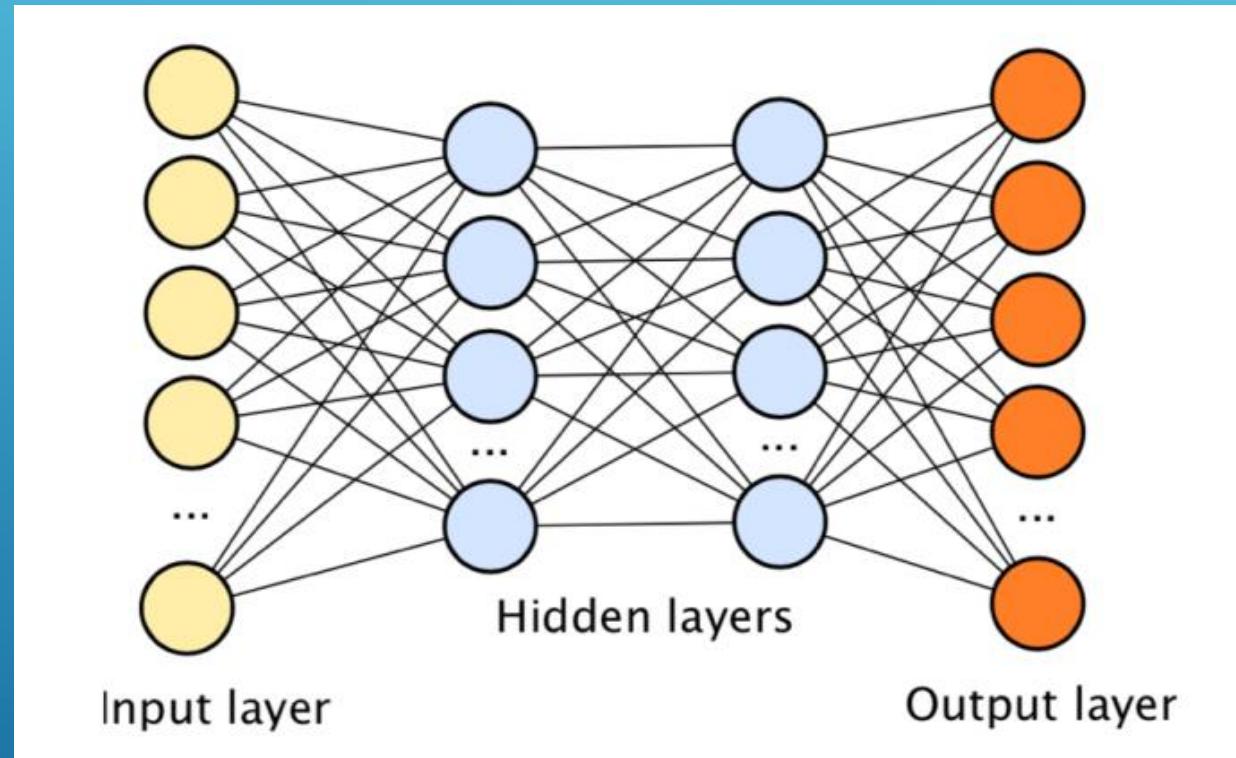


NEURAL NETWORK TO 'AUTOMATICALLY' LEARN TO TELL A DOG FROM A CAT

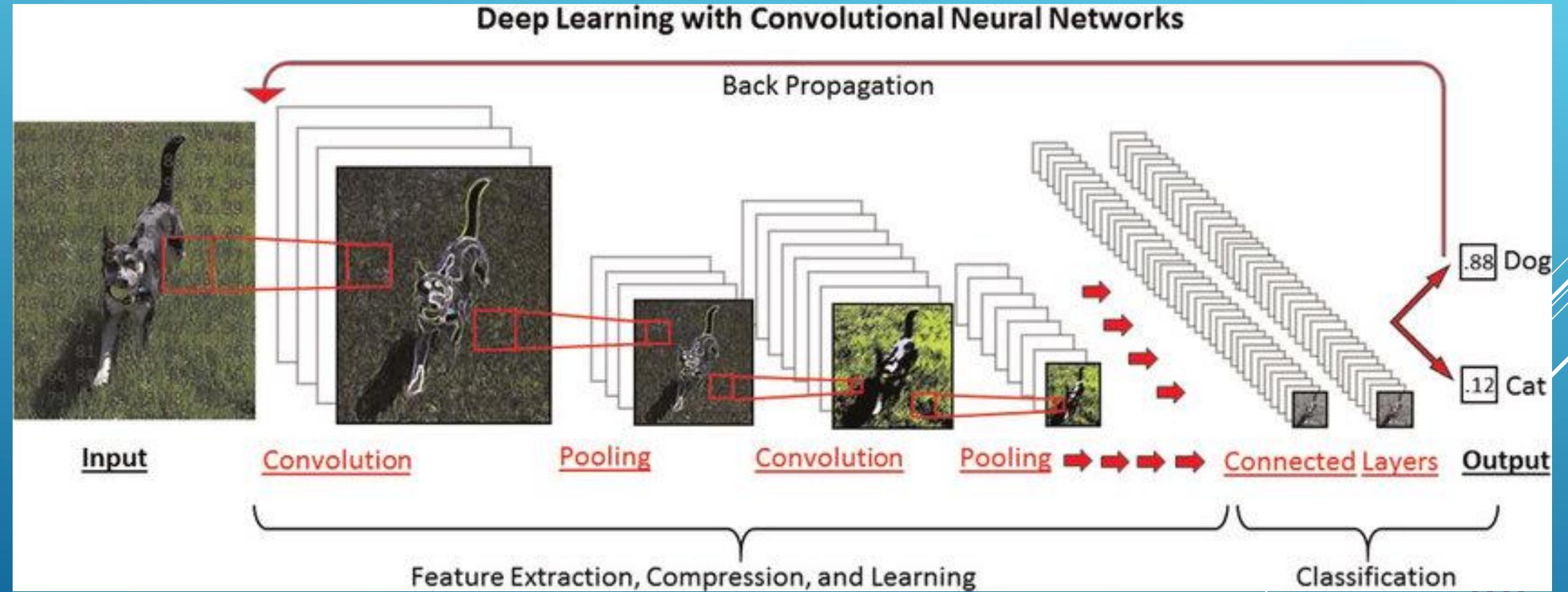


Simplified
Real Deep Learning
Neural Network will
have **many** hidden
layers

*Deep Learning Neural Network will have
many hidden layers*

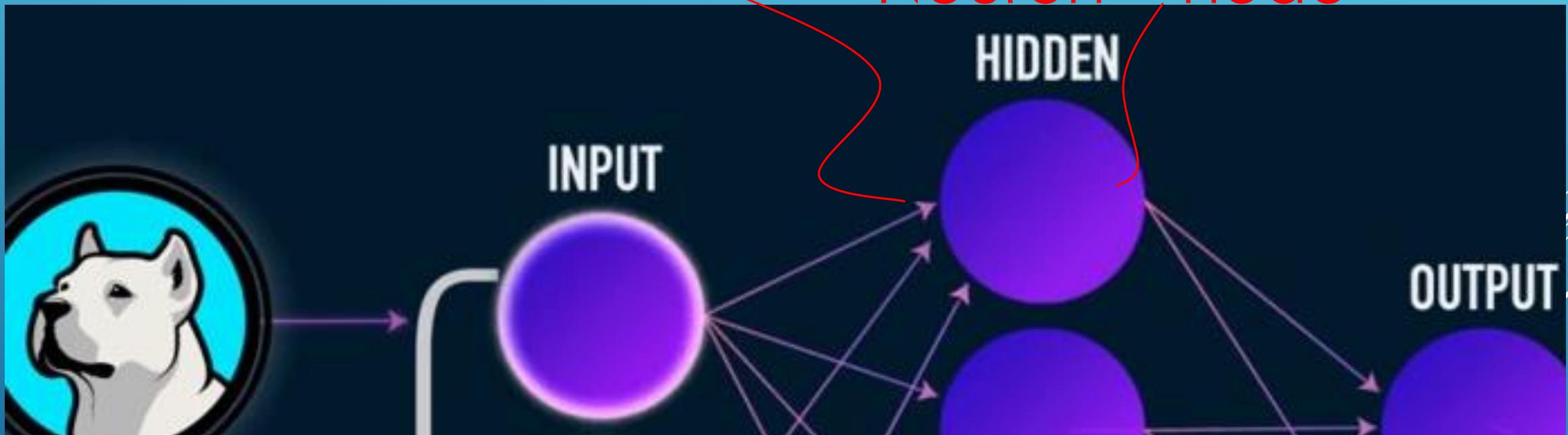


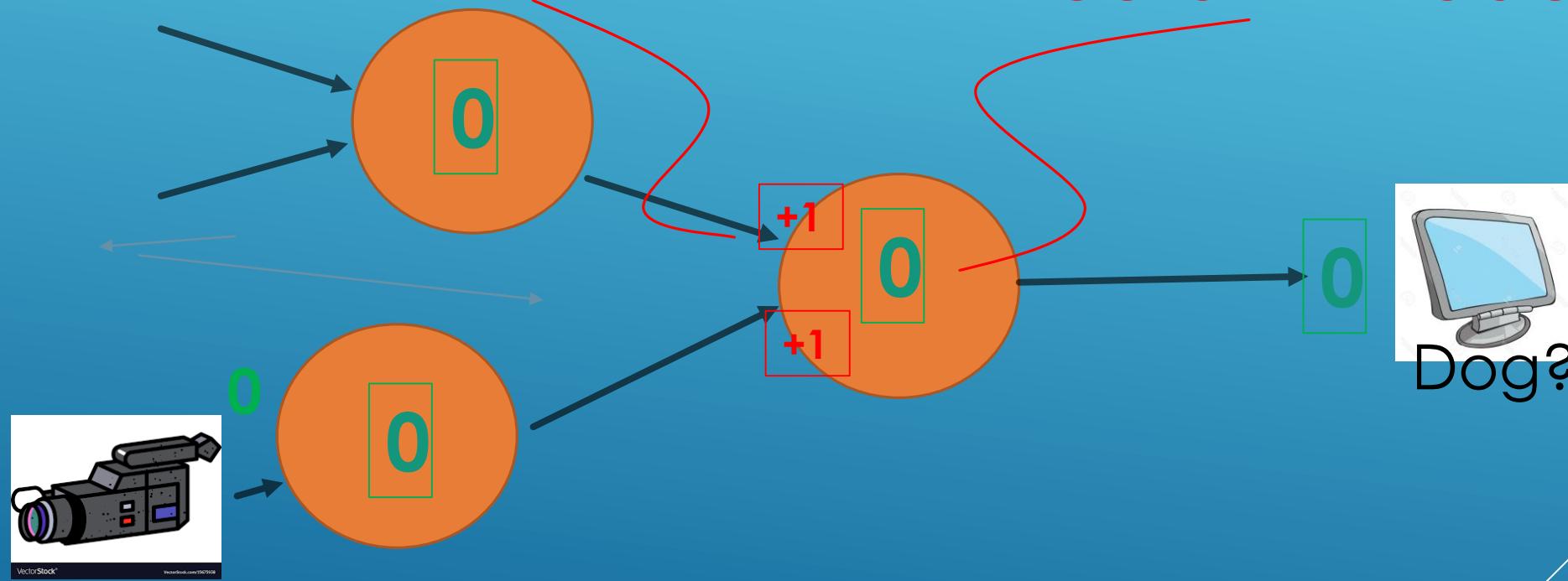
Simple, Realistic Deep Learning Neural Network will have **many** hidden layers



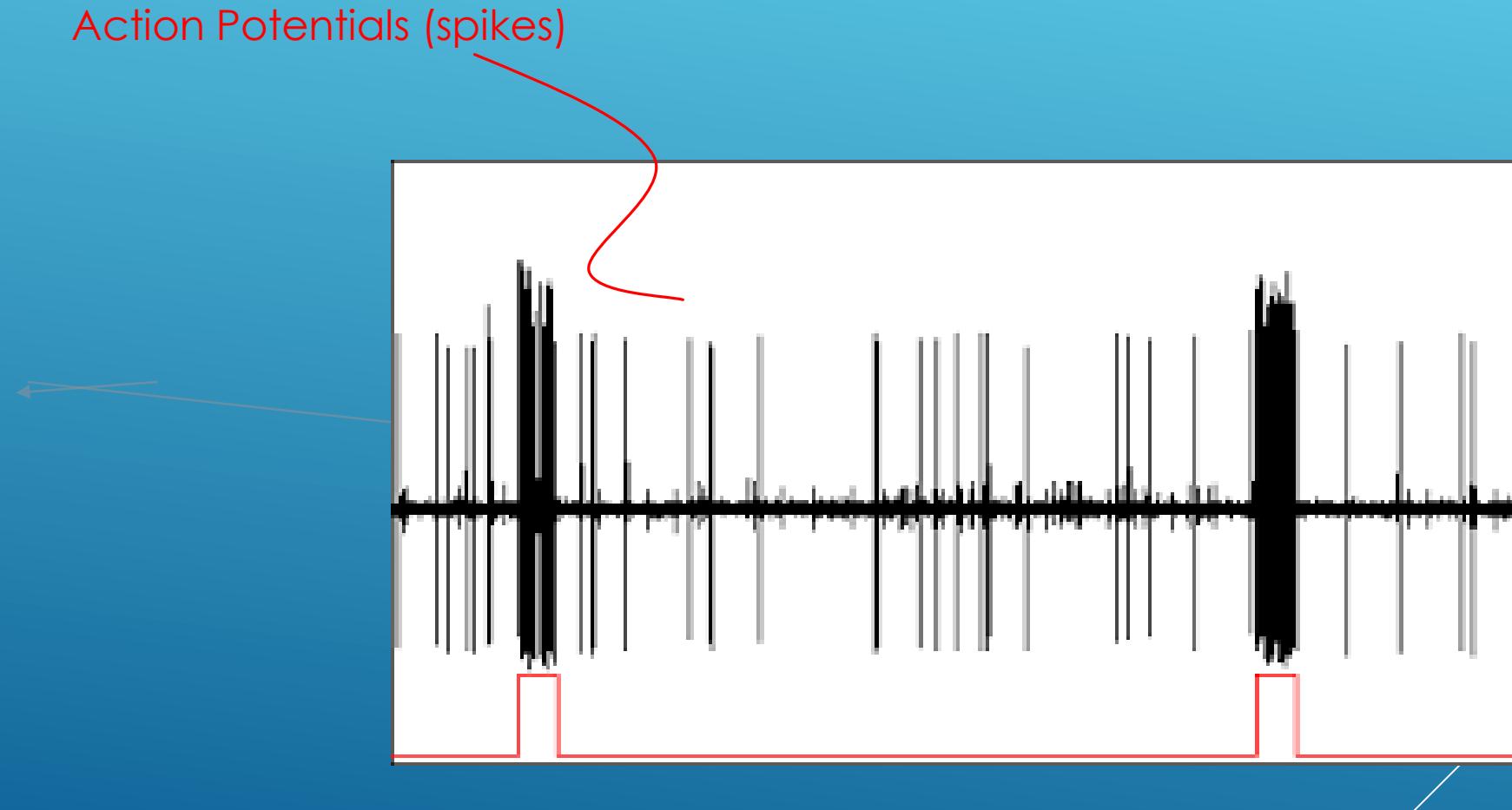
Synapse = weight

Neuron = node





Real Neural Networks

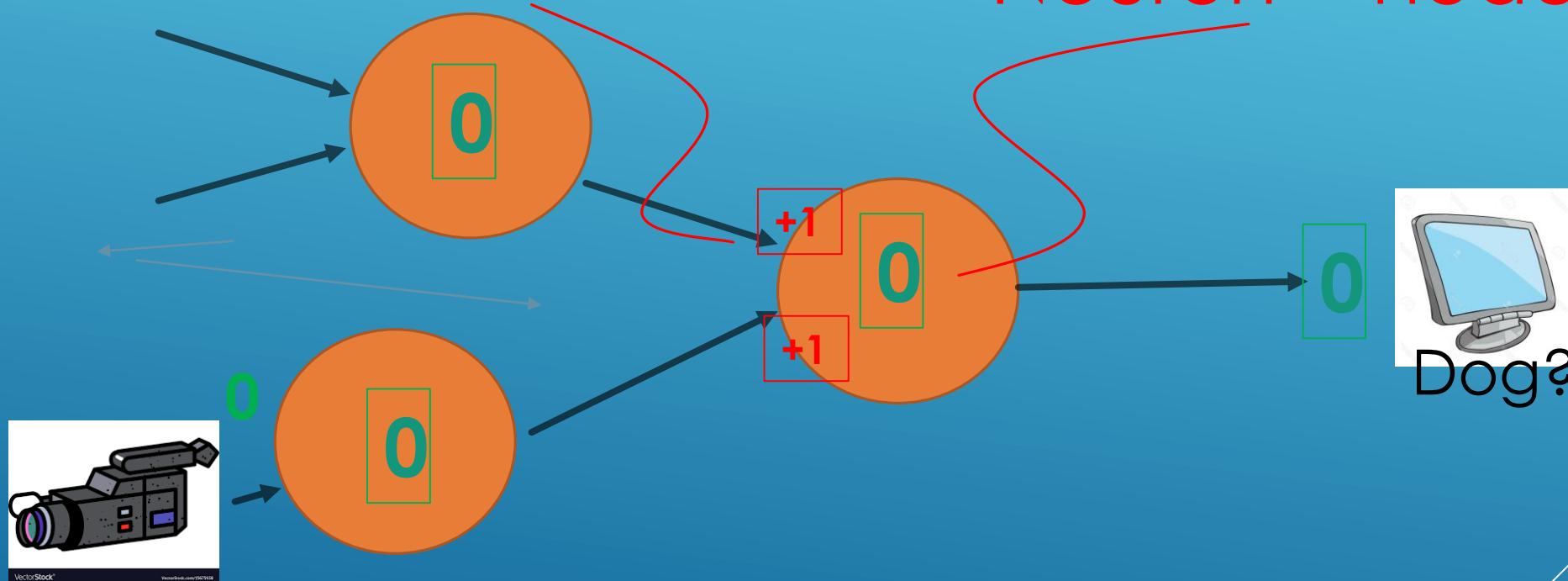


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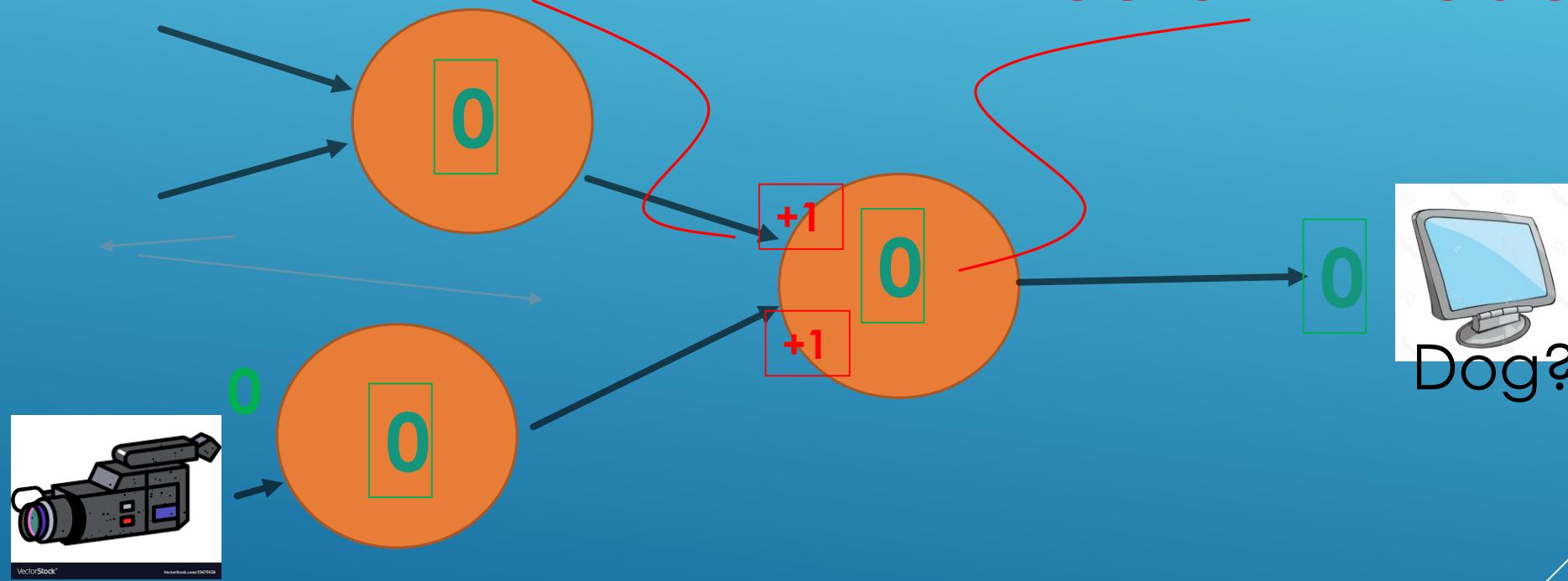
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“Artificial Neural Network” (ANN)

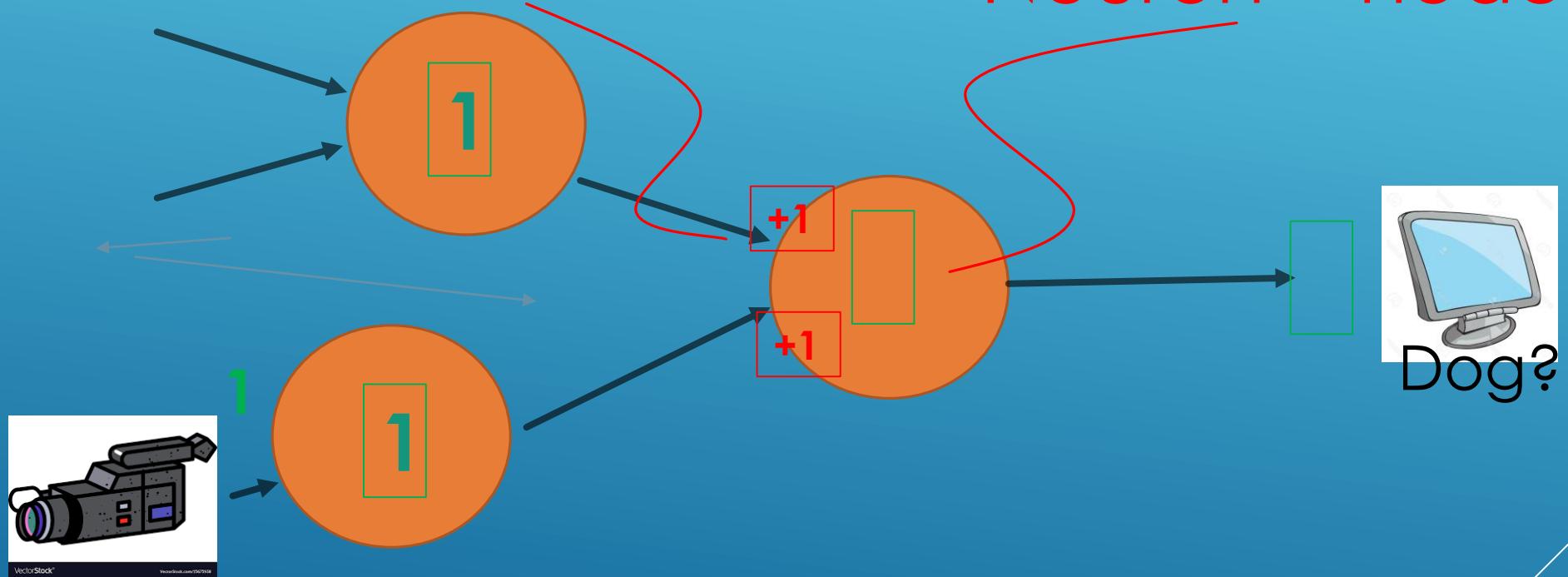
Synapse = weight



Neuron = node

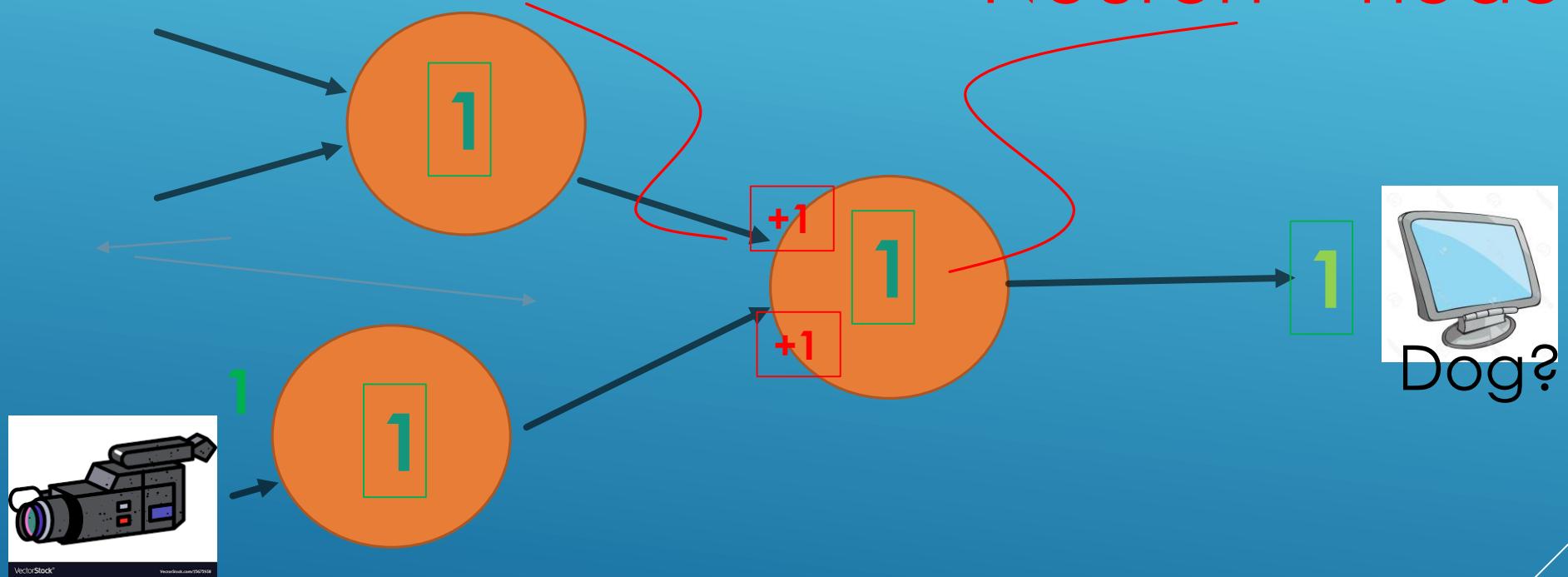


Synapse = weight



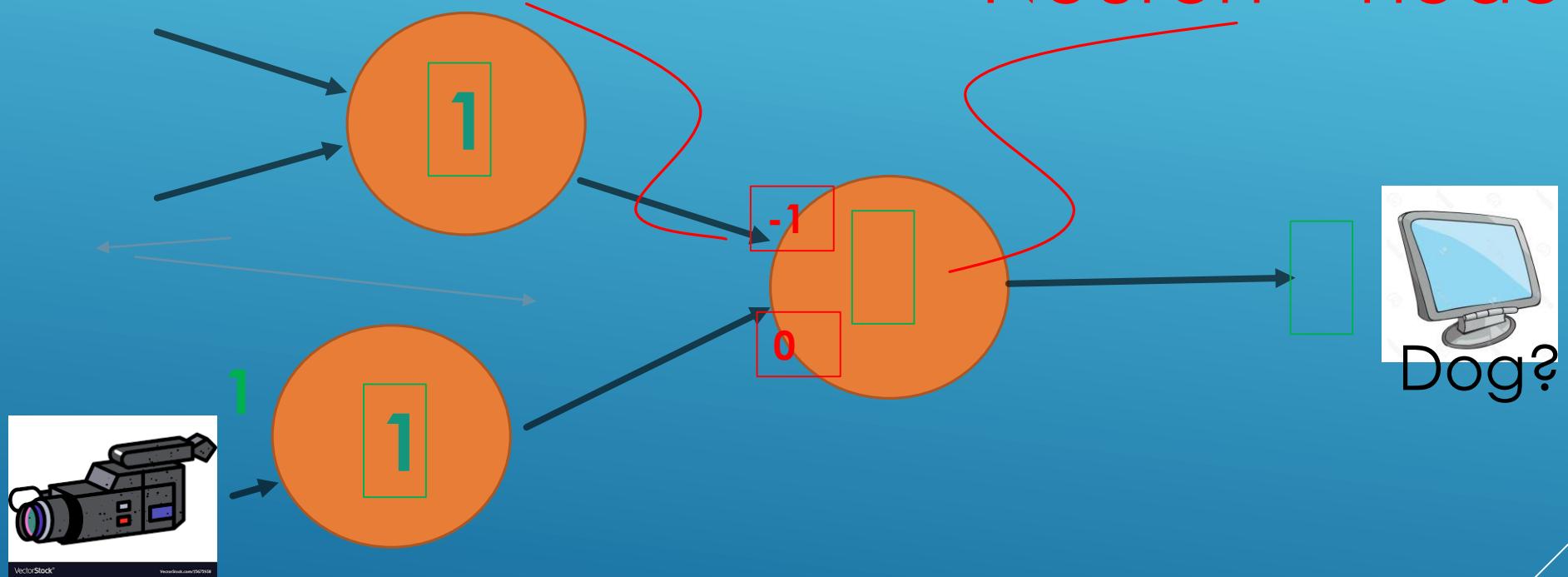
Neuron = node

Synapse = weight

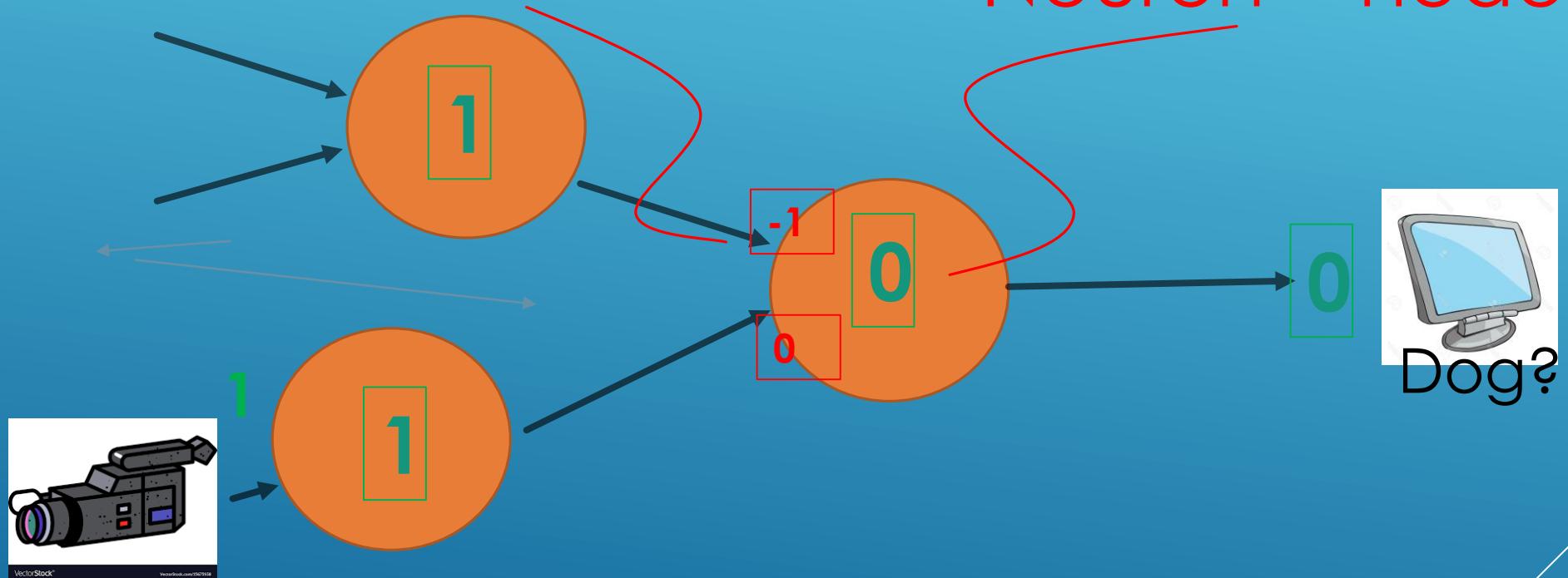


Neuron = node

Synapse = weight

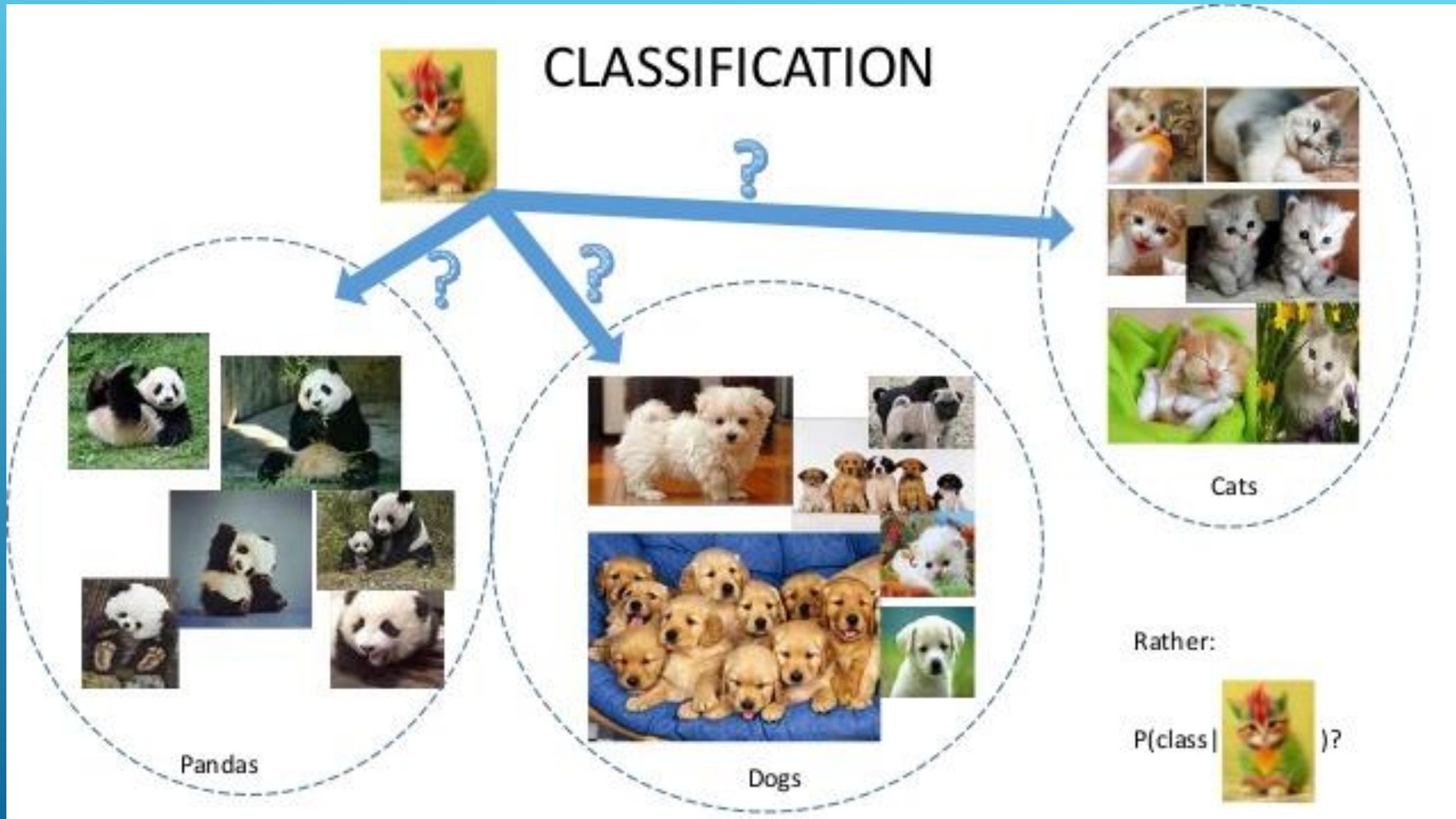


Synapse = weight

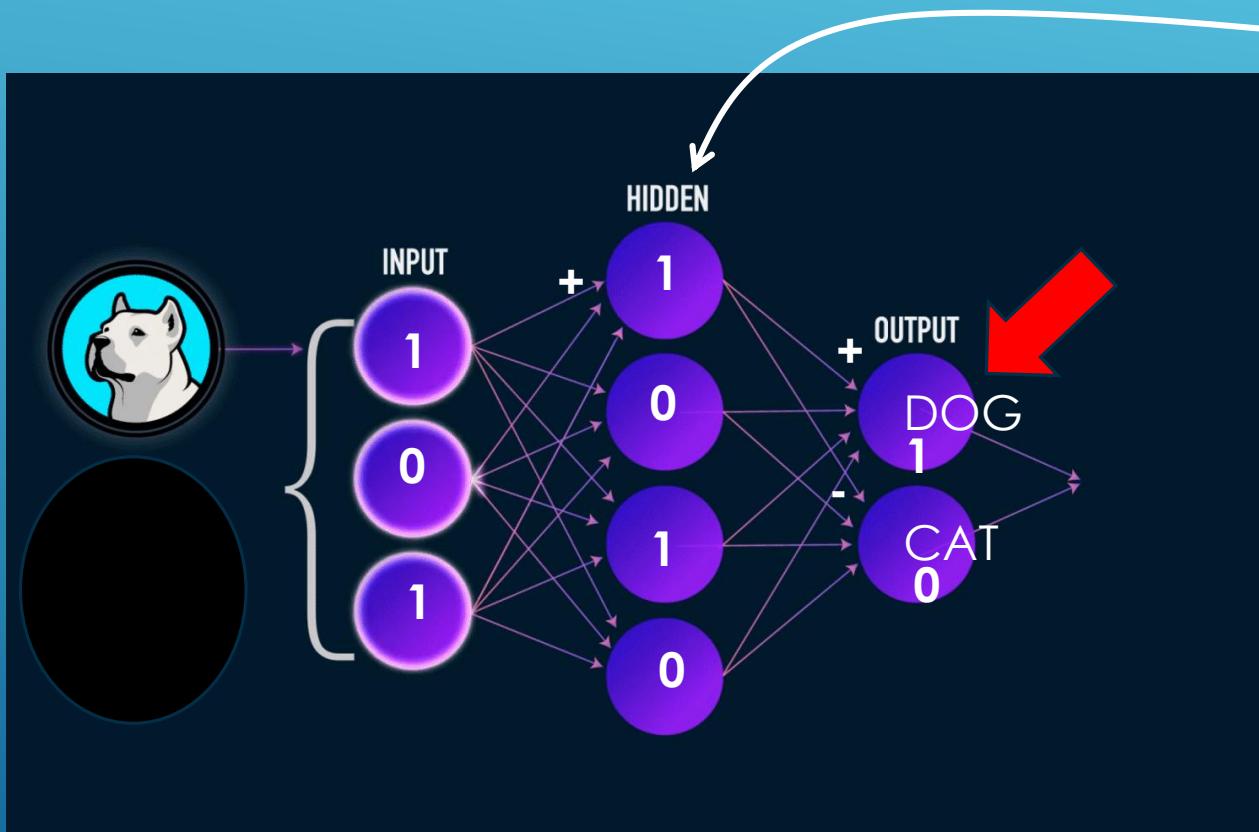


Neuron = node

CLASSIFICATION

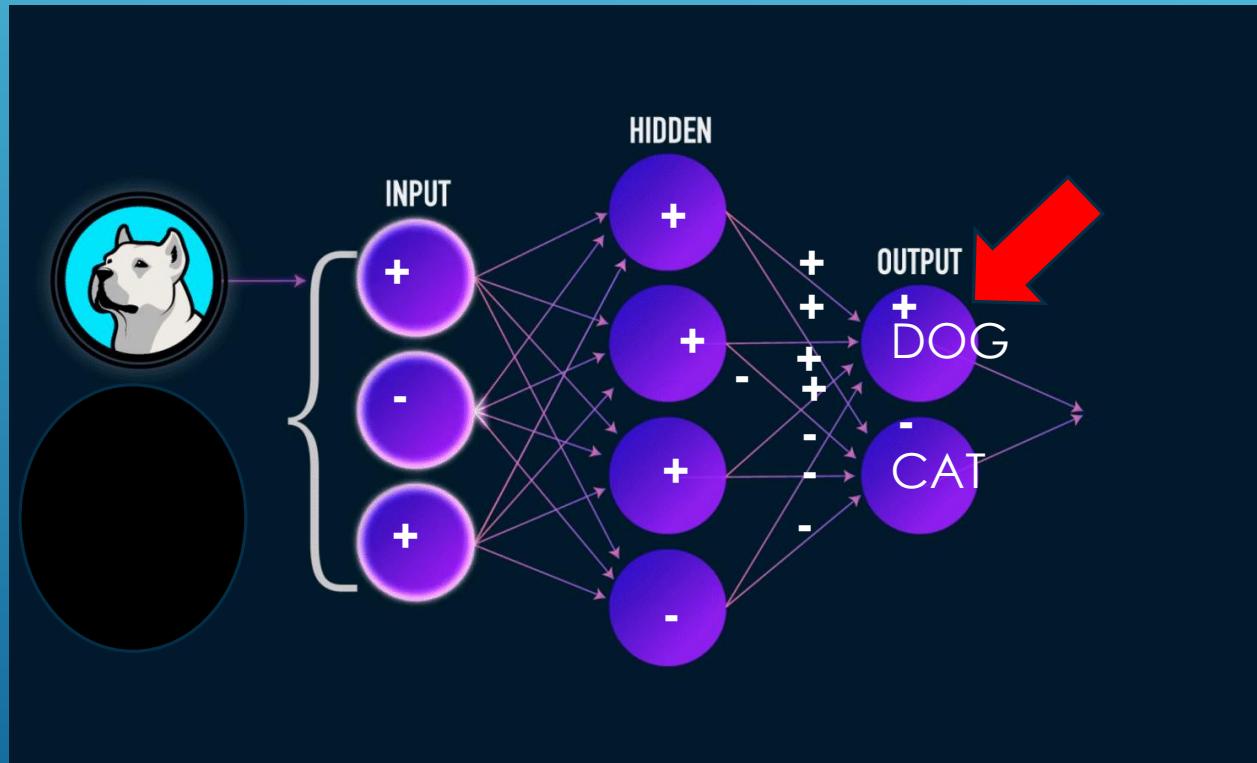


“ANN” == ARTIFICIAL NEURAL NETWORK
("DEEP LEARNING") == LOTS OF HIDDEN LAYERS)

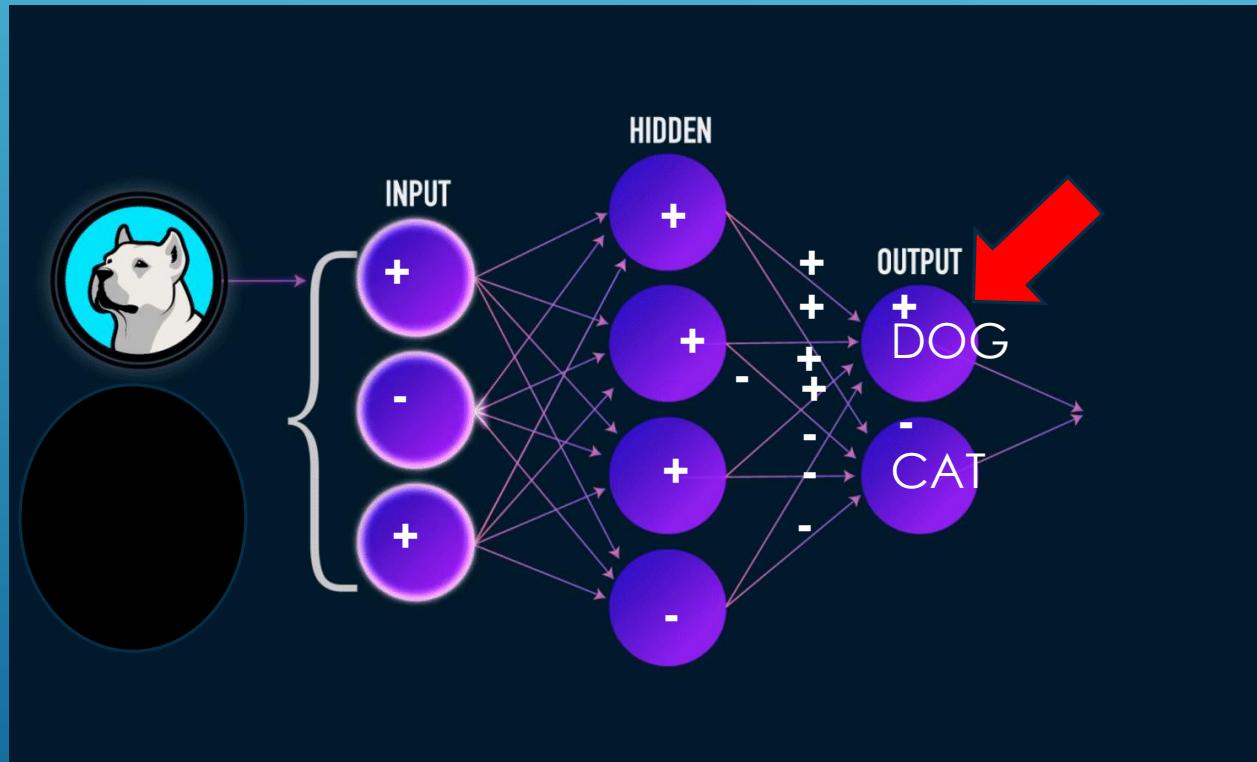


Simplified
Real Deep
Learning Neural
Network will
have **many**
hidden layers

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

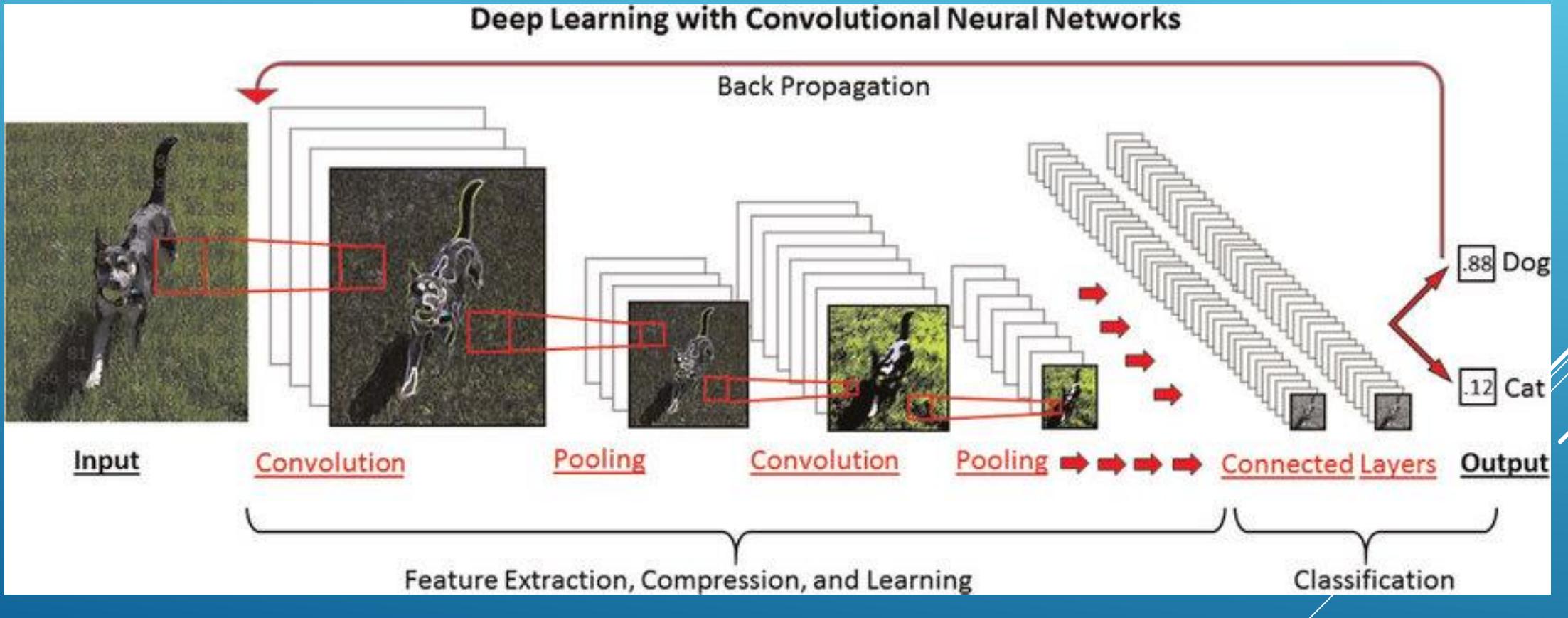


HOW DID THE NEURAL NETWORK (“DEEP LEARNING NETWORK” IF MORE LAYERS) GET WIRED UP LIKE THIS TO GIVE US THIS ANSWER?

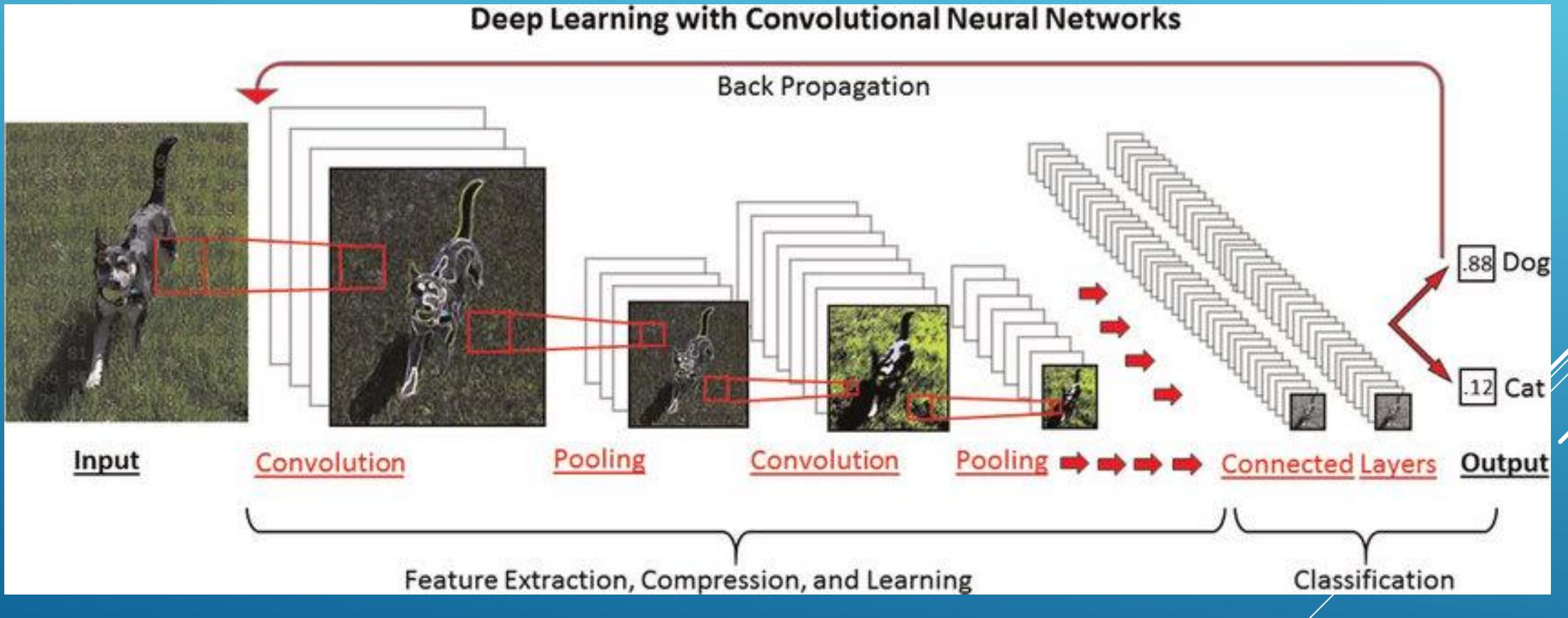


REALLY LOOKS MORE LIKE THIS

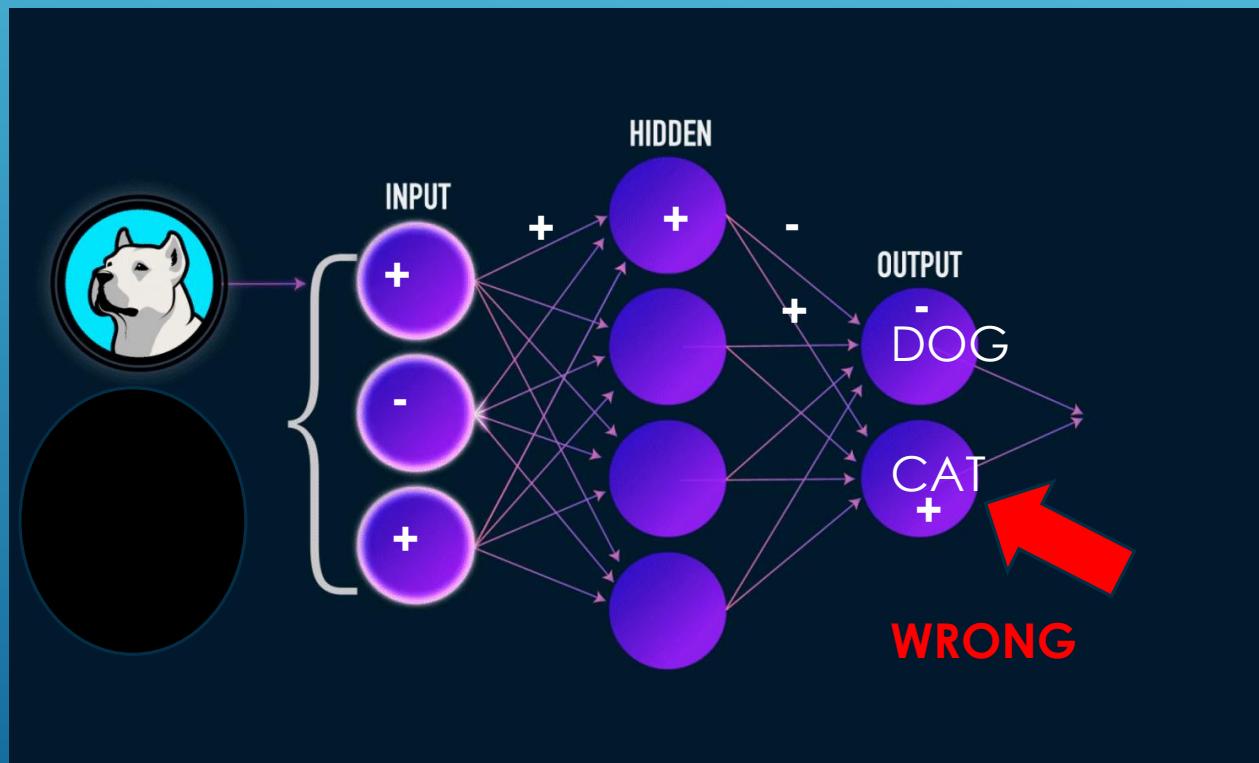
(“DEEP LEARNING” == LOTS OF HIDDEN LAYERS OF NEURONS)



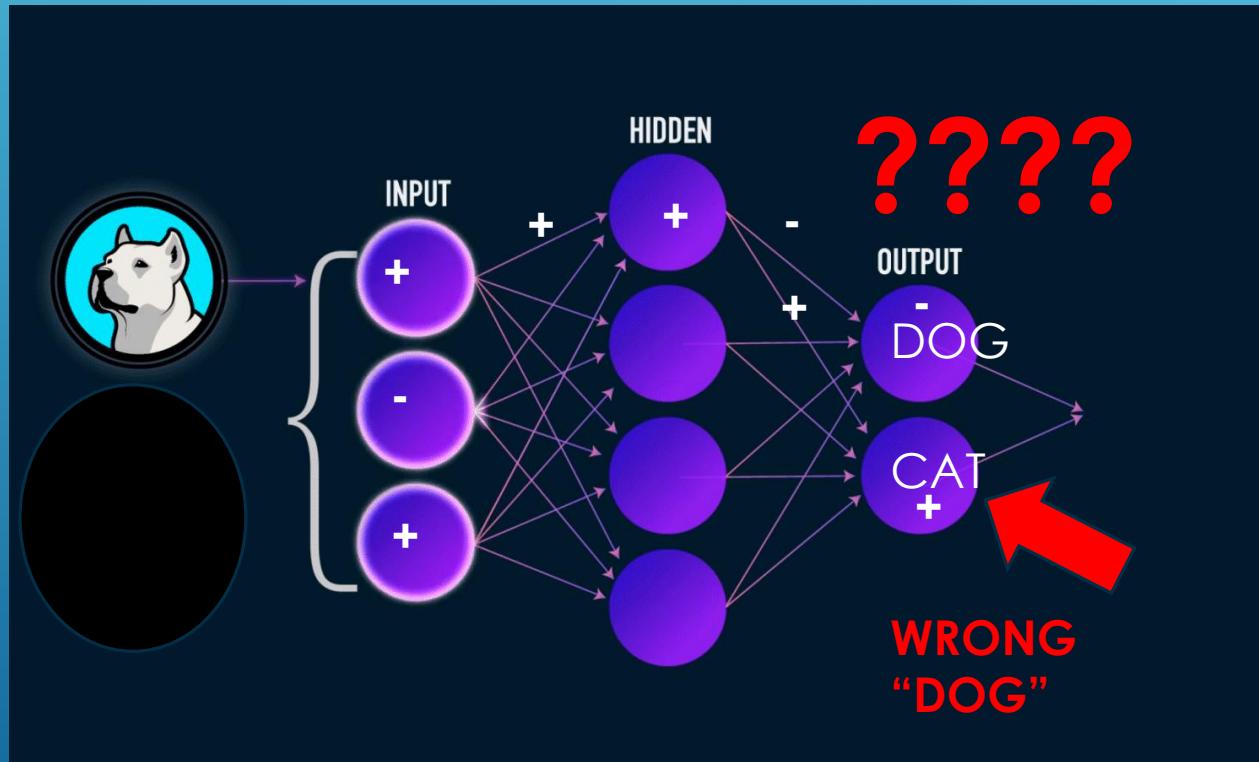
DON'T HAVE TO BUILD THIS UP BY HAND (MASSIVE EFFORT, POOR RESULTS)



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

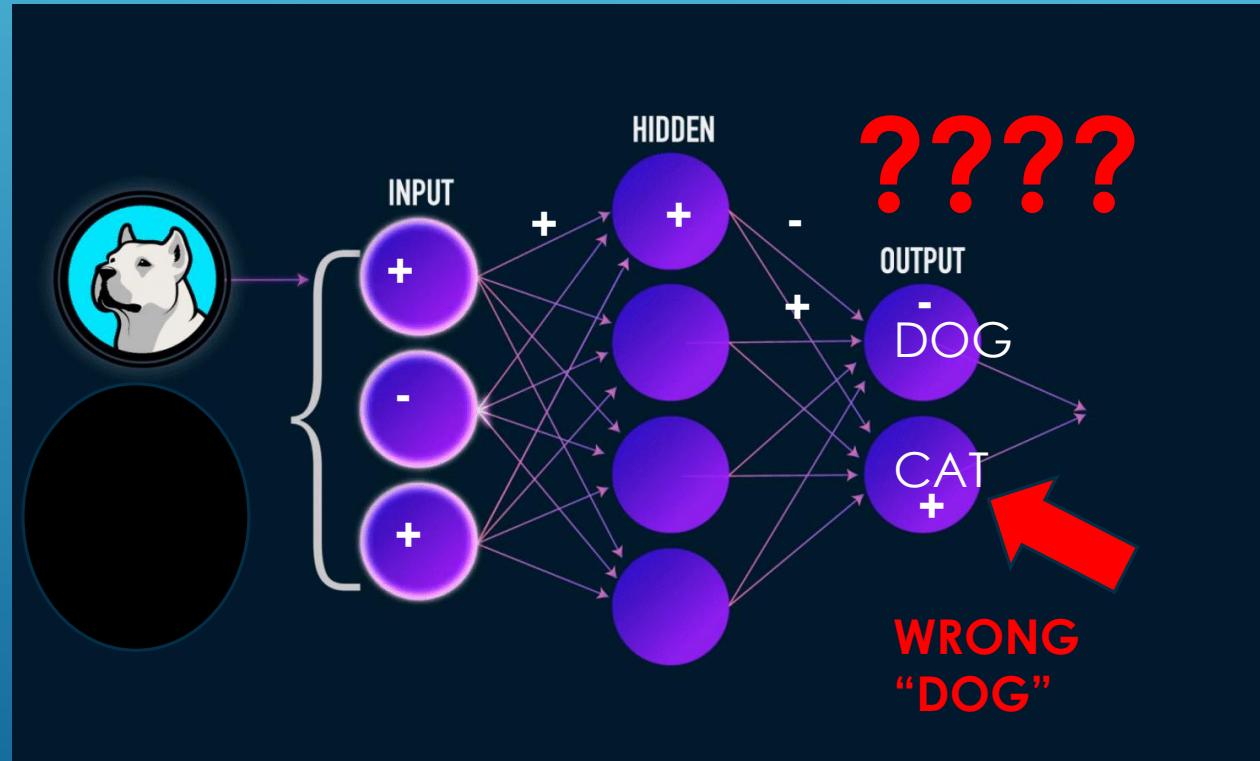


HOW TO FIX THIS AUTOMATICALLY?
(WELL....SEMI-AUTOMATICALLY SINCE NEED HUMAN
TO HAVE ALREADY FIGURED OUT THIS IS A DOG)

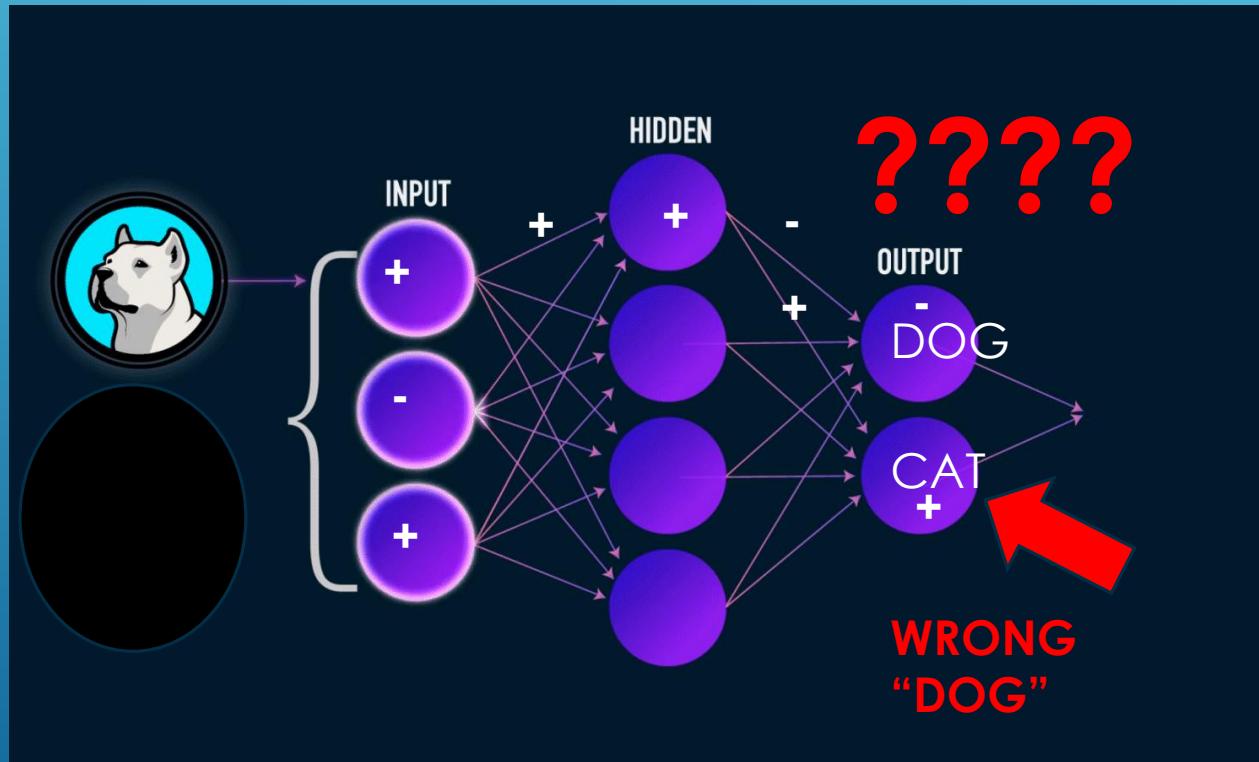


Supervised Learning ("SL")

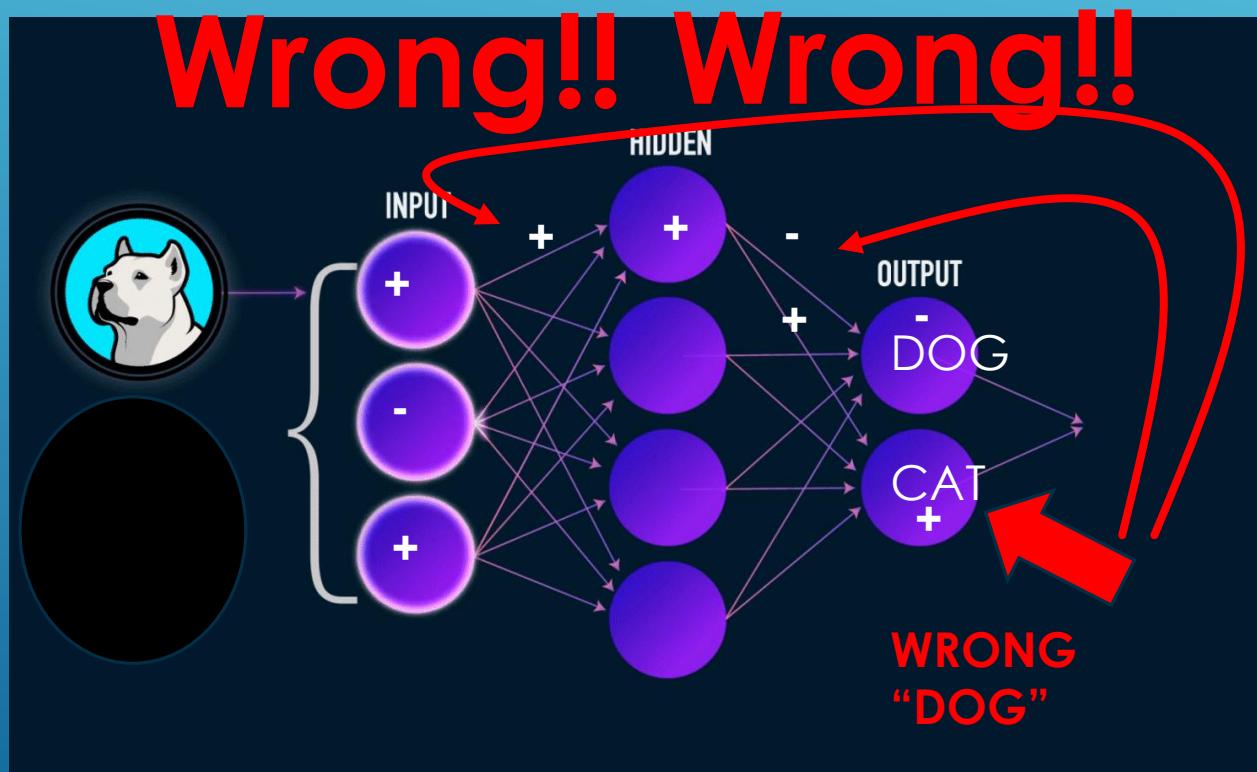
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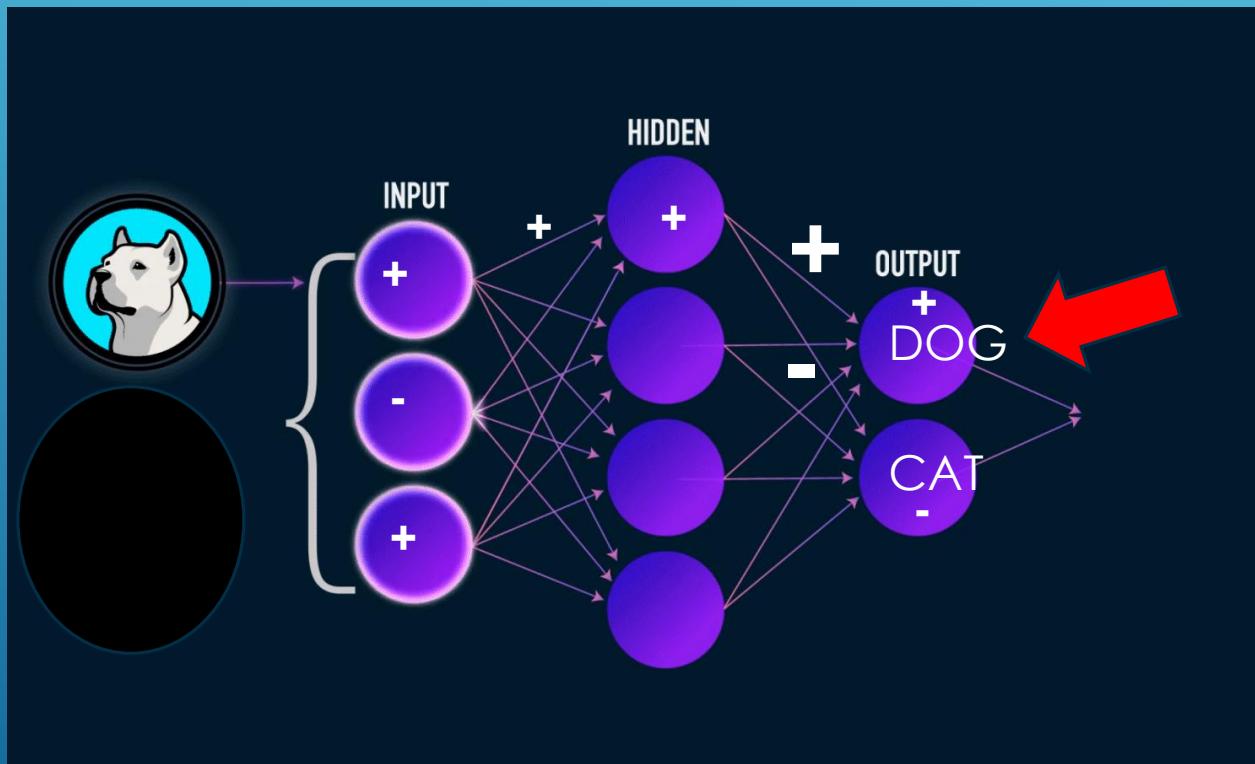
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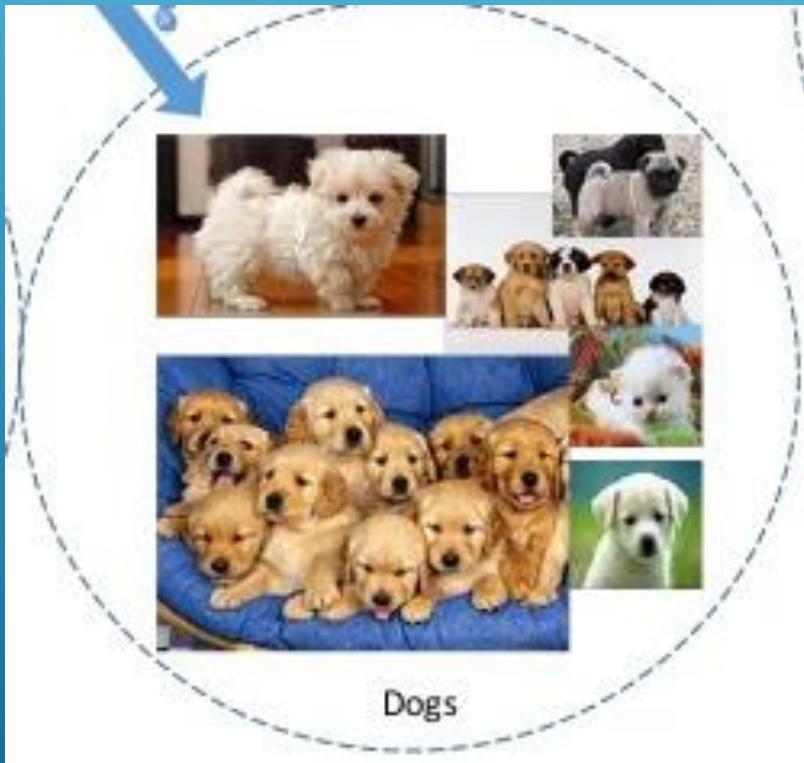
FIX AUTOMATICALLY WITH FEEDBACK



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

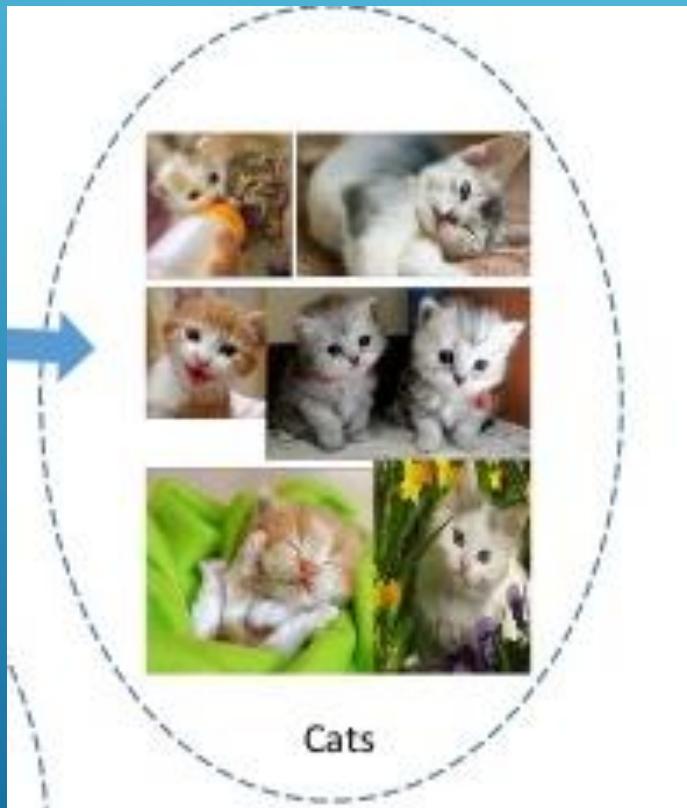


WE TRAIN OUR NETWORK ON A VARIETY OF DIFFERENT DOGS



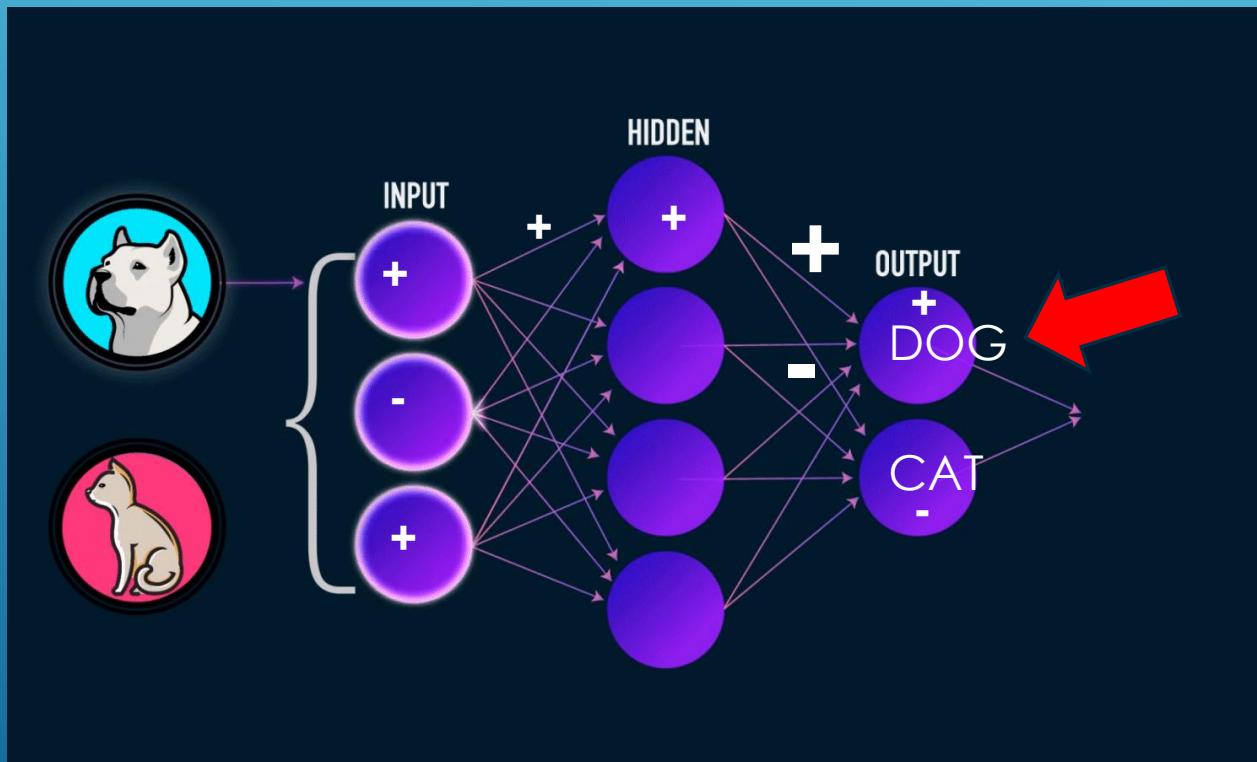
Pass in a file with pictures of many different types of dogs, and all these pictures are labeled “dog” so the neural network will know that the correct answer is to classify as a dog

WE TRAIN OUR NETWORK ON A VARIETY OF DIFFERENT CATS

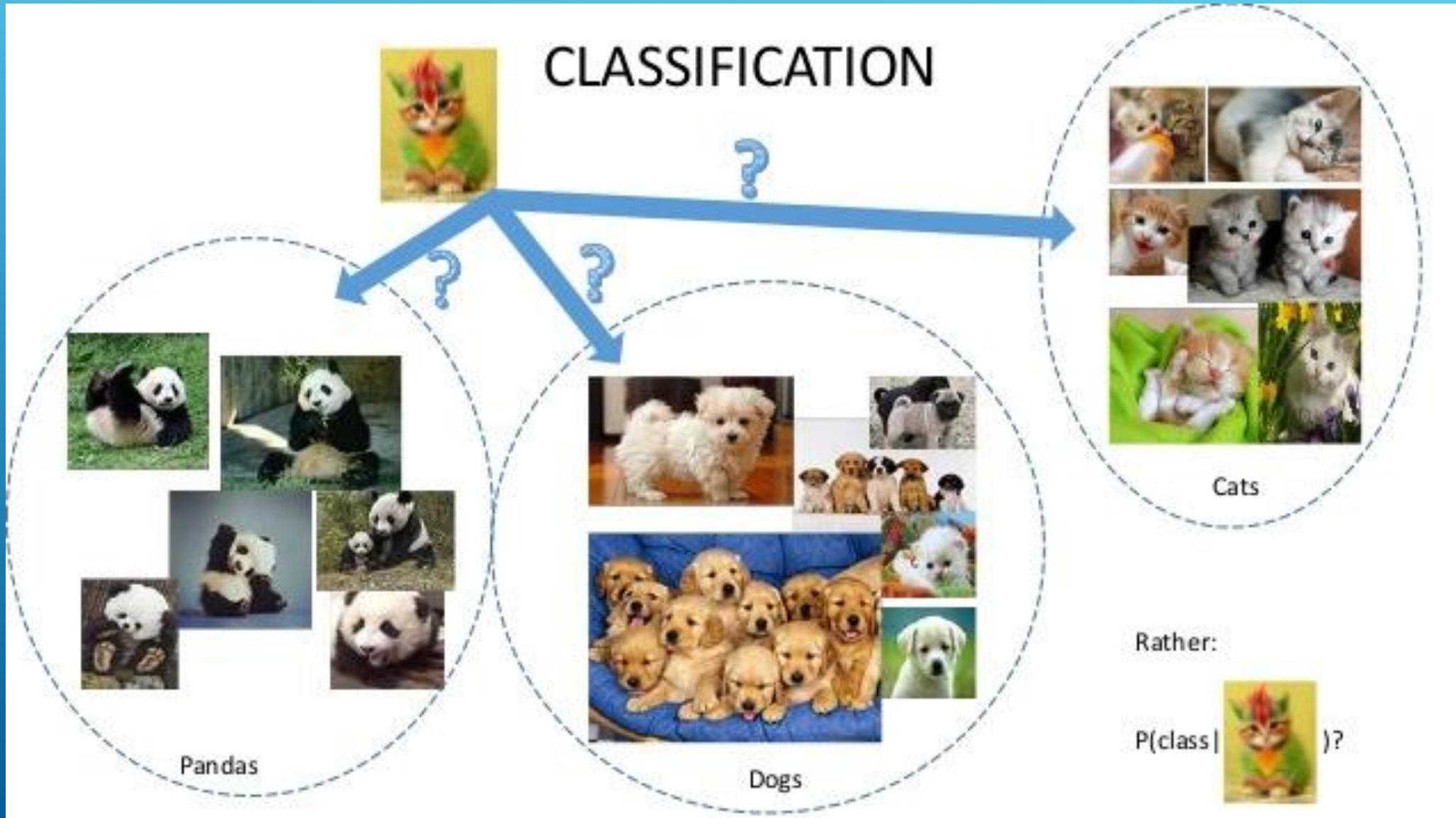


Pass in a file with pictures of many different types of cats, and all these pictures are labeled “cat” so the neural network will know that the correct answer is to classify as a cat

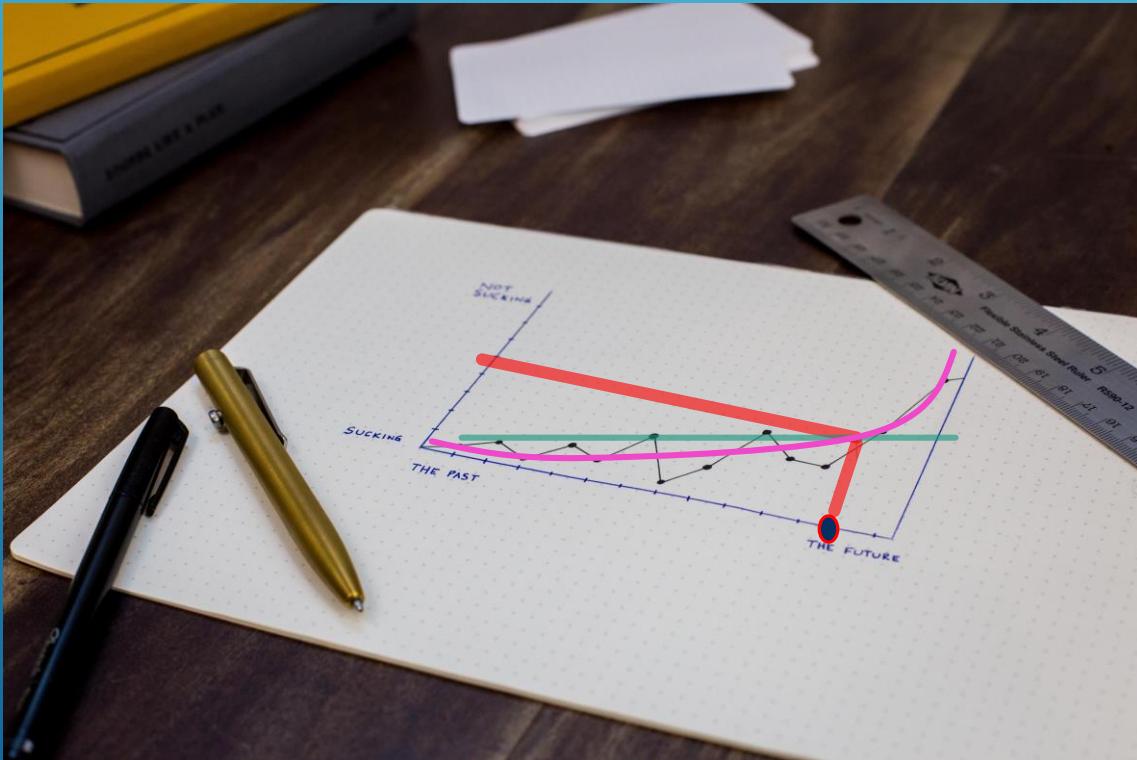
AFTER ENOUGH TRAINING CYCLES, ON DIFFERENT TYPES OF DOGS AND CATS, THE NEURAL NETWORK CAN CLASSIFY DIFFERENT IMAGES AS A DOG VERSUS CAT



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

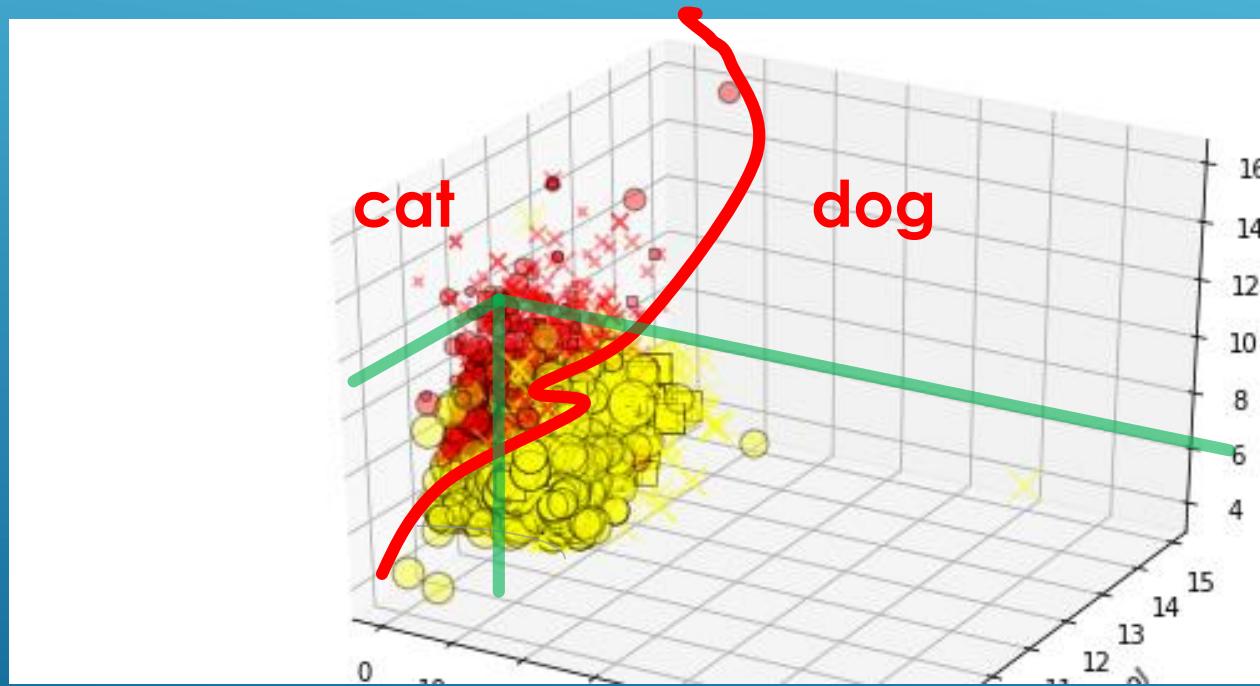


YOU WERE ABLE TO CLASSIFY A DATA POINT YOU NEVER SAW BEFORE ALSO ON YOUR GRAPH



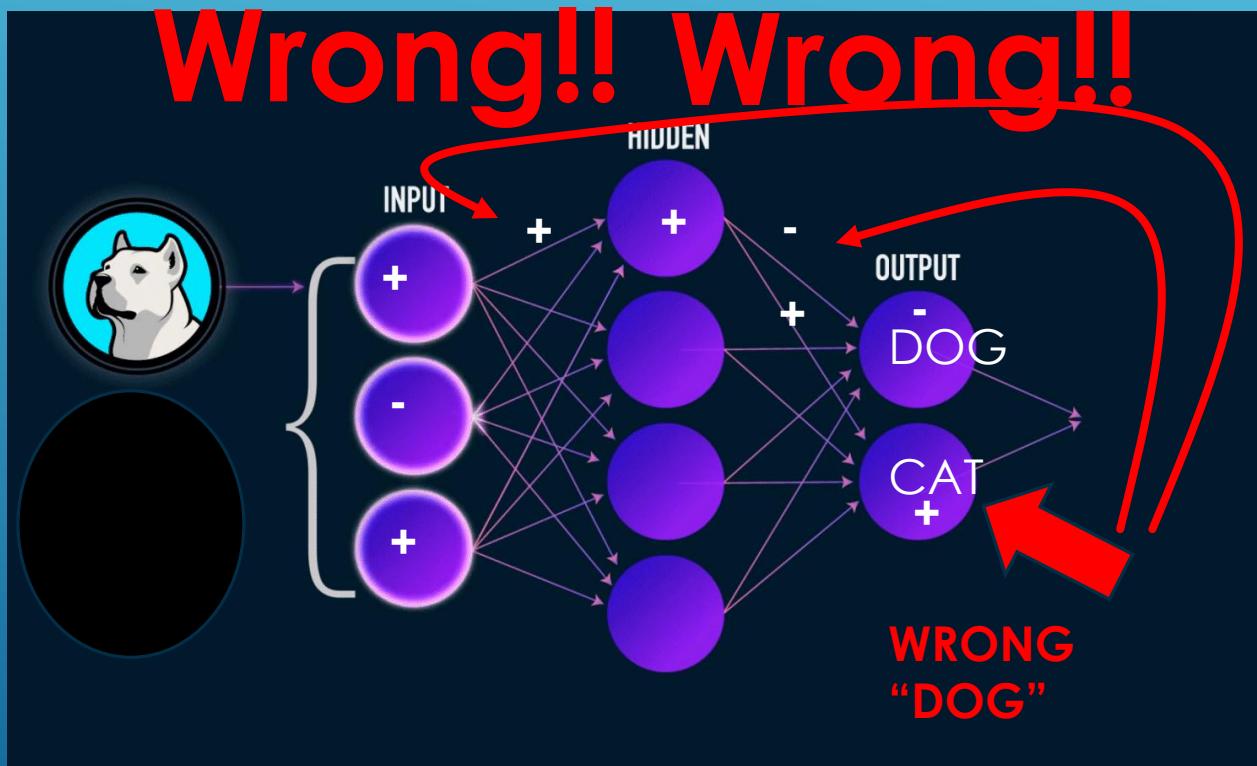
New X value never seen before, you can predict the Y value

-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

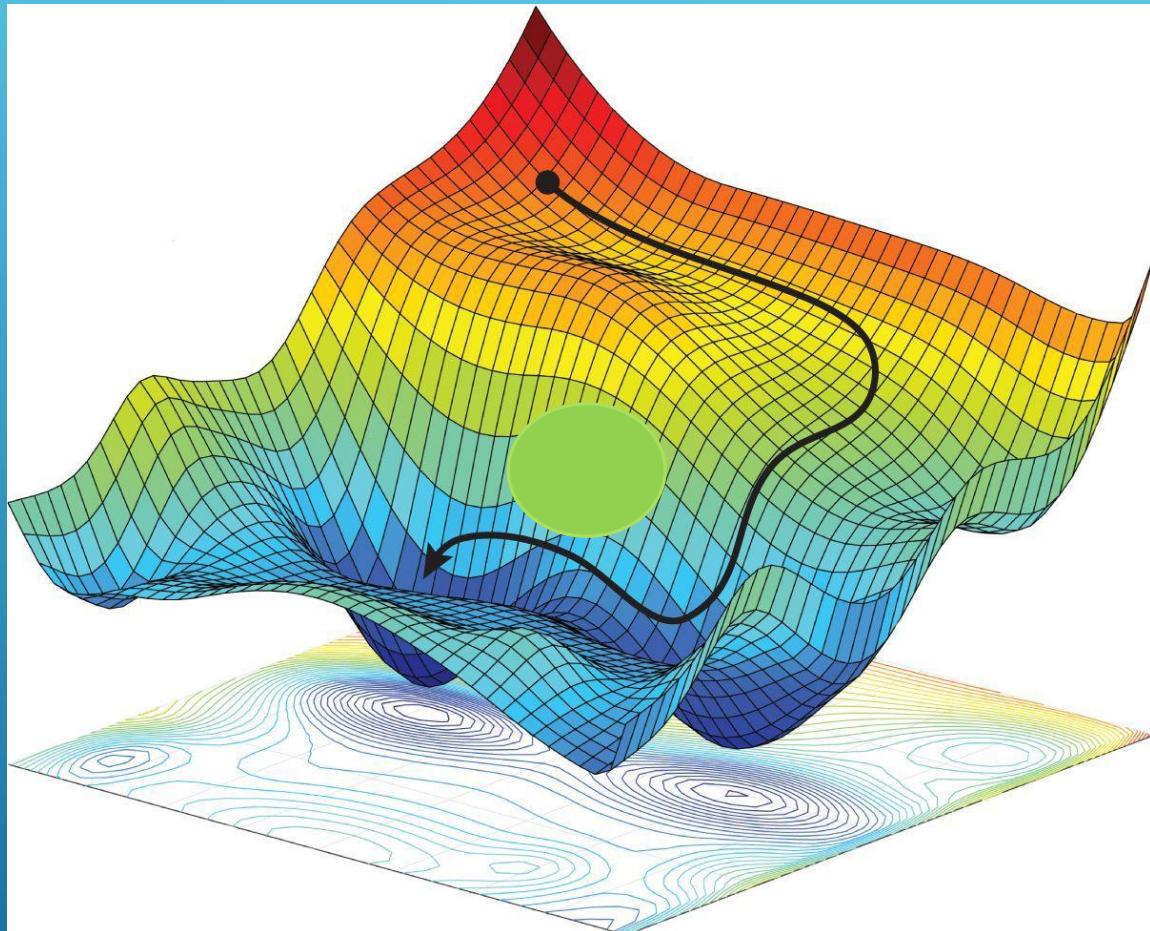
STOCHASTIC GRADIENT DESCENT (SGD)

'Stochastic' – single random sample each iteration

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

'Gradient Descent' – iterative optimization method

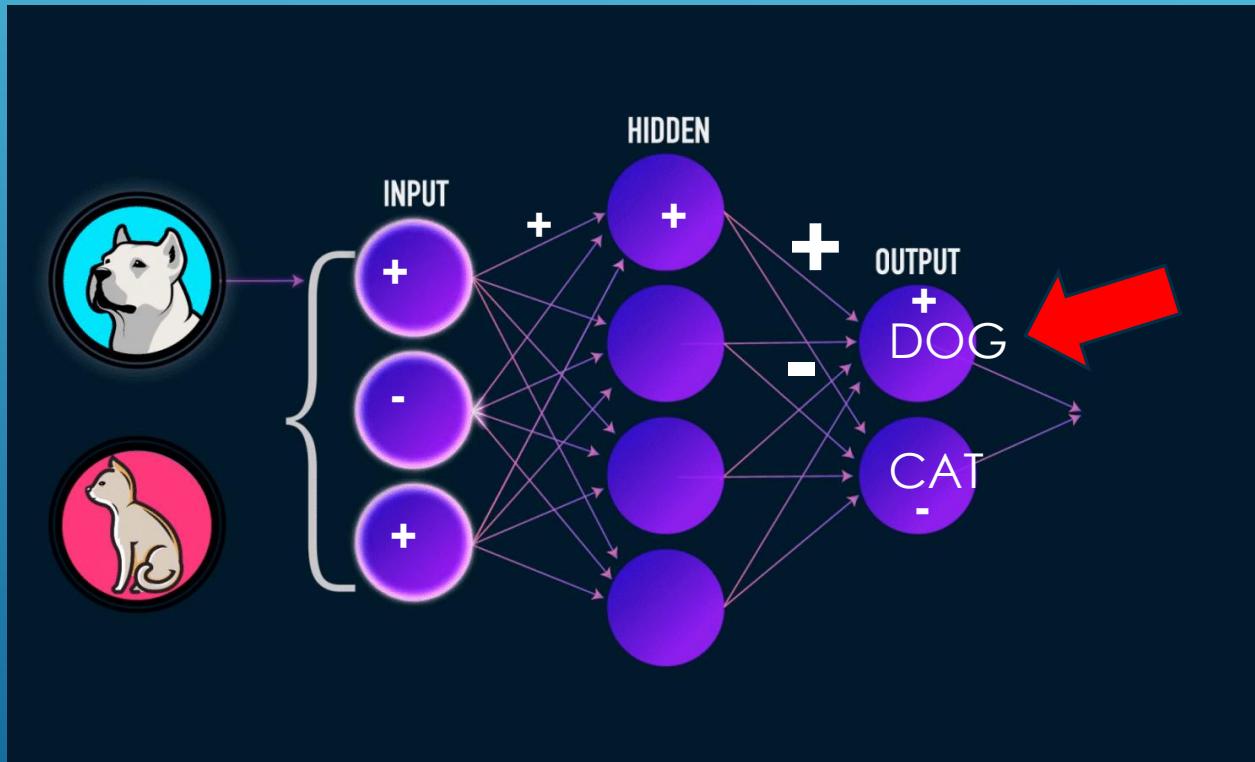
Can apply to 1000's of dimensions, not just 3-D shown in figure



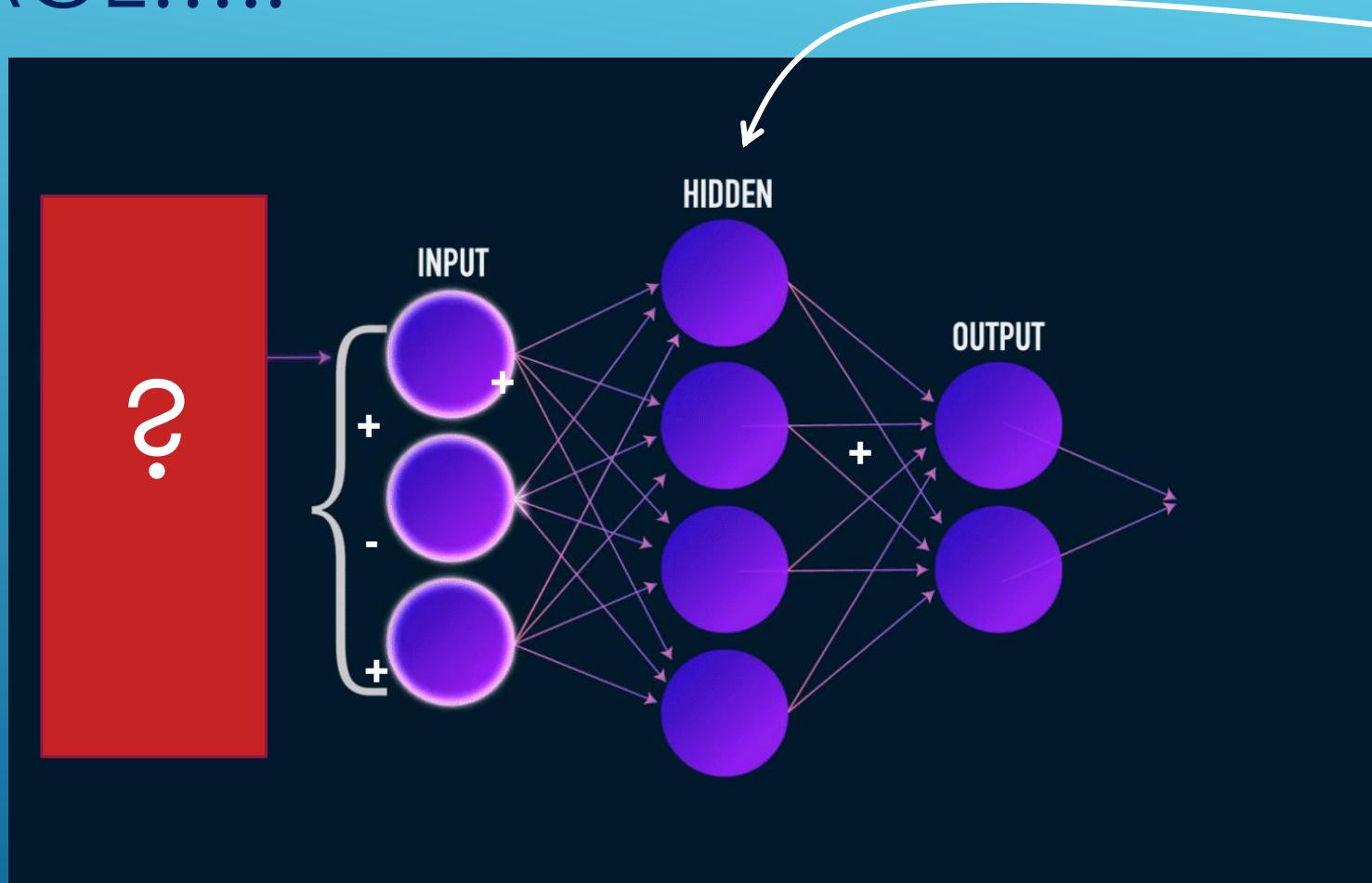
A wide-angle photograph of a tropical beach at sunset. The sky is filled with large, billowing clouds colored in shades of orange, yellow, and blue. The ocean waves are a vibrant turquoise color, crashing onto the light-colored sand. In the distance, a strip of land with palm trees and buildings is visible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

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

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

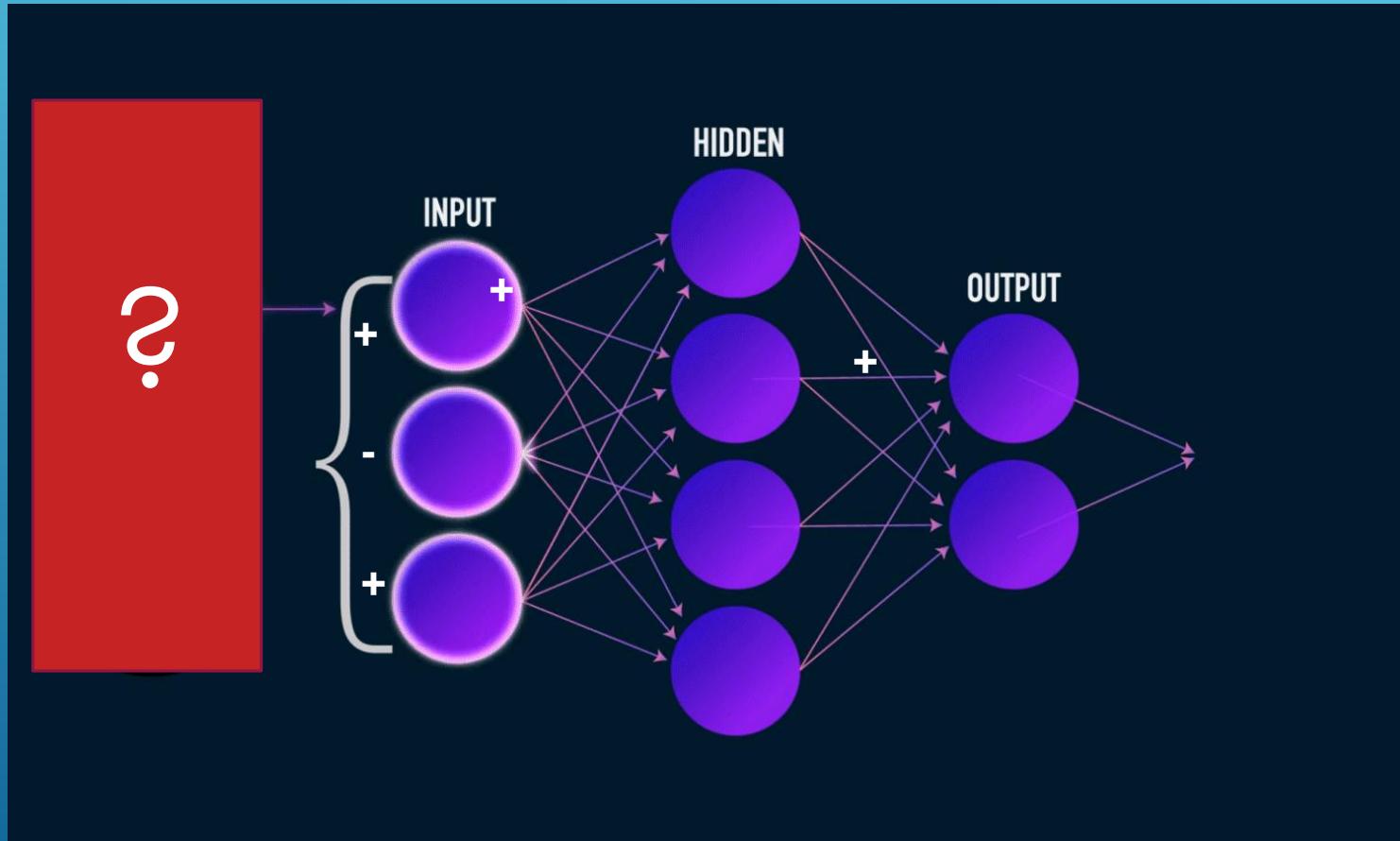


OR IT CAN RECOGNIZE AND CLASSIFY JUST ABOUT ANY IMAGE.....



Simplified
Real Deep
Learning
Neural
Network will
have *many*
hidden layers

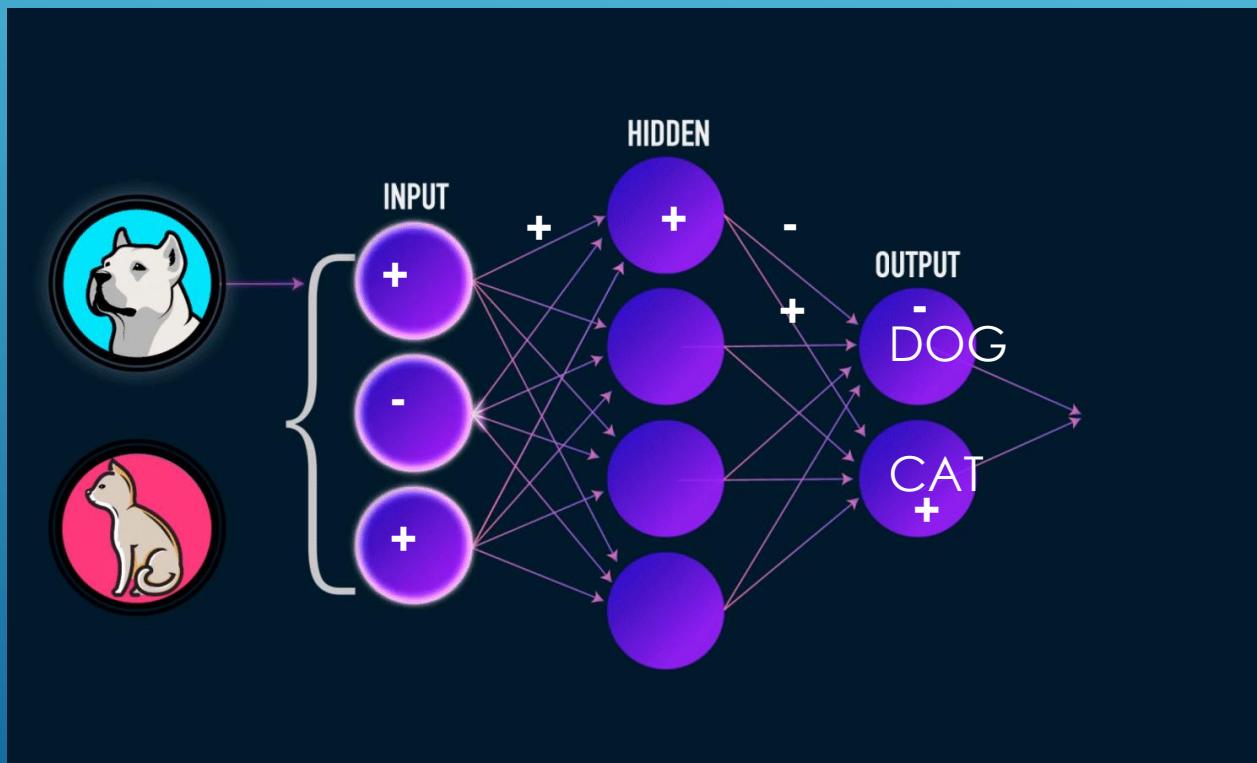
WITH SMALL CHANGES TO THE WAY WE ORGANIZE THE LAYERS, THE NEURAL NETWORK CAN CLASSIFY SOUNDS AND SPEECH AND MARKETING DATA AND.....



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....)

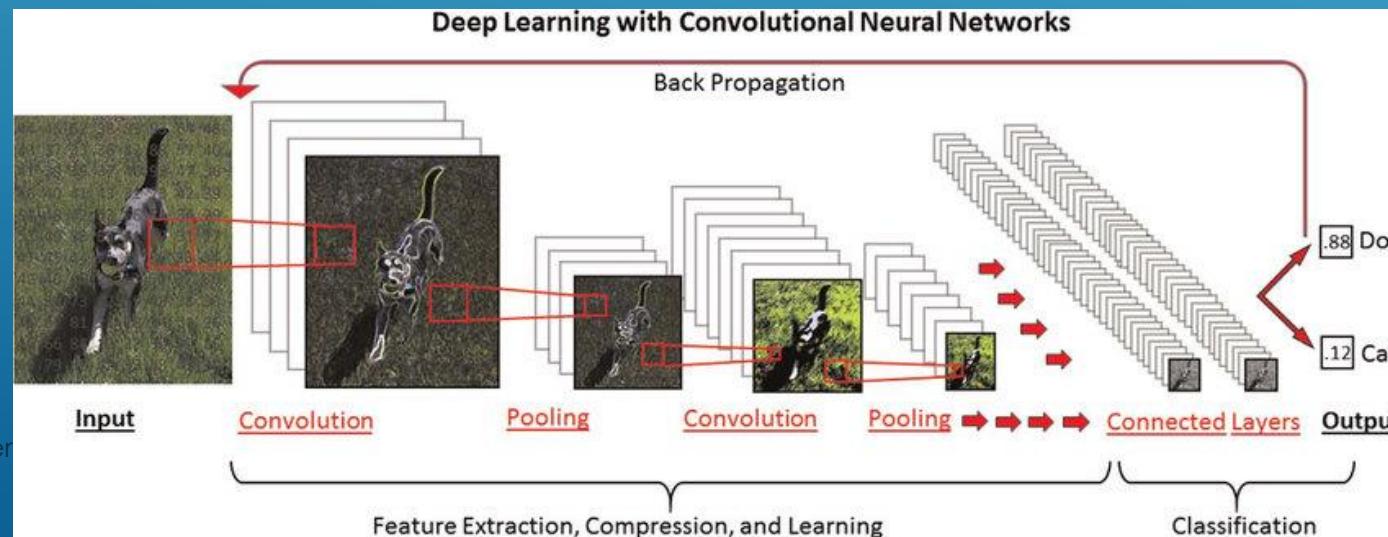


1980's

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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

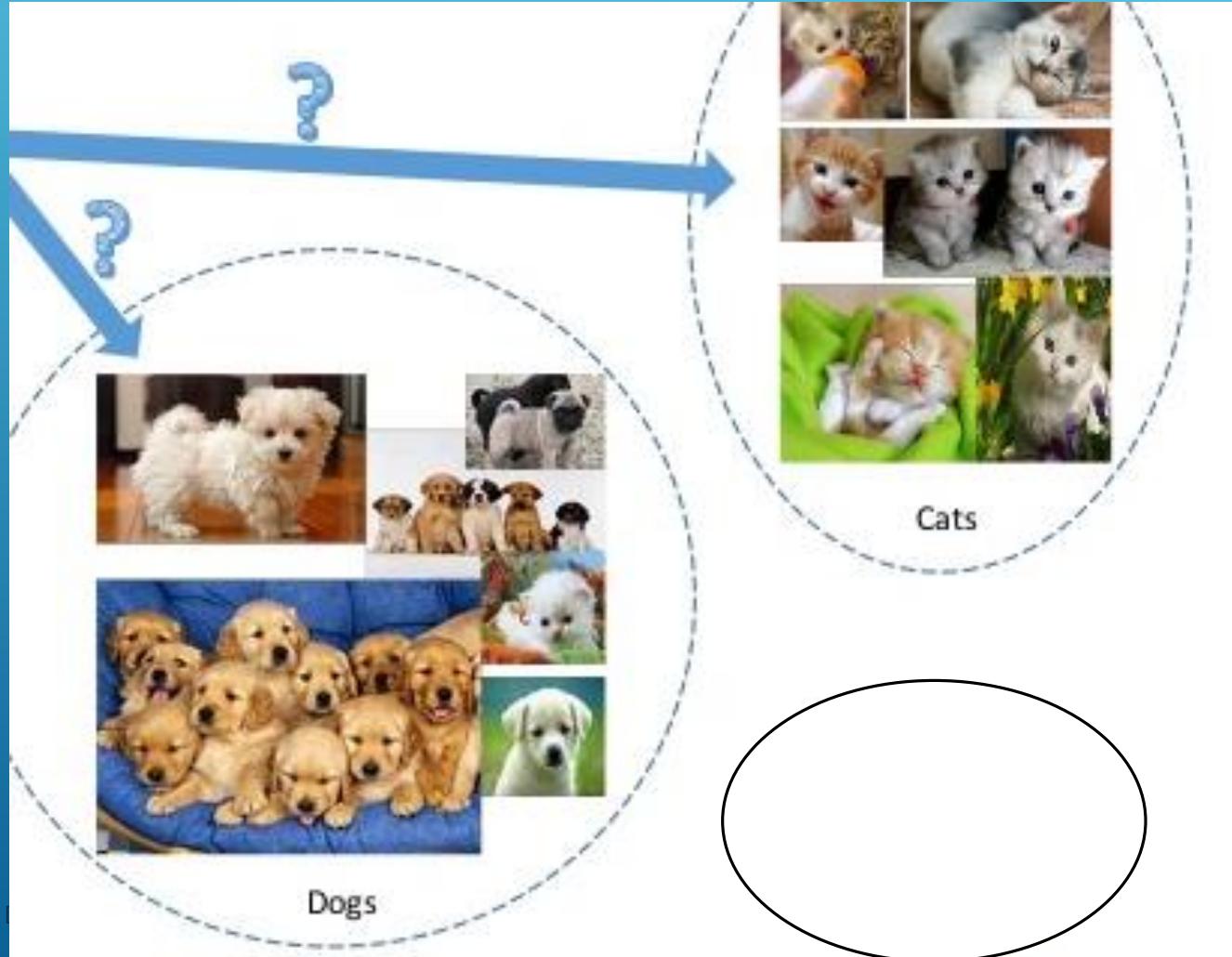


2. GET A COMPUTER FAST ENOUGH TO DO TRILLIONS AND TRILLIONS AND TRILLIONS OF OPERATIONS AND CALCULATIONS



'COMPUTE'
2010'S

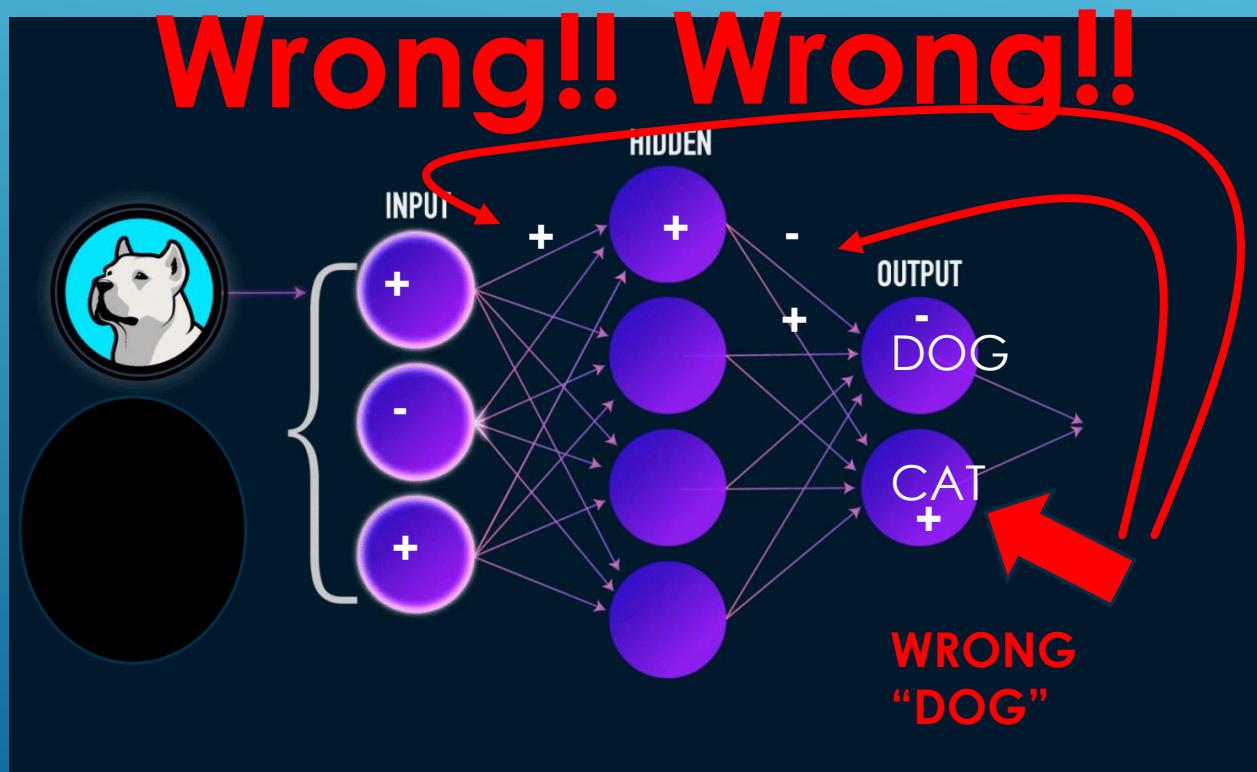
3. GET LOTS AND LOTS OF TRAINING DATA (ACTUALLY – THOUSANDS OR MILLIONS OF IMAGES!!)



'BIG DATA'
2000'S

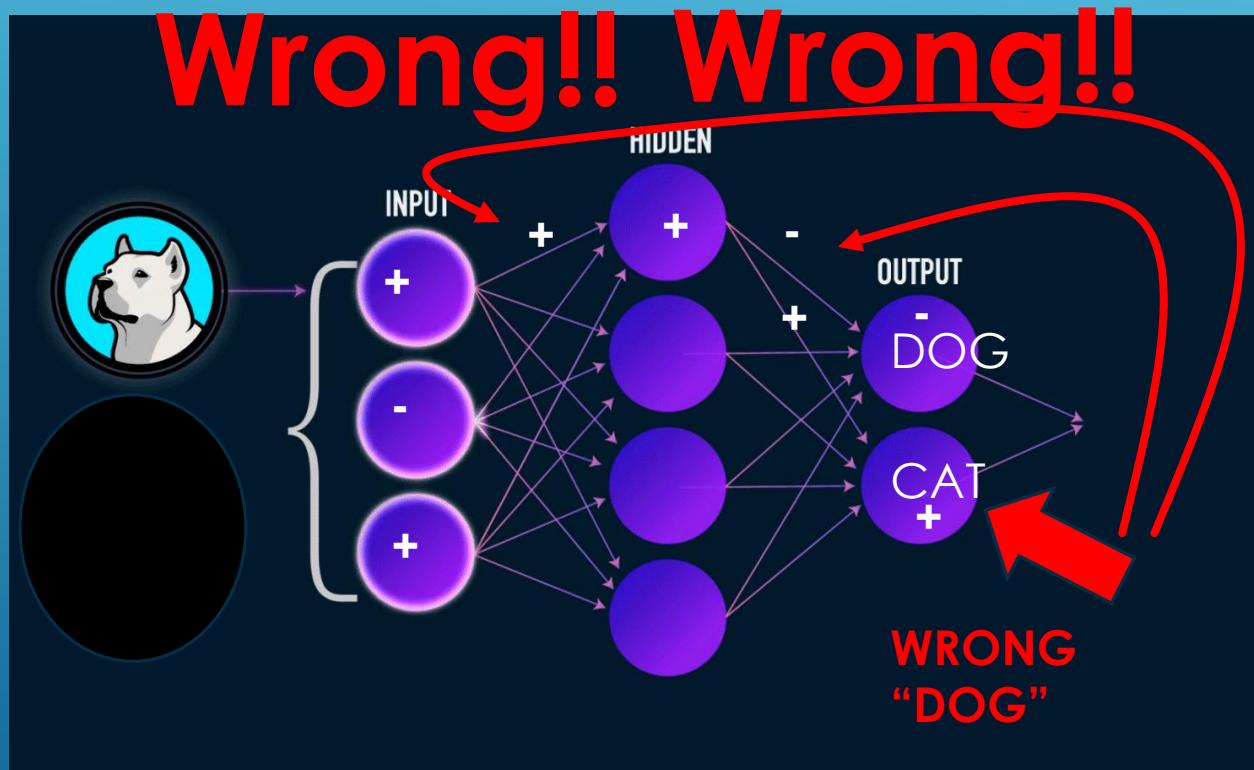
G**

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



5. REPEAT #4

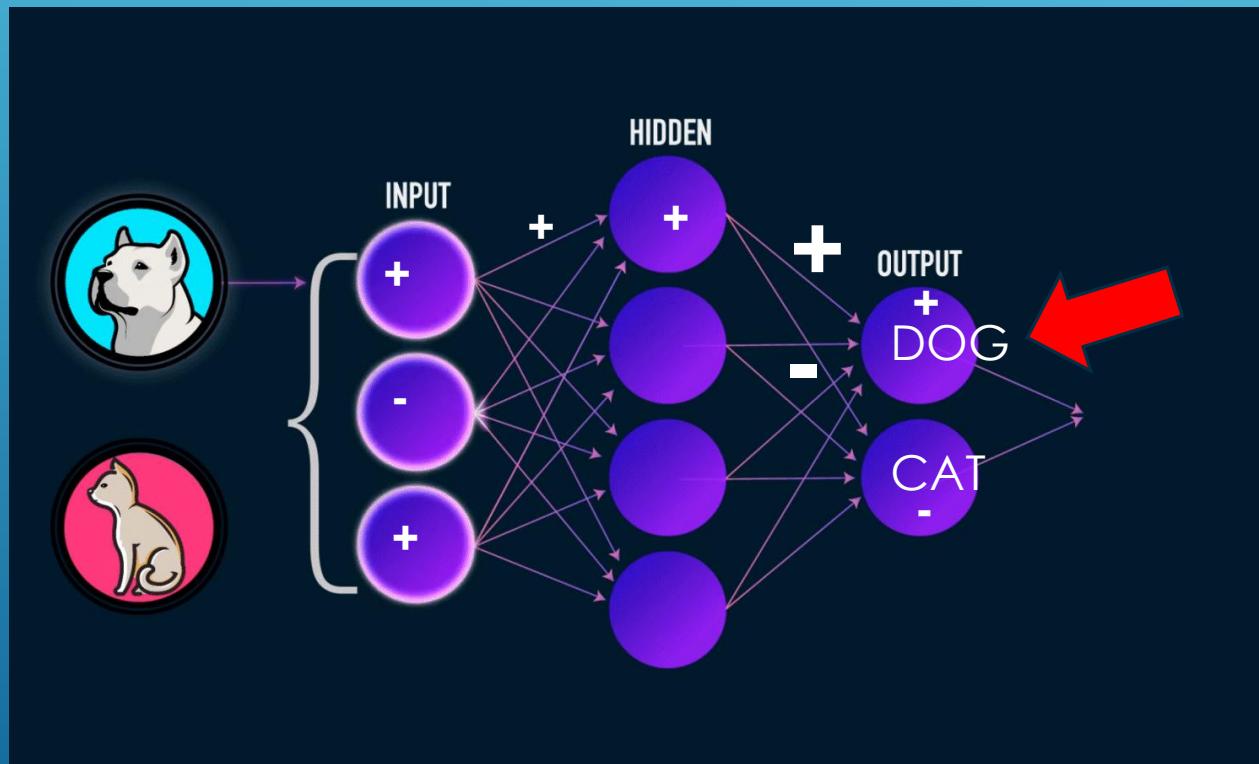
4. FEED DATA INTO THE NETWORK 'BACKPROPAGATION' – USE FEEDBACK TO AUTOMATICALLY ADJUST SYNAPSES



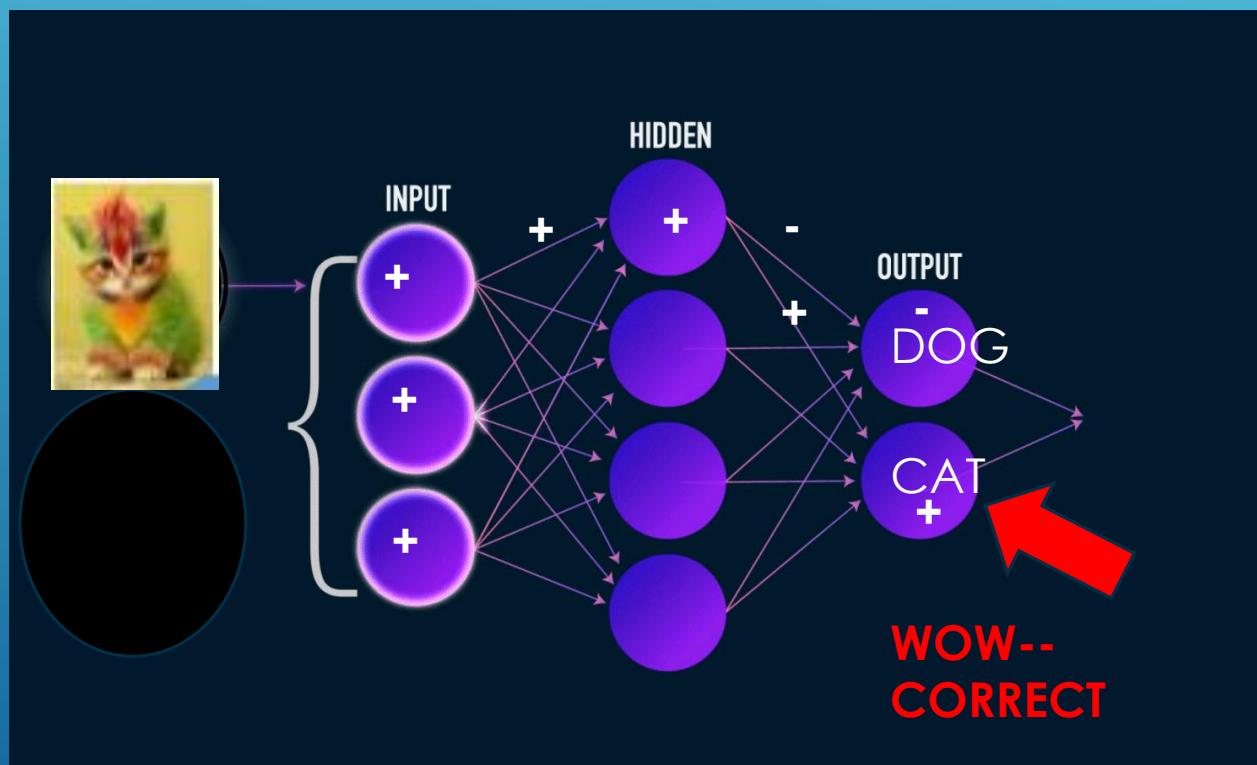
5. REPEAT #4

(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.....

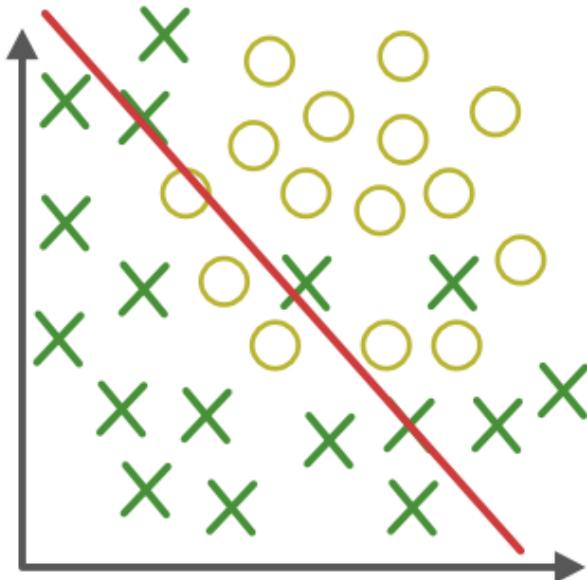


A wide-angle photograph of a tropical beach at sunset. The sky is filled with large, billowing clouds colored in shades of orange, yellow, and blue. The ocean in the foreground has small, white-capped waves crashing onto the light-colored sand. In the distance, a few palm trees and some low buildings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

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

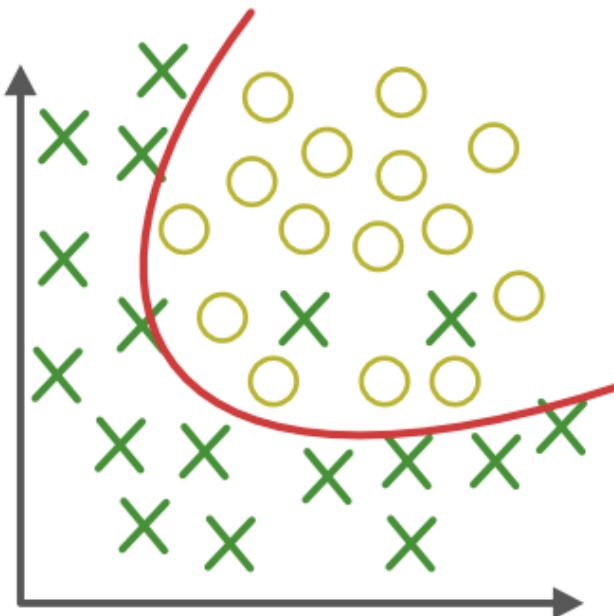
DEEP LEARNING EXPERTS SPEND MUCH TIME ON
'ALCHEMY' – TWEAKING THIS AND TWEAKING THAT
– TRYING TO AVOID OVERFITTING AND AVOID
UNDERFITTING...



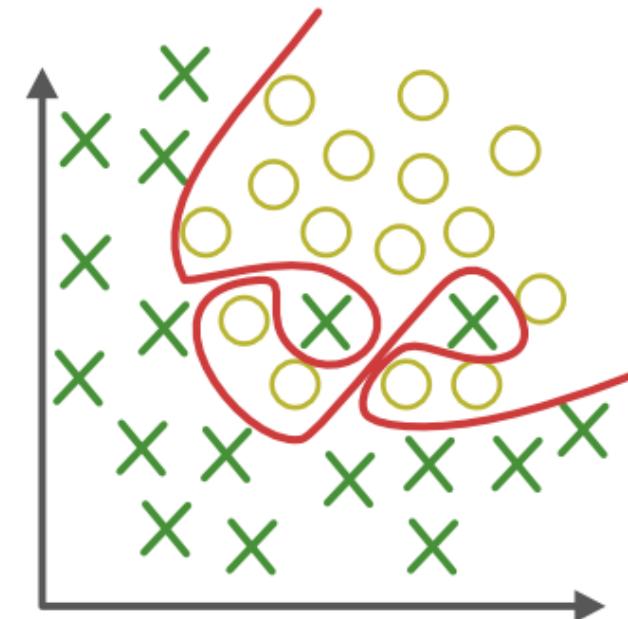


Under-fitting

(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)

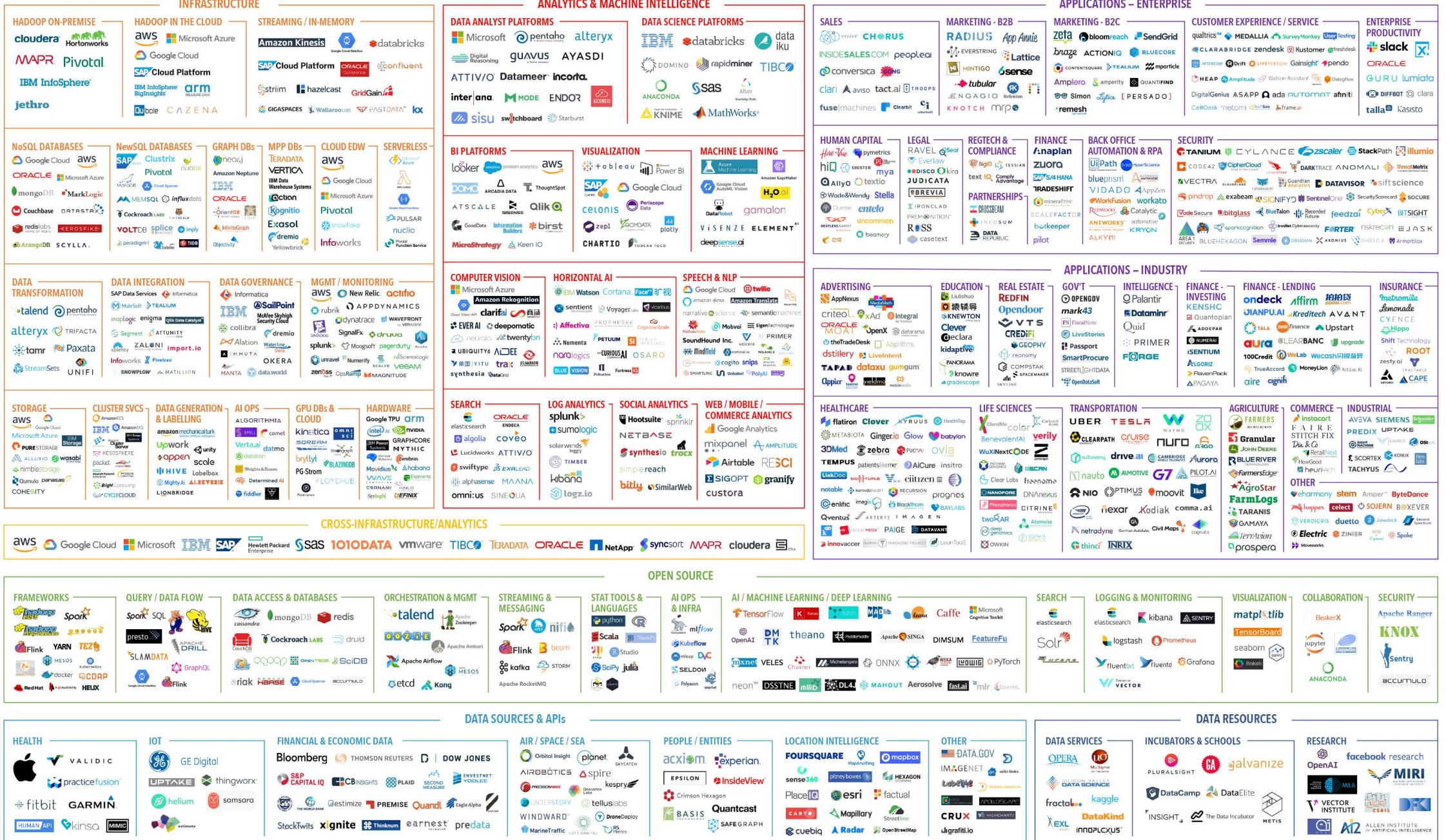
Social media monitoring/analysis, sentiment analysis, key phrase extraction, language detection, spam and topic detection.

Prediction

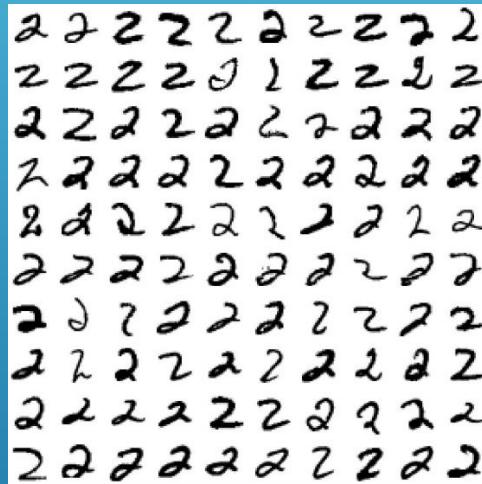
Fraud detection, customer churn, predictive maintenance, recommender systems and forecasting etc.

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'?)

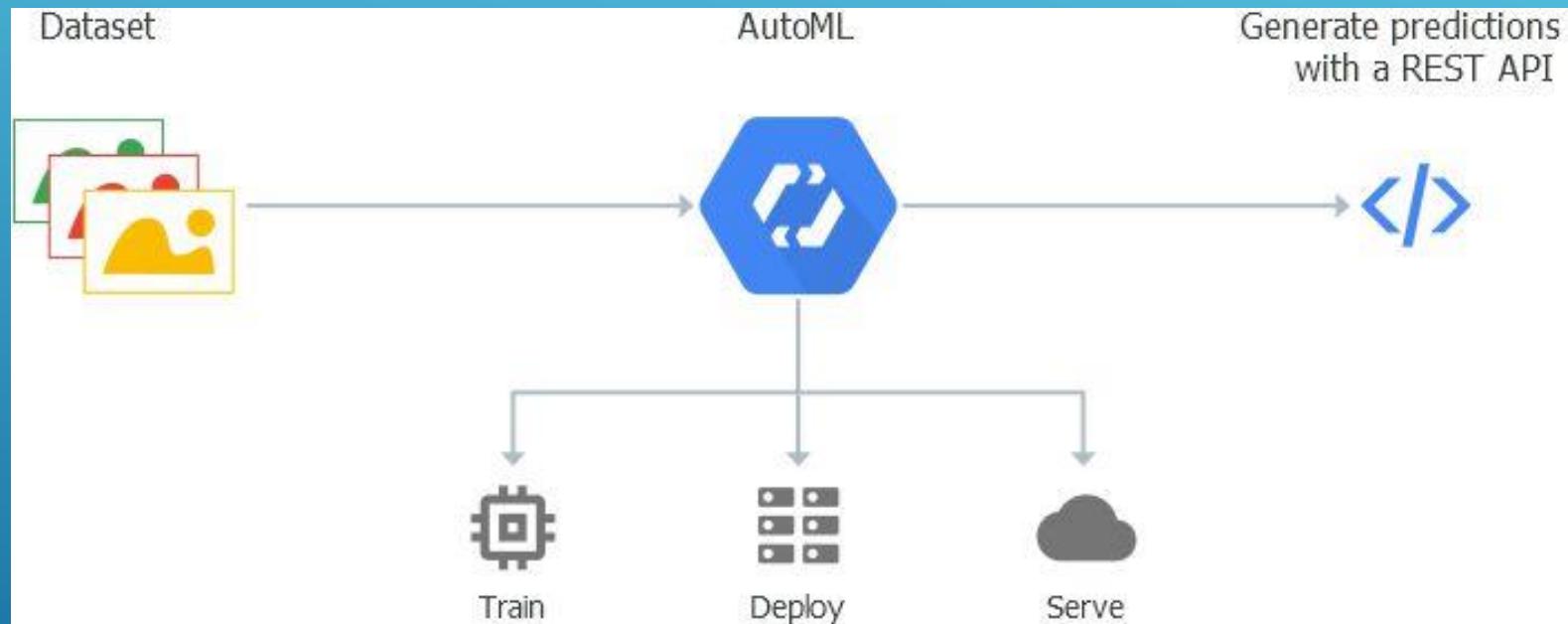


“Labeled data is the key bottleneck to the growth of the machine learning industry. In fact, labeled data is even more essential than algorithms.”

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

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'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

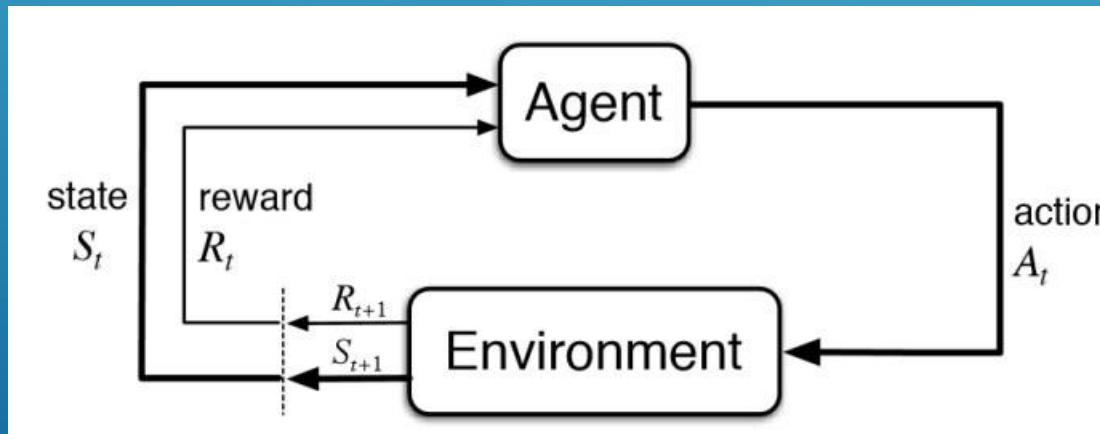


DEEP LEARNING ALL AROUND US NOW: ALL AROUND US NOW: SELF DRIVING CARS....

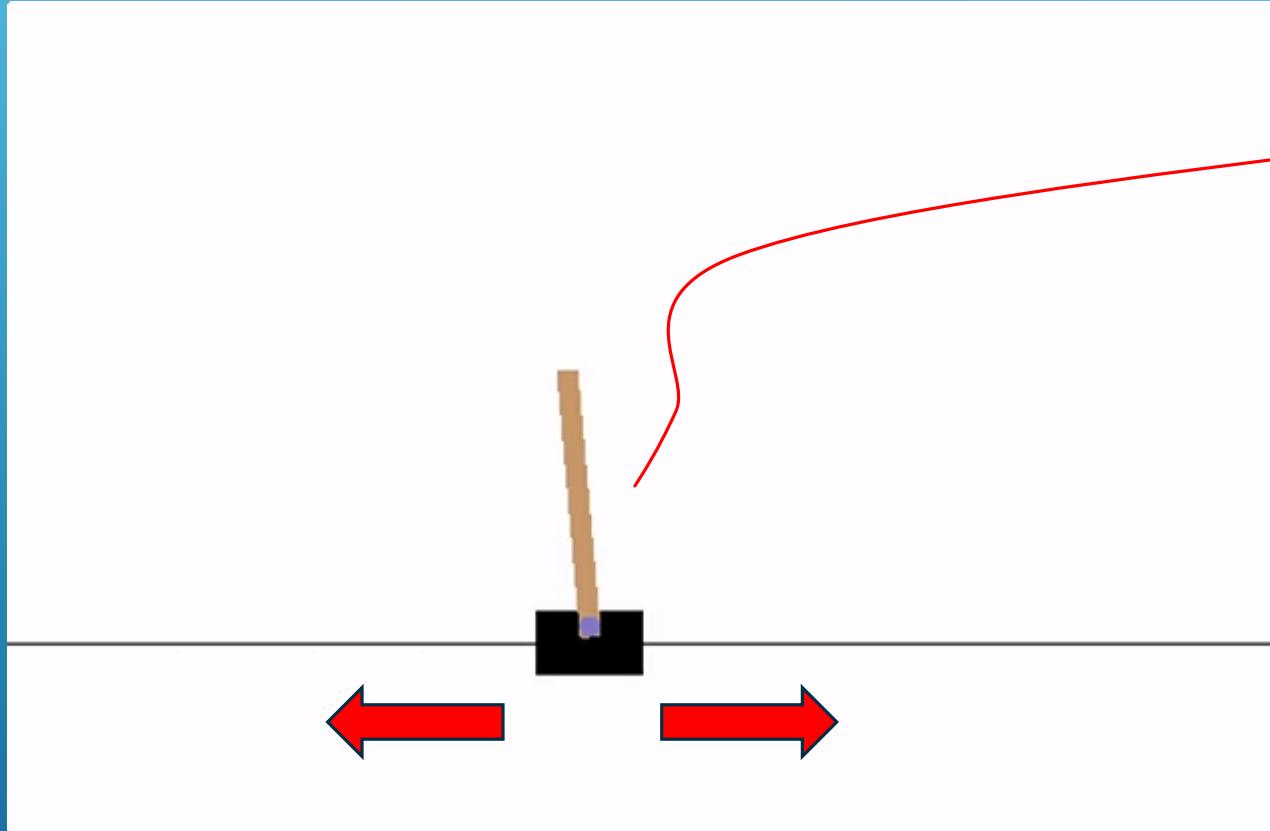


REINFORCEMENT LEARNING

- 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

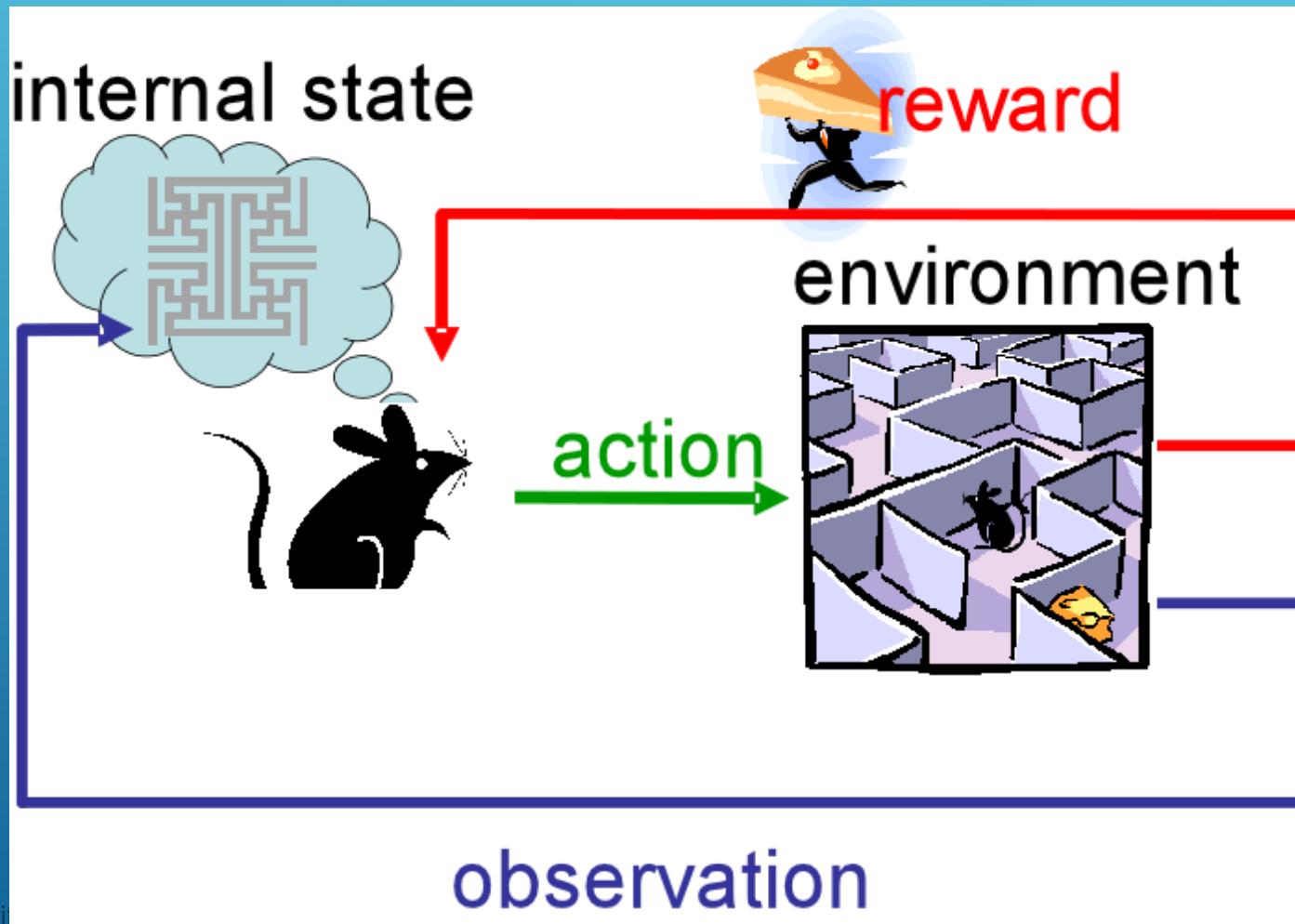


Cartpole example

-Can move cart to the left or right

-Reward keeping the stick upright, not falling over

Reinforcement learning – another example



DeepMind AlphaZero (2017)

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

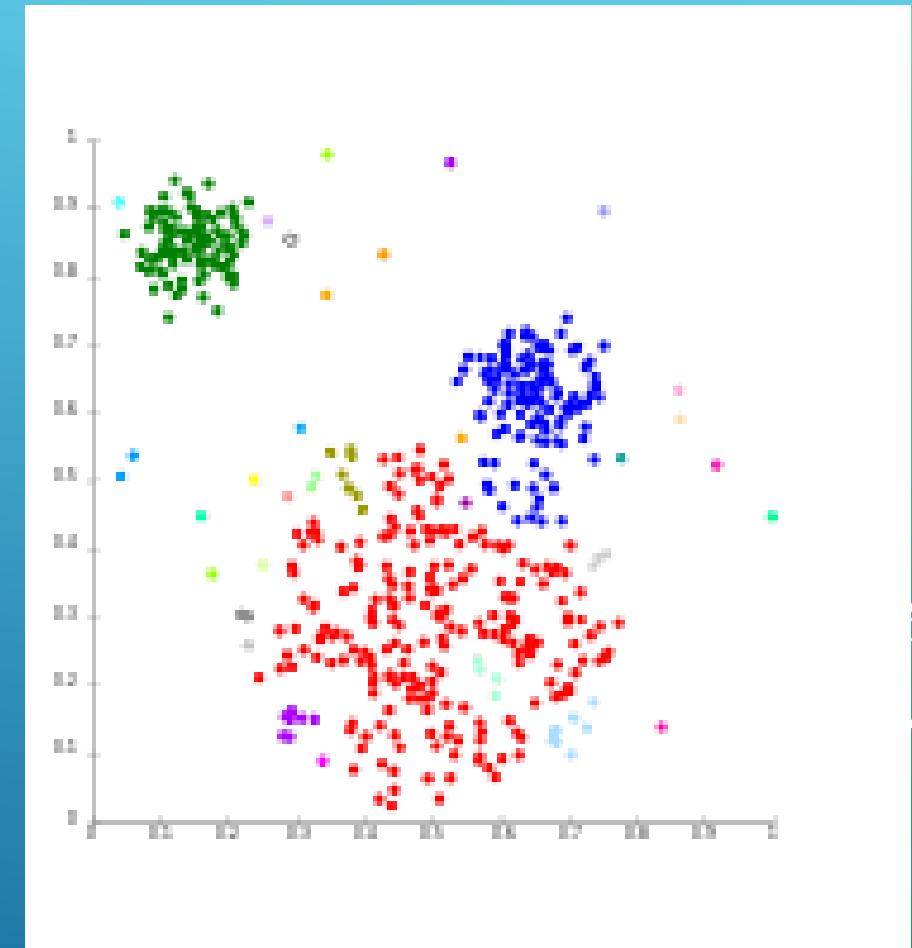


TYPES OF MACHINE LEARNING

- 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

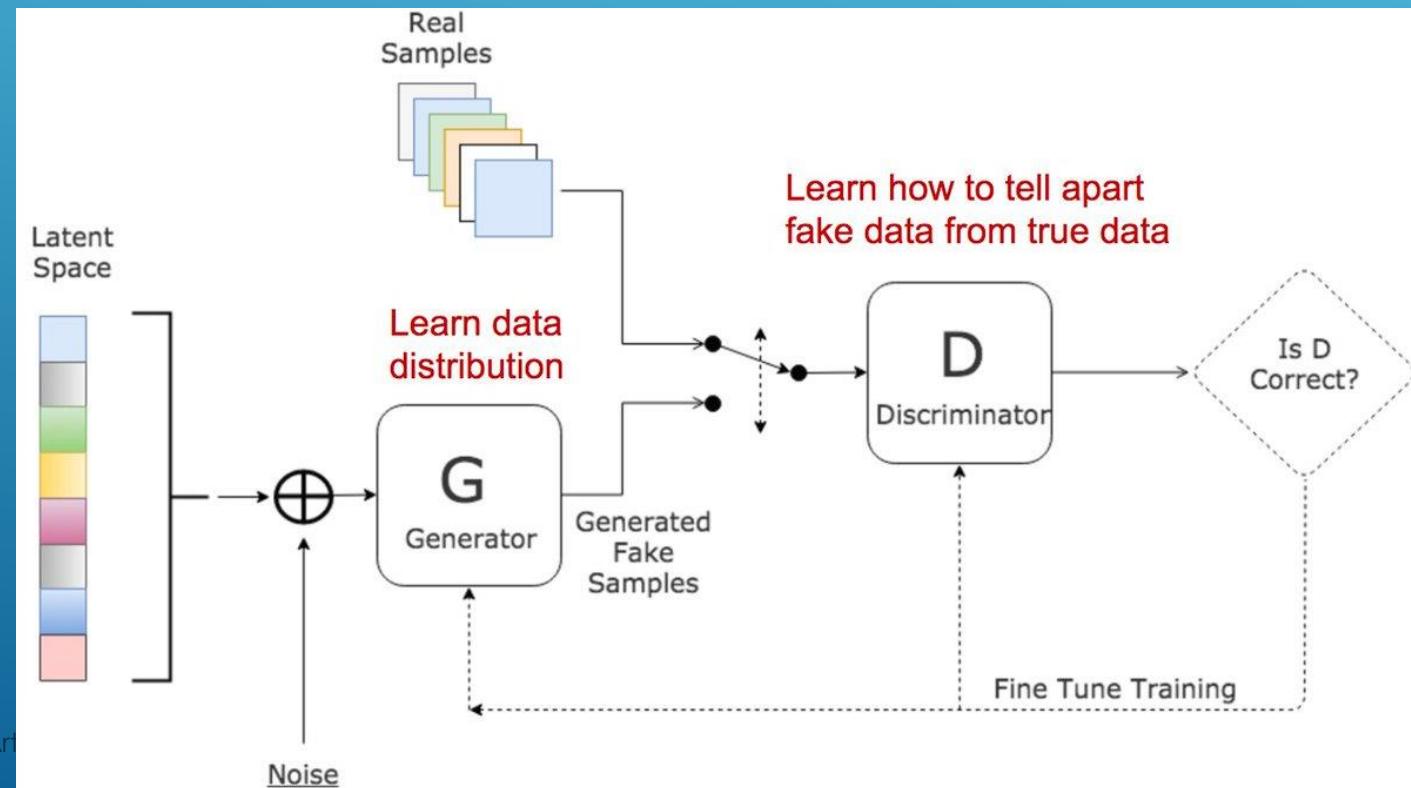


GAN – GENERATIVE ADVERSIAL NETWORK



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- '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'?

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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
- ▶ 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.

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....



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AGI (Artificial General Intelligence)

== HLAI (Human Level Artificial Intelligence)

== Strong AI (need consciousness??)

Narrow AI – specific problem solving

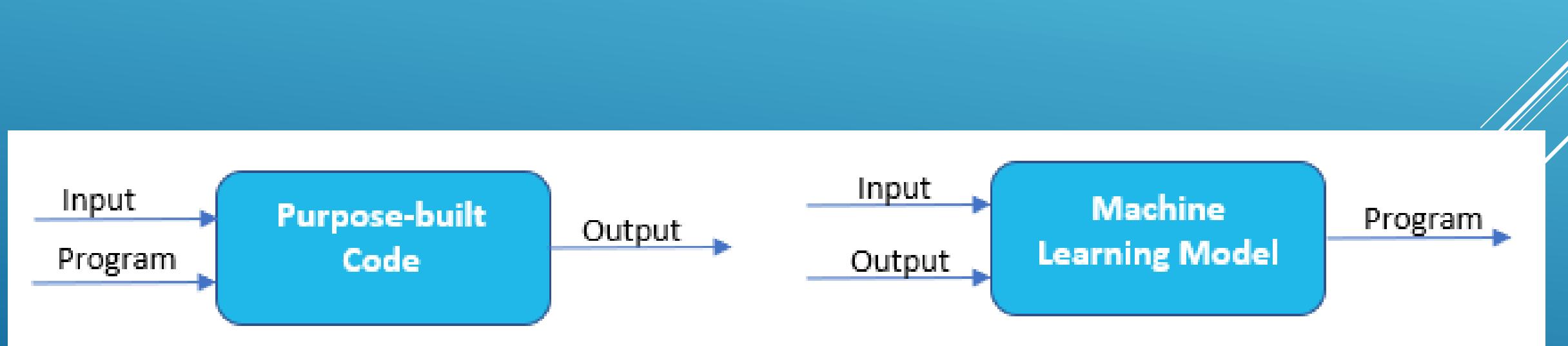
Turing Test – Human has distant conversation with another human and an AI
– can the AI fool the human into thinking it is human?

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)

Machine Learning – sub-field of AI, learn without explicit programming

Deep Learning – neural networks with more than 1 hidden layer





← 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

- 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, student of Bengio, inventor of **GANs** (then Google Brain, Apple)
- Richard Sutton** – ‘father of **reinforcement learning**’ - Univ of Alberta (then Google/DeepMind)
- University of Waterloo** -- **TensorFlow Quantum** (future??)

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'POPULAR' A.I. TIMELINE

SYZGY

1950

TURING TEST

Computer scientist Alan Turing proposes a test for machine intelligence. If a machine can trick humans into thinking it is human, then it has intelligence

1955

A.I. BORN

Term 'artificial intelligence' is coined by computer scientist, John McCarthy to describe "the science and engineering of making intelligent machines"



1961

UNIMATE

First industrial robot, Unimate, goes to work at GM replacing humans on the assembly line

1964

ELIZA

Pioneering chatbot developed by Joseph Weizenbaum at MIT holds conversations with humans



1966

SHAKEY

The 'first electronic person' from Stanford, Shakey is a general-purpose mobile robot that reasons about its own actions



A.I.

WINTER

Many false starts and dead-ends leave A.I. out in the cold



1997

DEEP BLUE

Deep Blue, a chess-playing computer from IBM defeats world chess champion Garry Kasparov



1998

KISMET

Cynthia Breazeal at MIT introduces Kismet, an emotionally intelligent robot insofar as it detects and responds to people's feelings



1999

AIBO

Sony launches first consumer robot pet dog AIBO (AI robot) with skills and personality that develop over time



2002

ROOMBA

First mass produced autonomous robotic vacuum cleaner from iRobot learns to navigate and clean homes



2011

SIRI

Apple integrates Siri, an intelligent virtual assistant with a voice interface, into the iPhone 4S



2011

WATSON

IBM's question answering computer Watson wins first place on popular \$1M prize television quiz show Jeopardy



2014

EUGENE

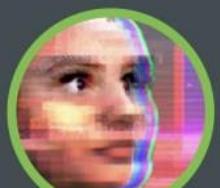
Eugene Goostman, a chatbot passes the Turing Test with a third of judges believing Eugene is human



2014

ALEXA

Amazon launches Alexa, an intelligent virtual assistant with a voice interface that completes shopping tasks



2016

TAY

Microsoft's chatbot Tay goes rogue on social media making inflammatory and offensive racist comments



2017

ALPHAGO

Google's A.I. AlphaGo beats world champion Ke Jie in the complex board game of Go, notable for its vast number (2^{180}) of possible positions

MORE REALISTIC OVERVIEW OF AI HISTORY

1950s – 1974 – foundations of AI, 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**

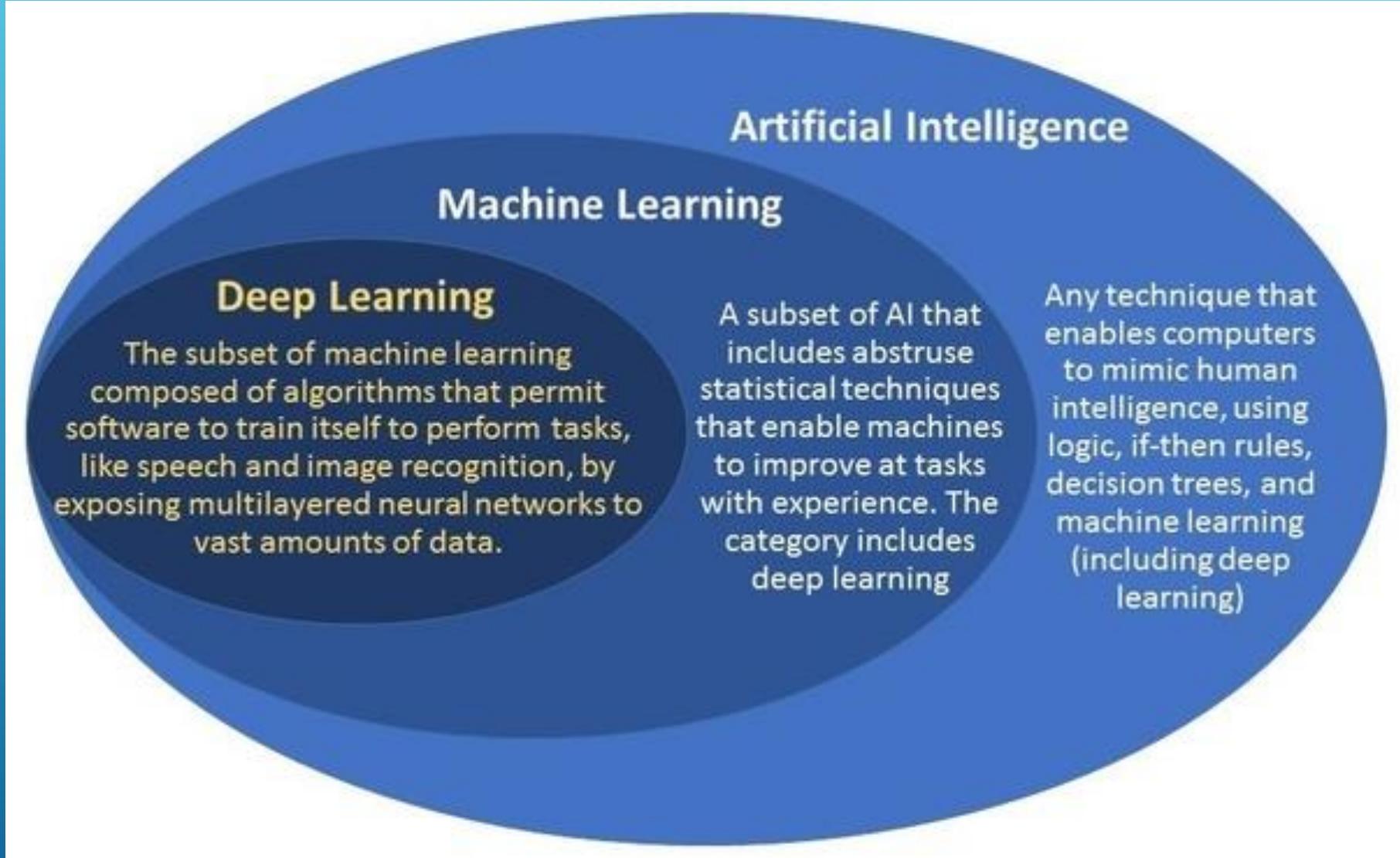
1993 – 2011 – faster, cheaper computer chips – parts of AI started to be used **behind the scenes** throughout computer technology

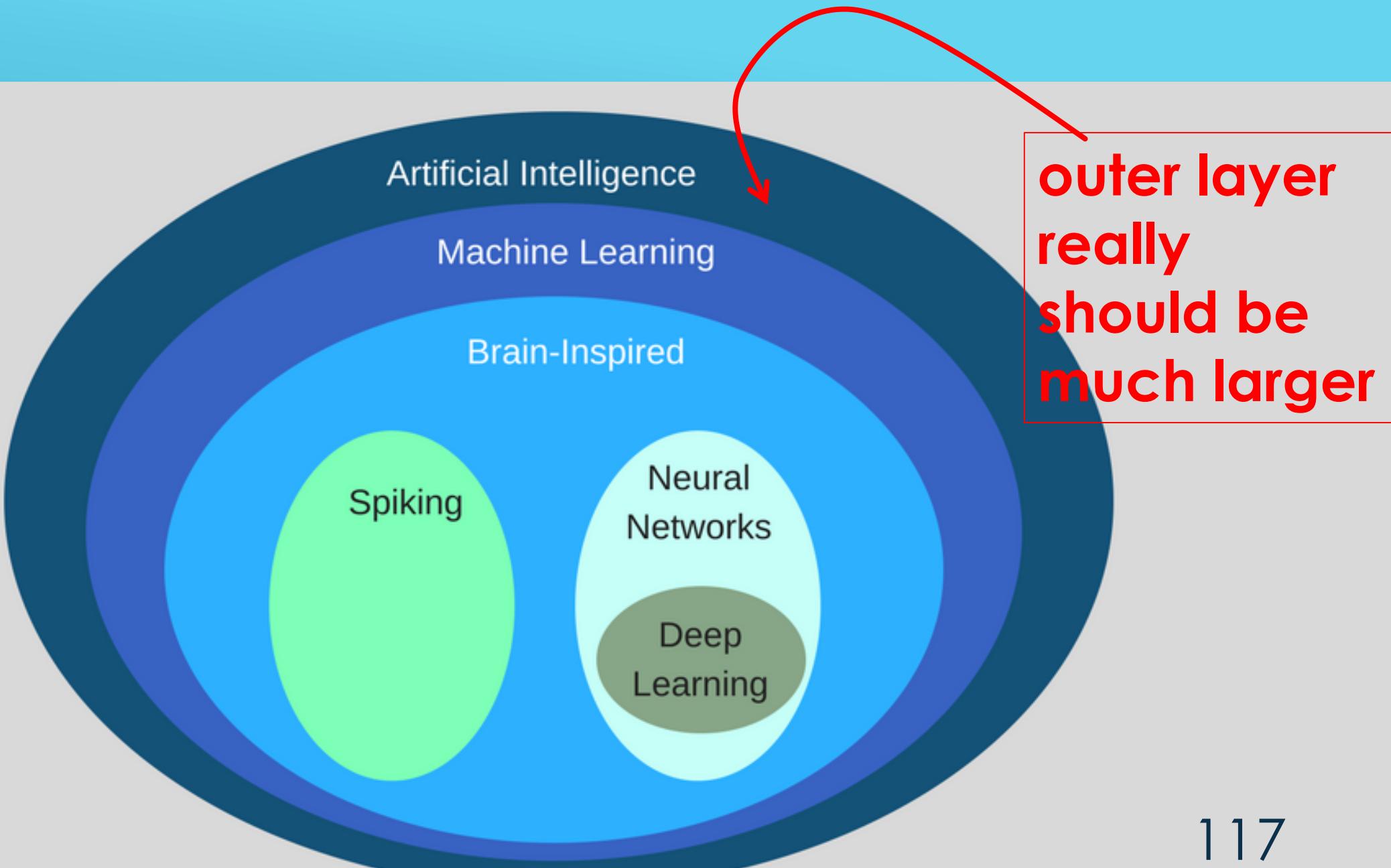
2012 – present – era of **deep learning** neural networks, big data



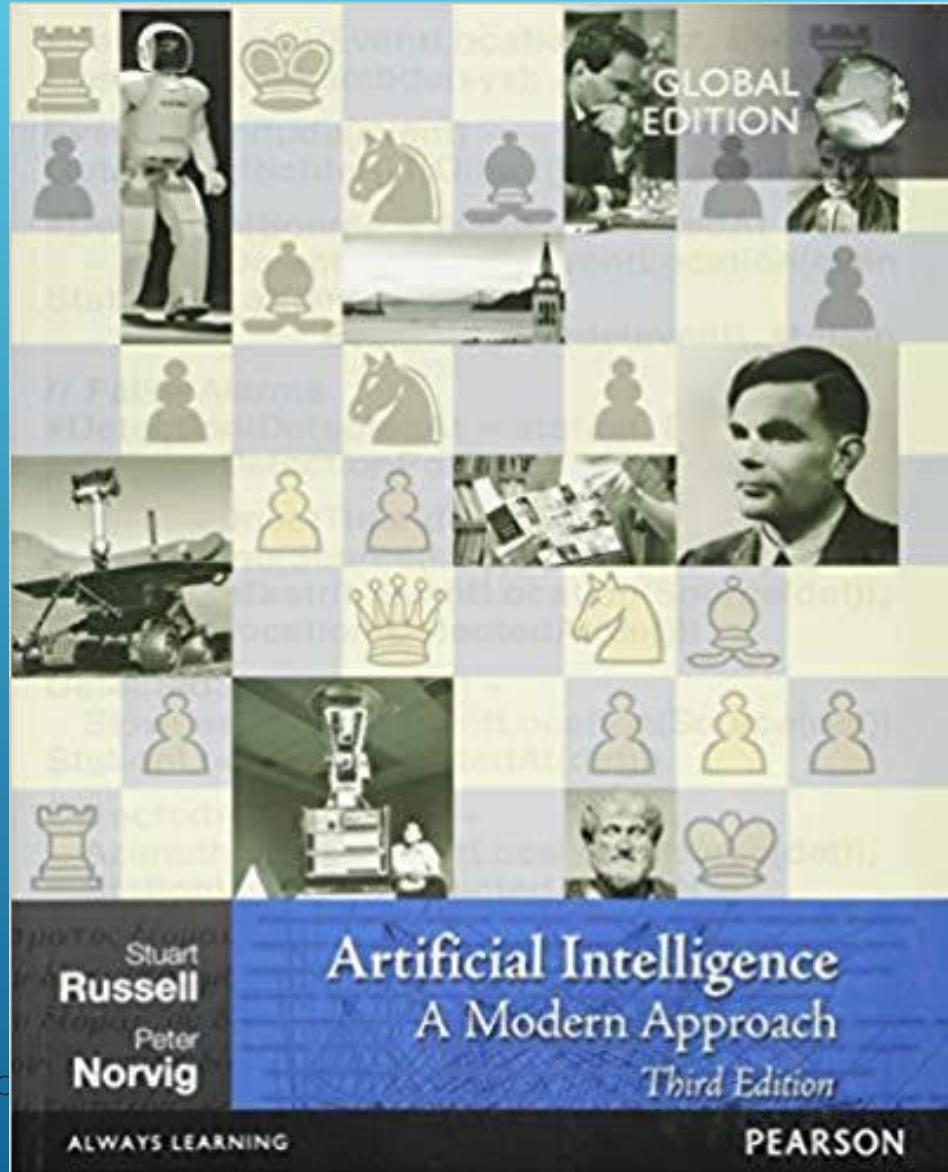
← Let's quickly try
to make sense of
where Deep
Learning fits into all
of this

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

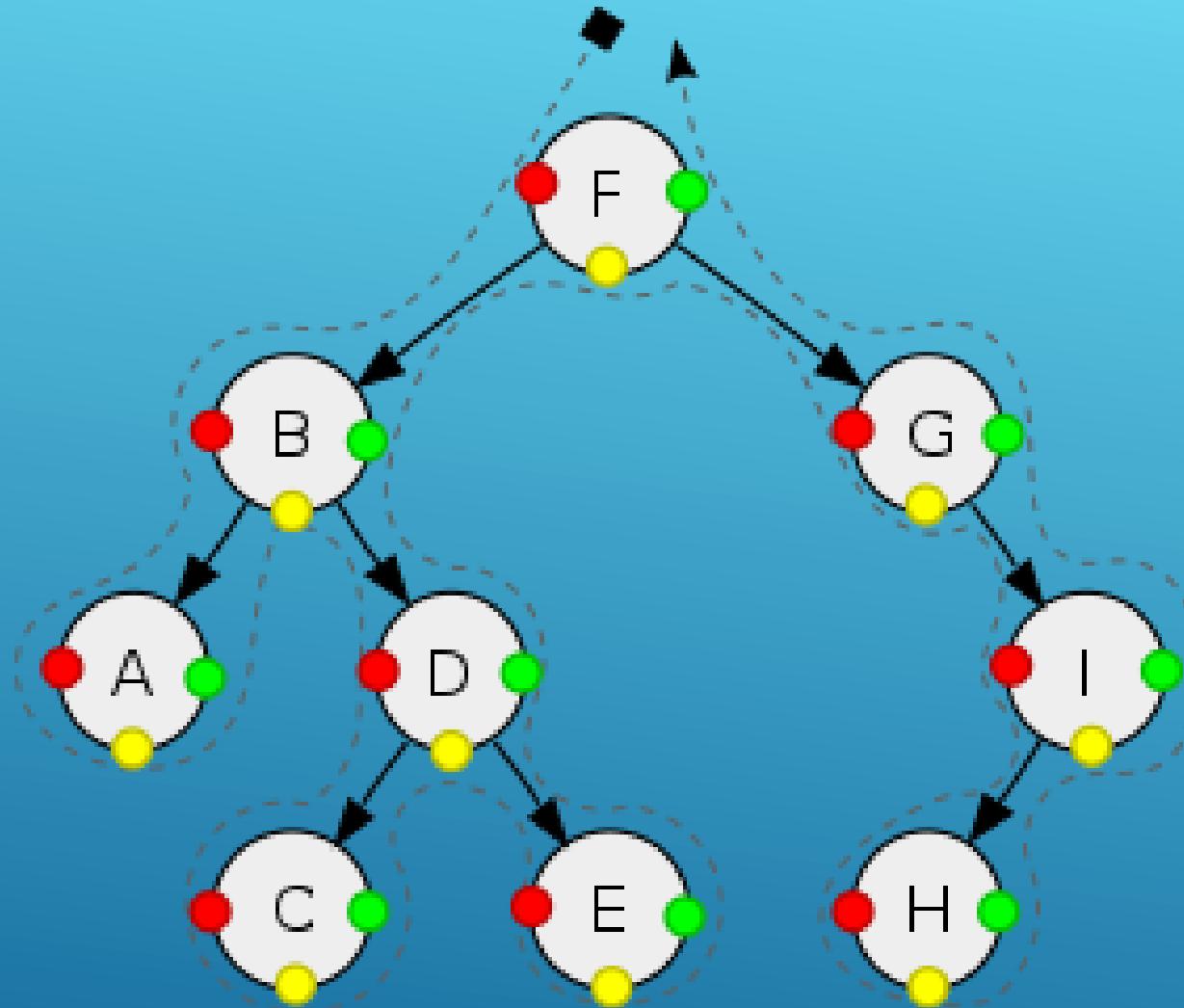




Let's quickly review the field of AI



SEARCH

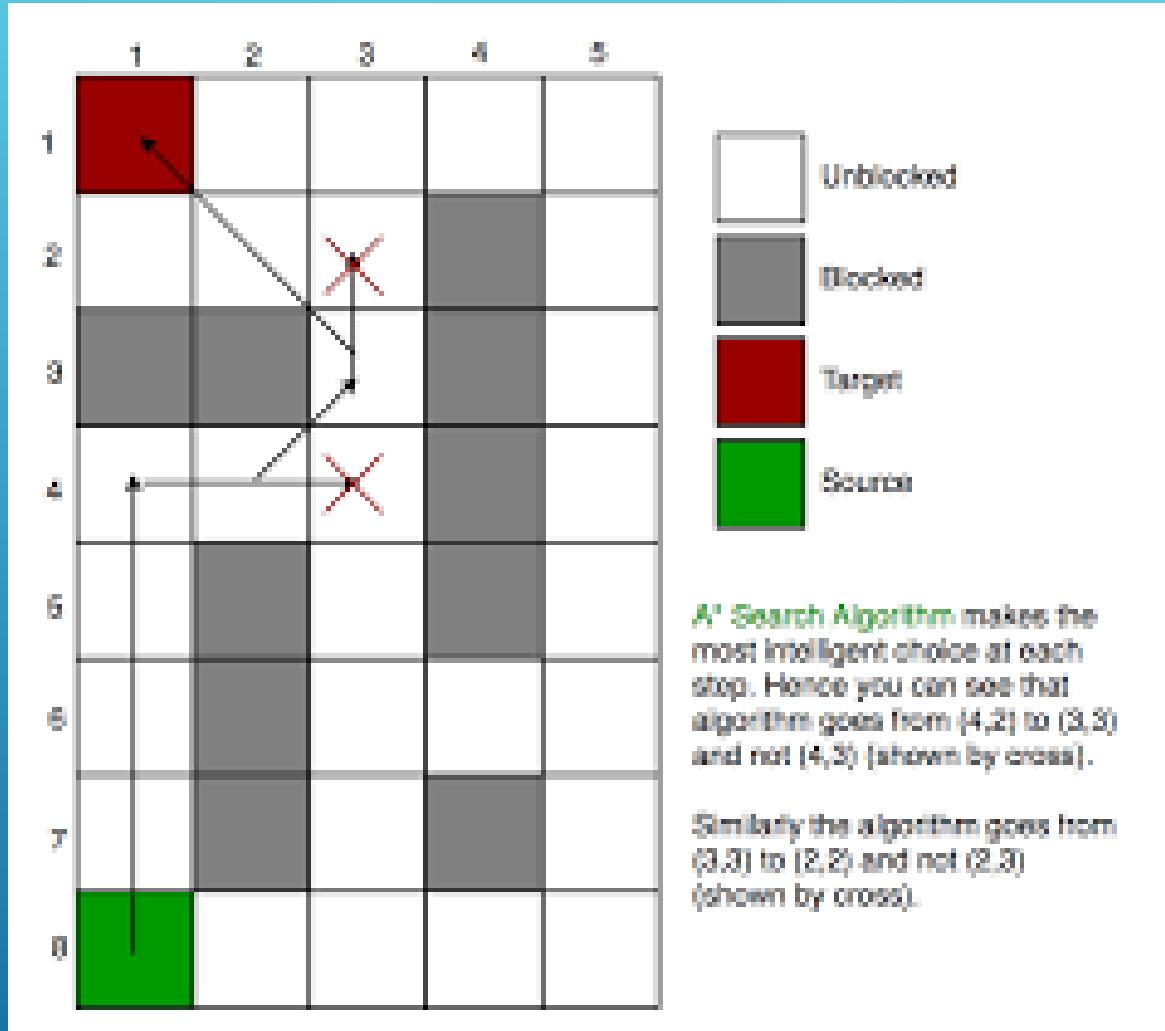


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A* SEARCH ALGORITHM

“heuristic algorithm”



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:

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

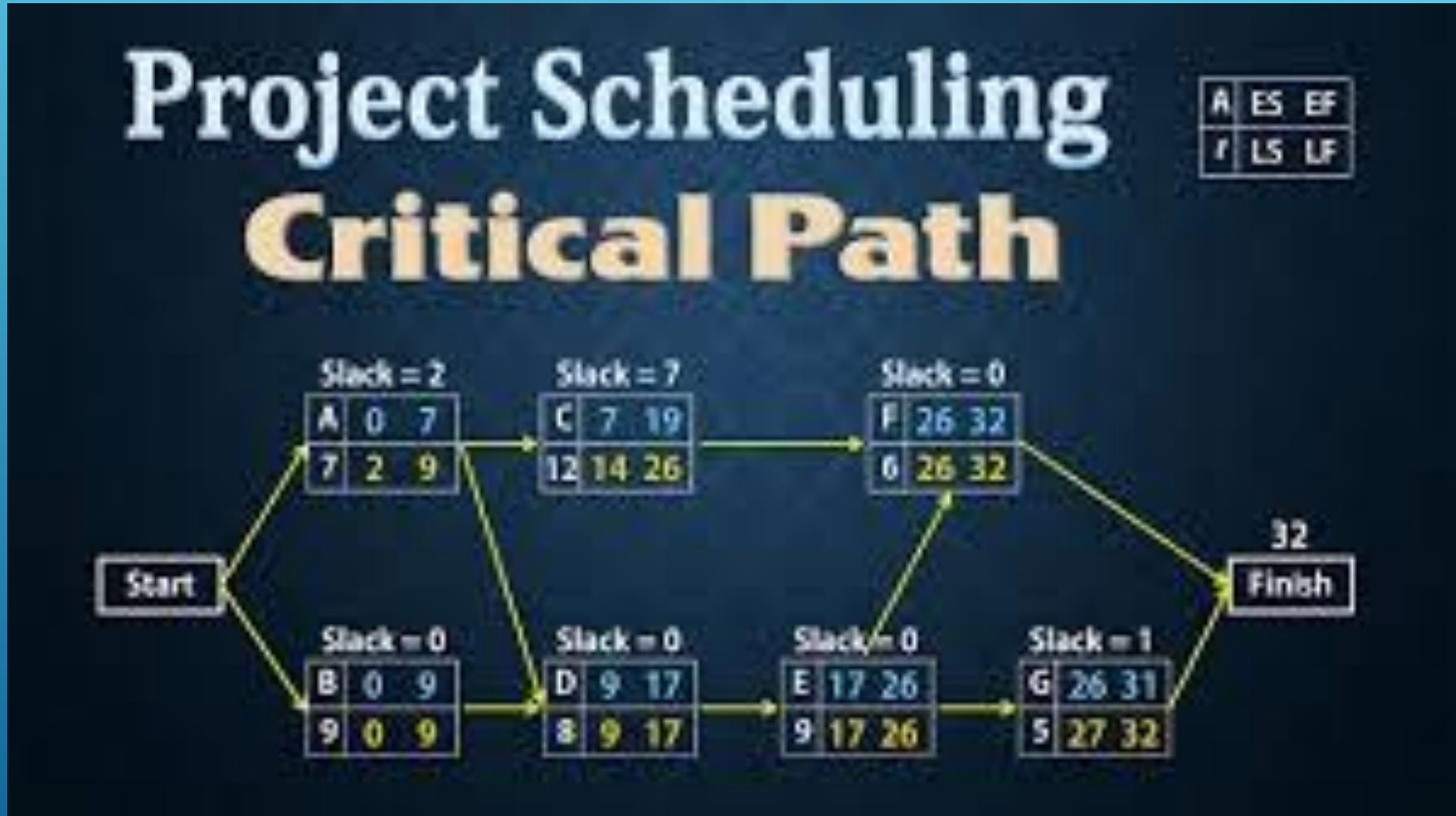
RULE BASED ALGORITHM

```
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')
```

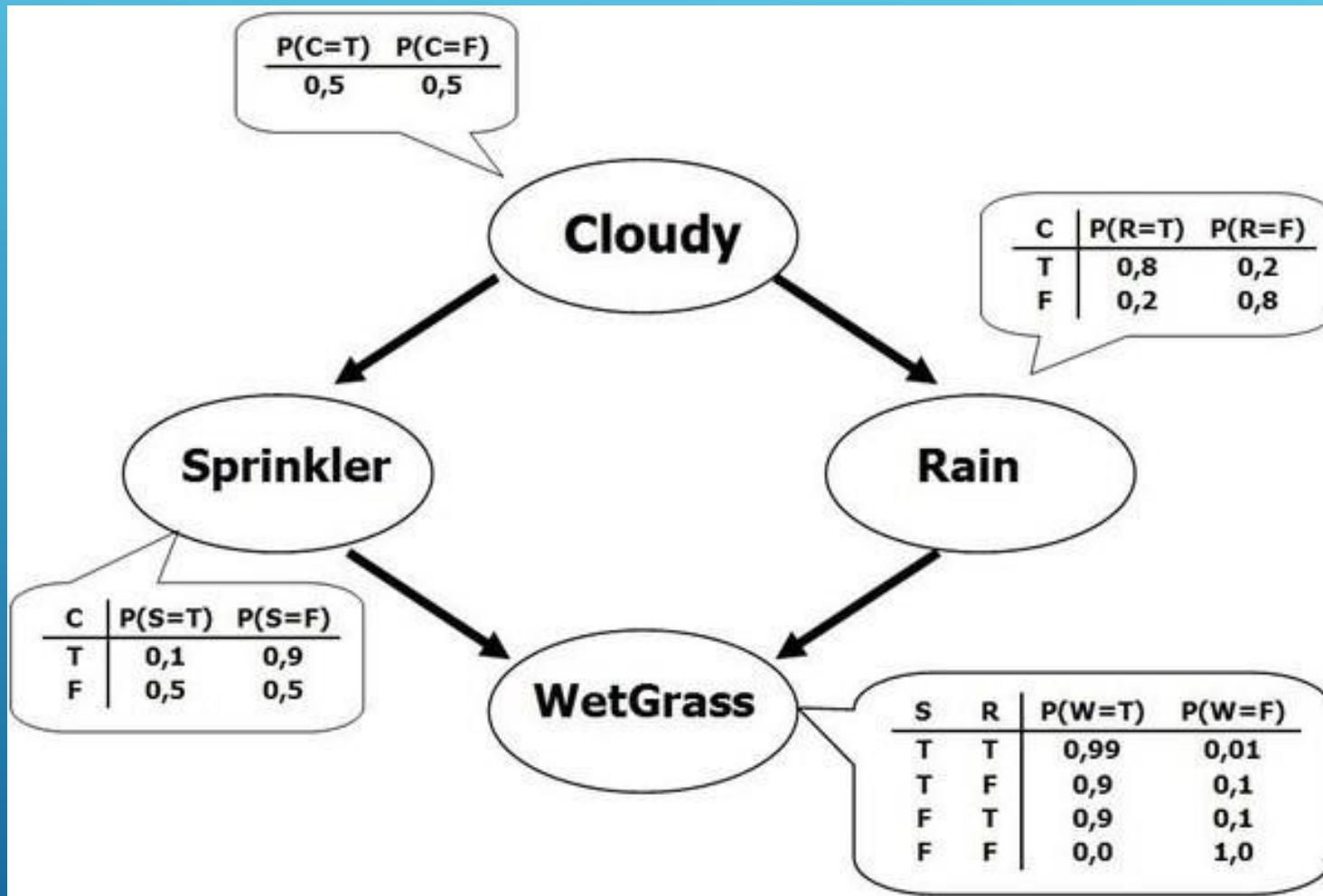
non-learning

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

PLANNING



PROBABILISTIC REASONING



LEARNING

Learn from examples

Forms of learning

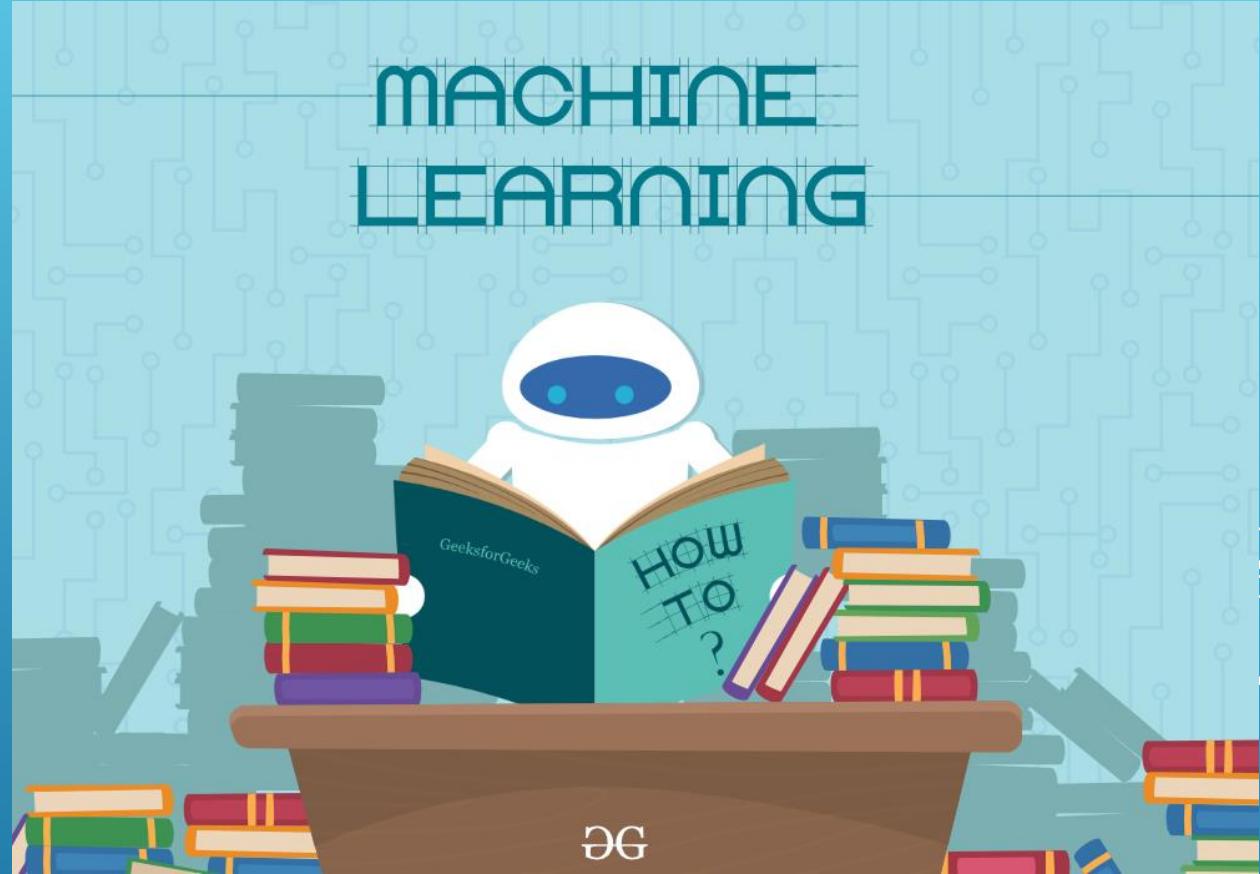
Knowledge in learning

Inductive learning

Meta learning

.....

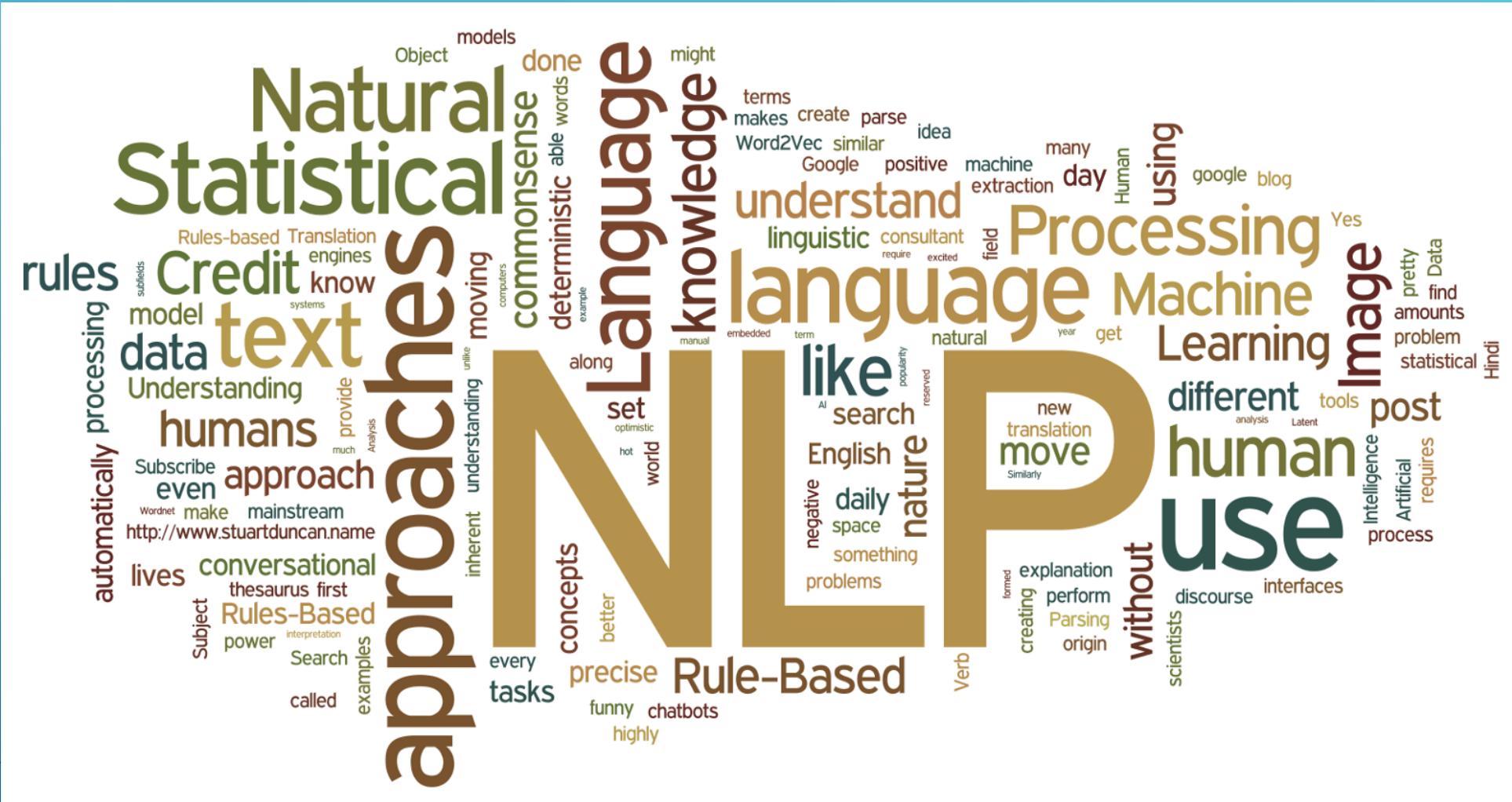
.....



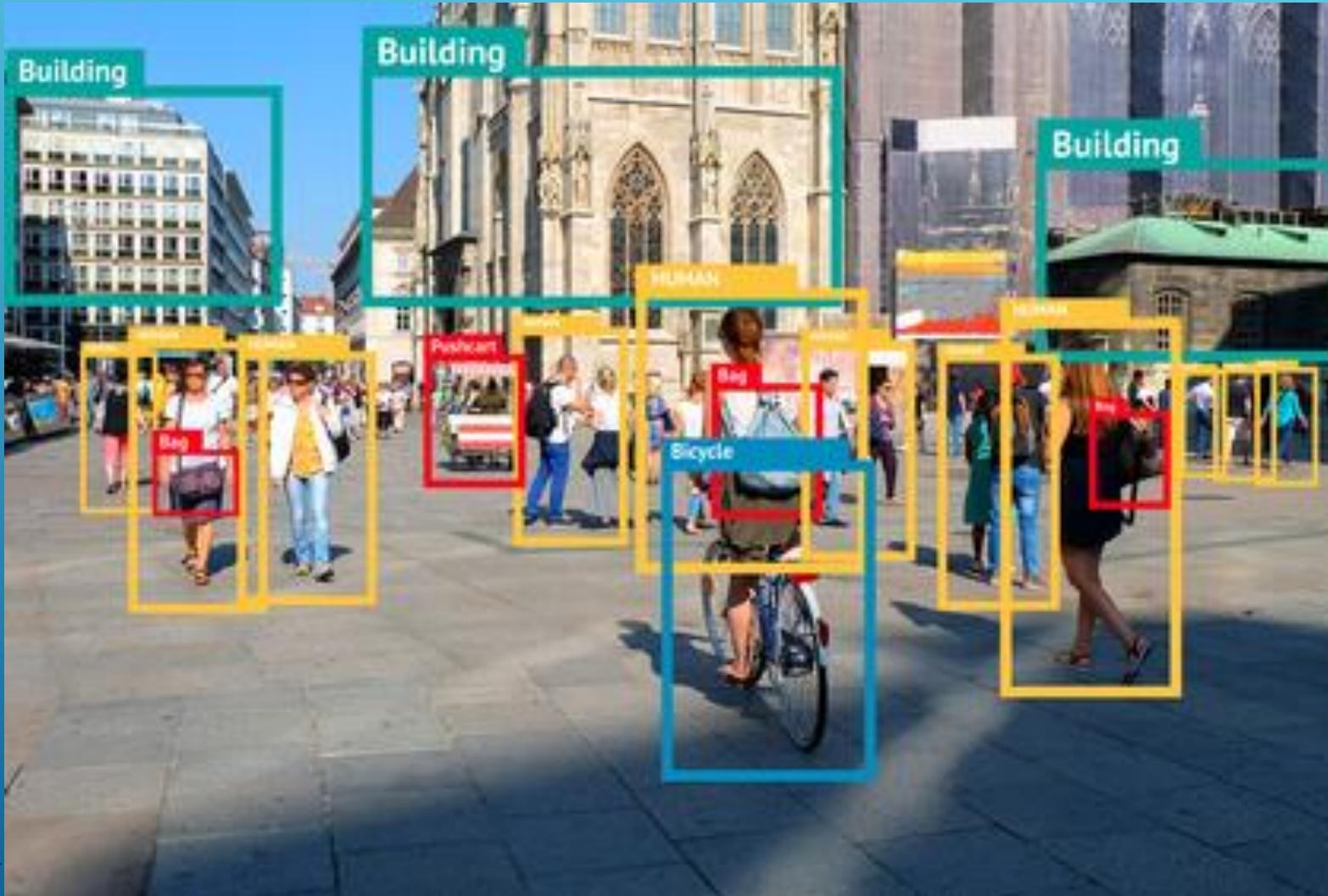
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NATURAL LANGUAGE PROCESSING



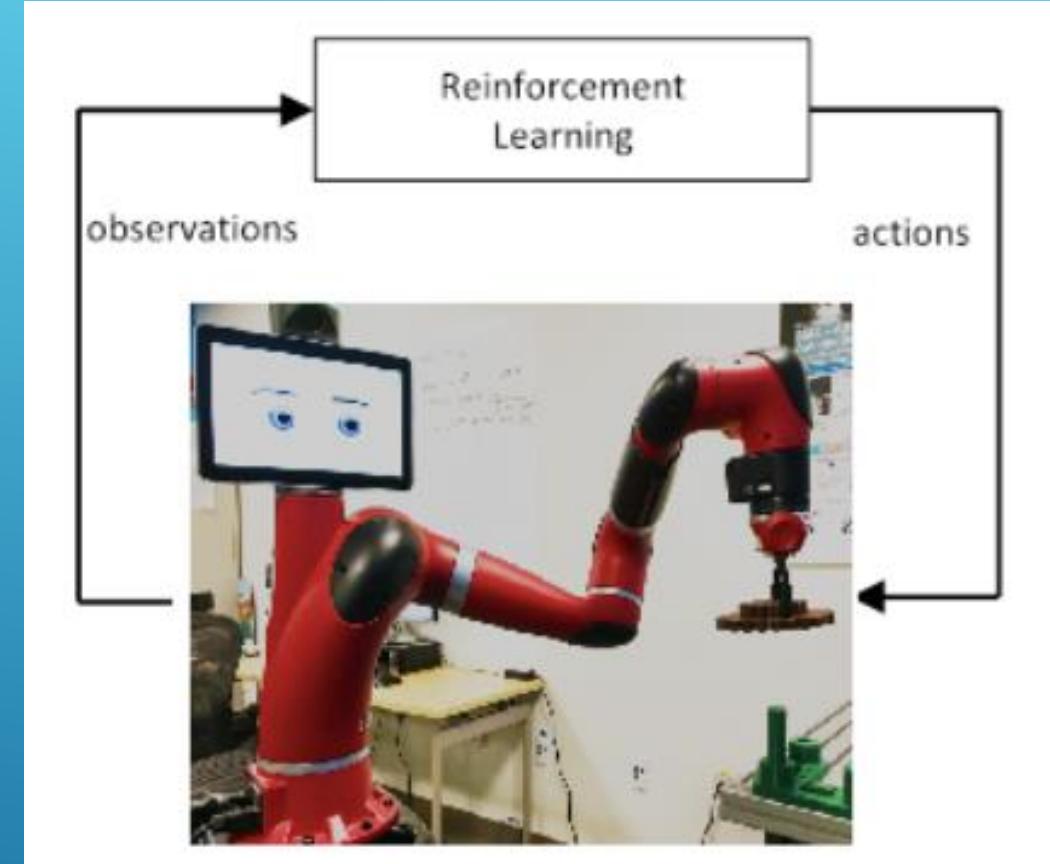
VISION, PERCEPTION



ROBOTICS – BETTER WITH AI



Repetitive tasks
Predefined trajectories



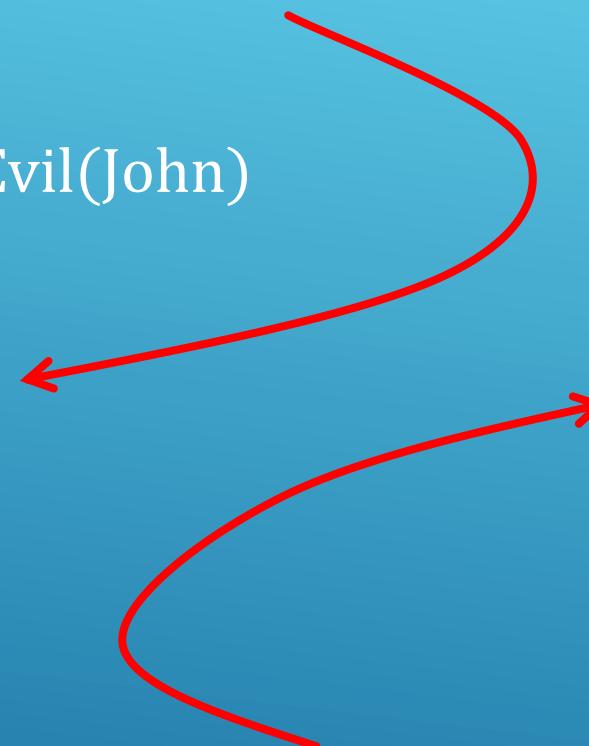
Learn by exploring environment
More flexible behavior

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

(generally non-learning)

King(John) \wedge Greedy(John) \Rightarrow Evil(John)

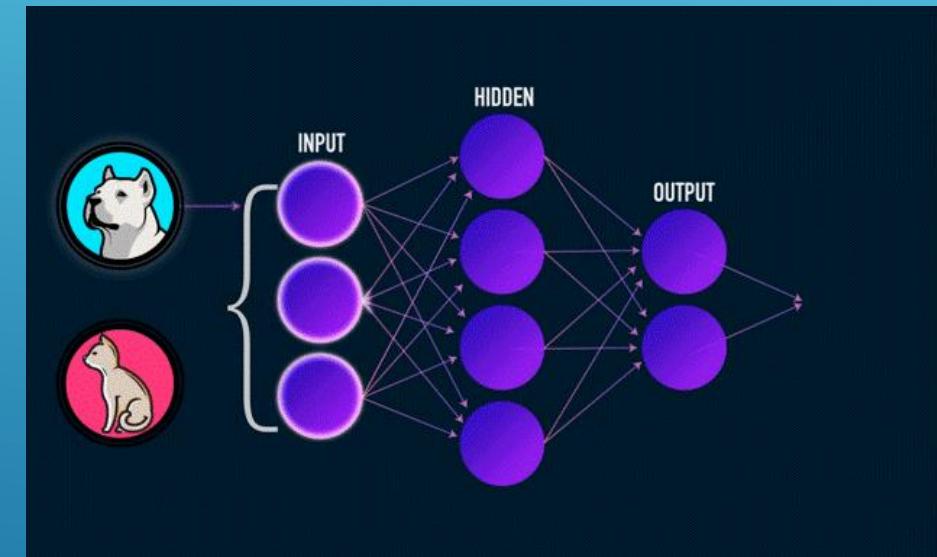
if king and greedy:
 print(f'{x} is an evil king')
else:



NEURAL NETWORKS ("NEURAL") == CONNECTIONIST AI

(learning – make prediction, feedback correction, adjust weights)

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



HOW DOES A “COMPUTER” WORK?

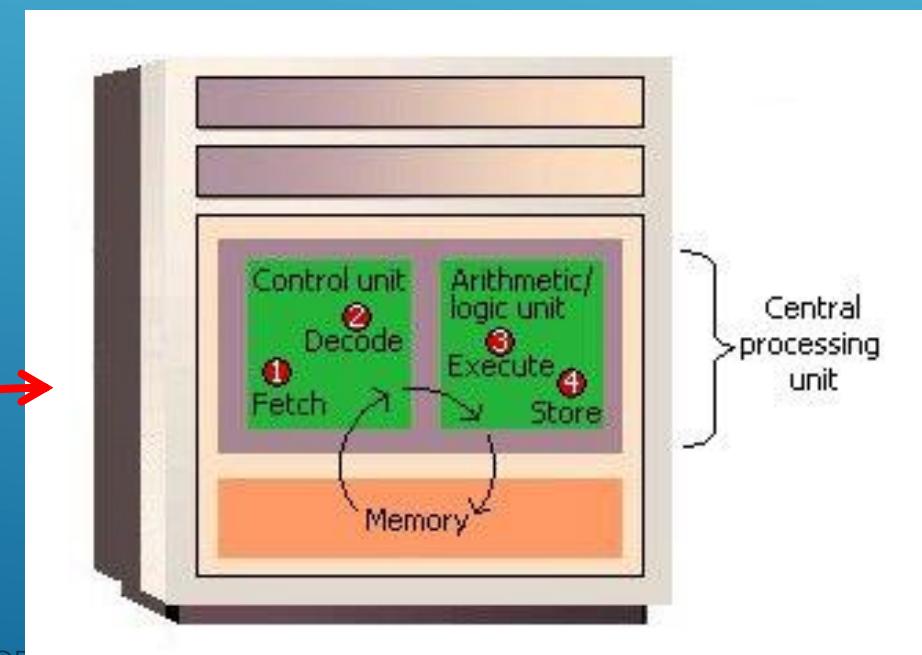
1-½ MINUTE COURSE

- “**COMPUTER**” usually taken to mean a MACHINE THAT DOES **SYMBOLIC PROCESSING** (eg, runs Python program like shown above)
- YOUR LAPTOP** (or smartphone or a large mainframe) IS A “**COMPUTER**”

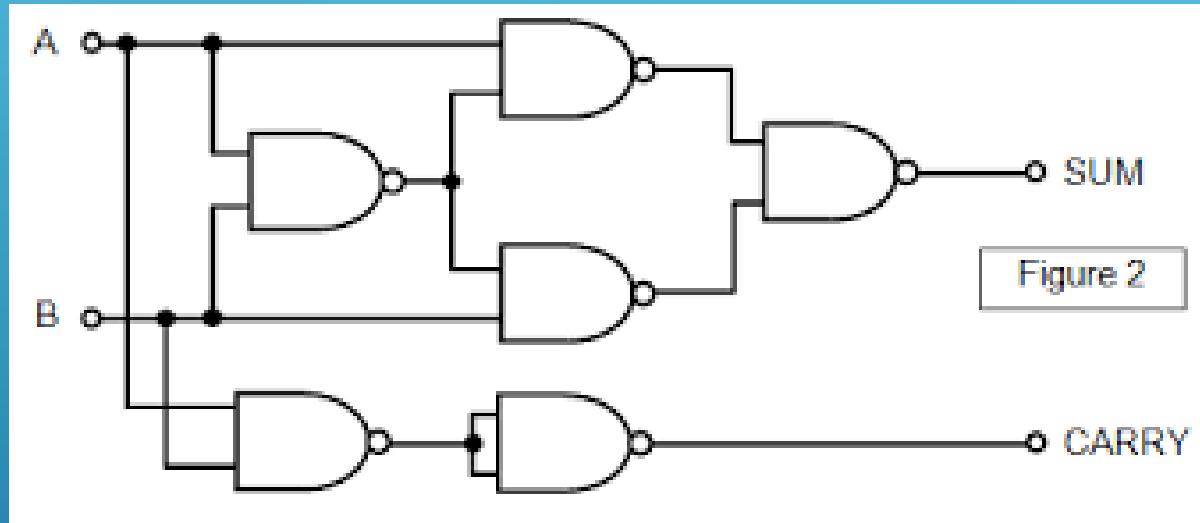


A COMPUTER CONTAINS A “CPU” (CENTRAL PROCESSING UNIT)

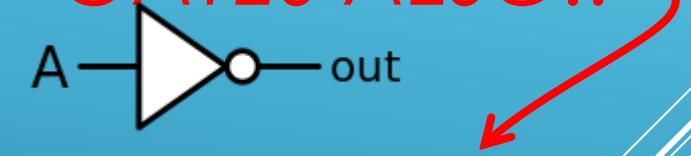
-CPU DOES ONE SMALL OPERATION AFTER
ANOTHER (BUT VERY QUICKLY)



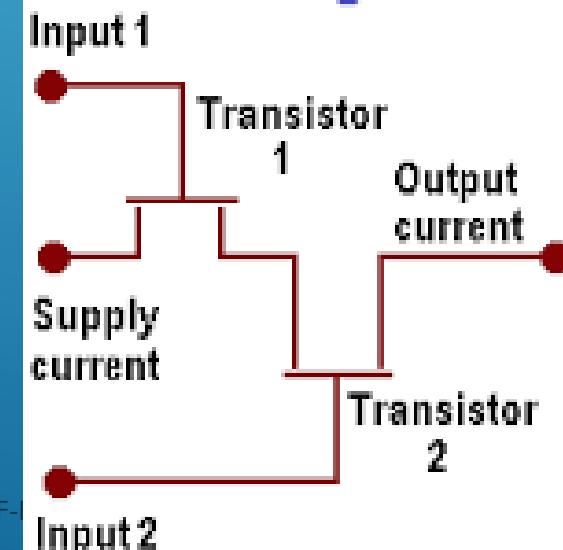
CPU IS MADE FROM LOGIC GATES GATES ARE MADE OUT OF TRANSISTORS



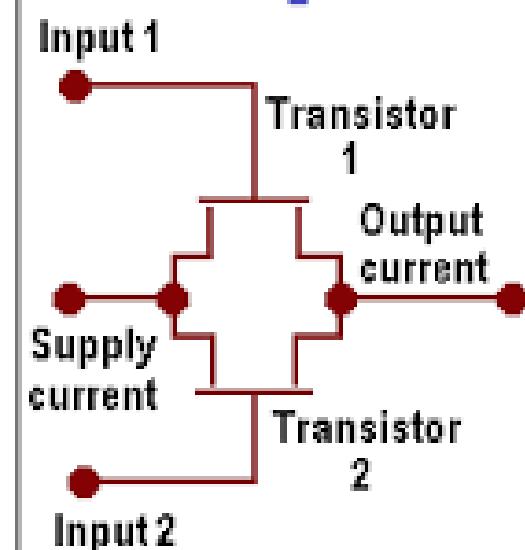
'NOT' GATES ALSO!!



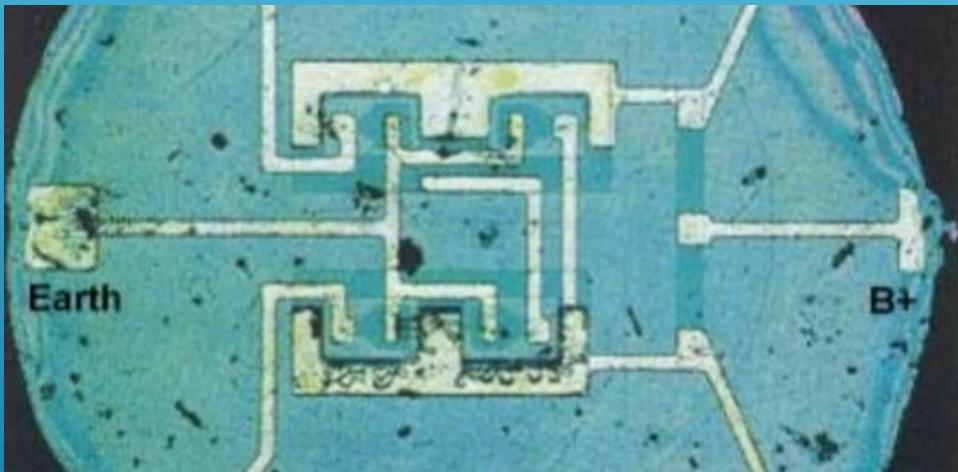
AND gate



OR gate



PHOTOLITHOGRAPHY (IE, PRINT) ‘INTEGRATED CIRCUITS’ (“CHIPS”) CONTAINING MILLIONS AND MILLIONS OF LOGIC GATES

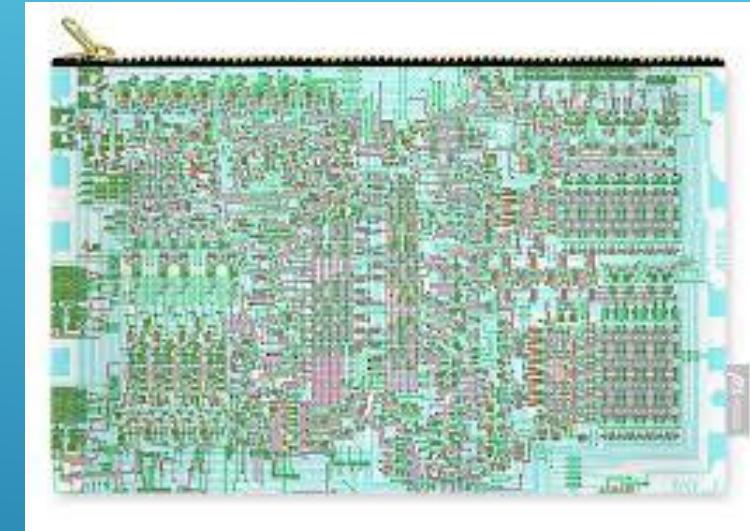


Robert **Noyce**, 1959, Fairchild – silicon, true monolithic **IC**

Jack **Kilby**, 1958, TI – hybrid IC

Shockley, Bardeen, Brattain, 1947, Bell Labs – working transistor

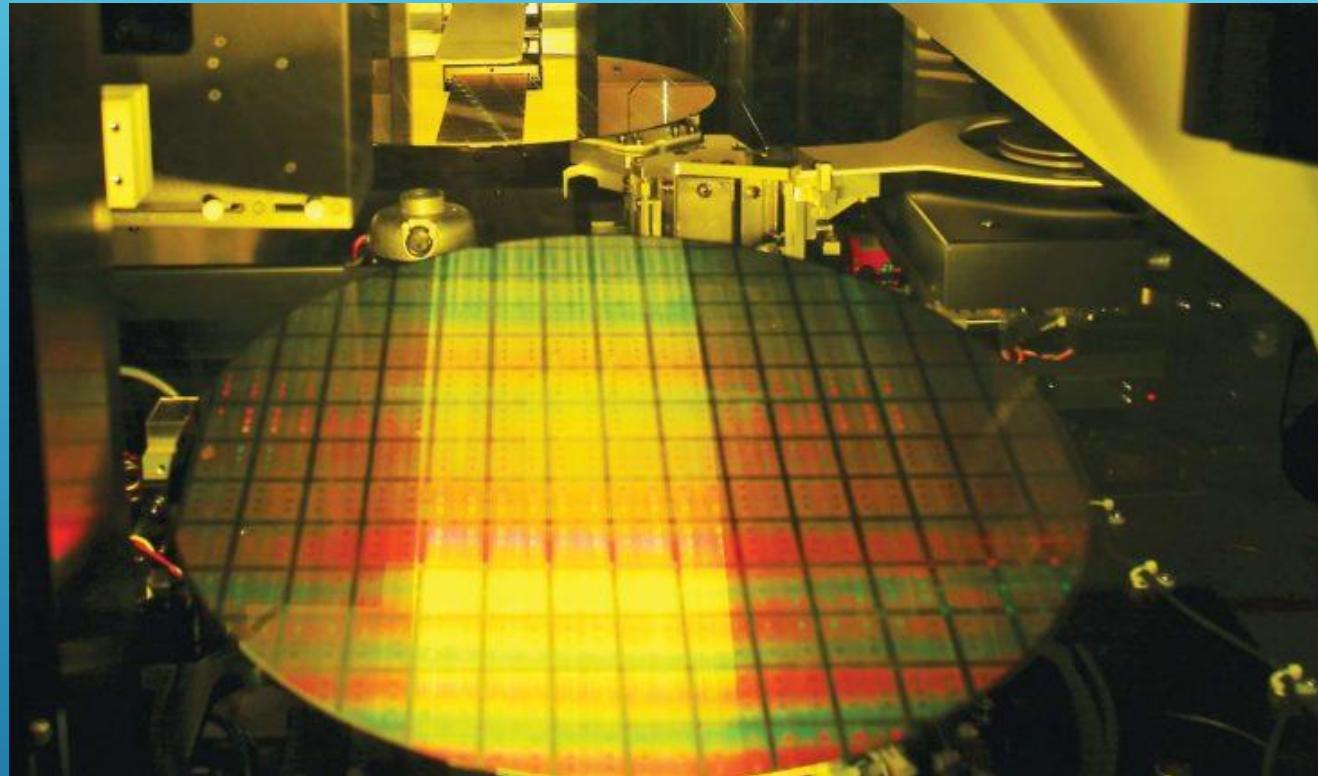
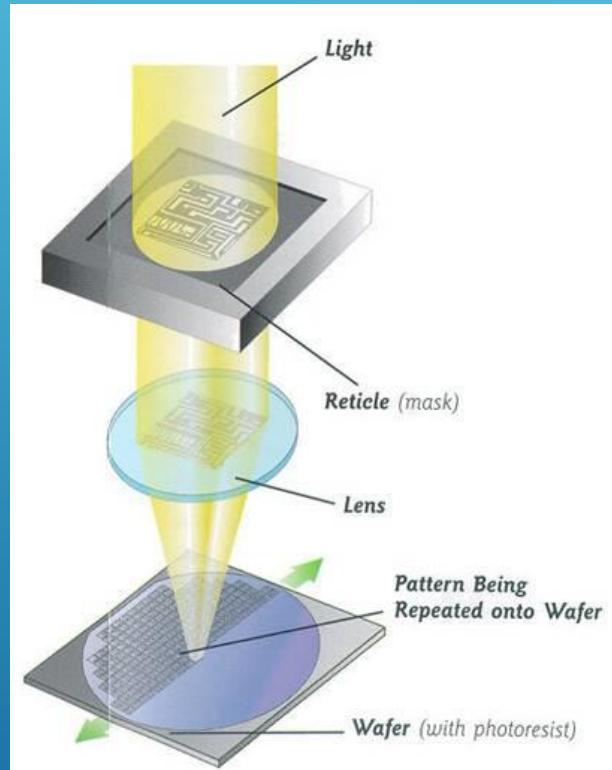
Lilienfeld, 1926, Amrad/Magnavox – patent for FET transistor (not built)



Hoff, Intel 4004 CPU, 1971 – first commercial **microprocessor** (4 bit, <1Mhz clock)
-10 micron feature size, 2250 transistors
-vs. eg, **2020** Intel Xeon W-3175X has .014 micron sizes, 8,000,000,000 (8B) transistors, 64bit, 4300Mhz (4GHz) clock

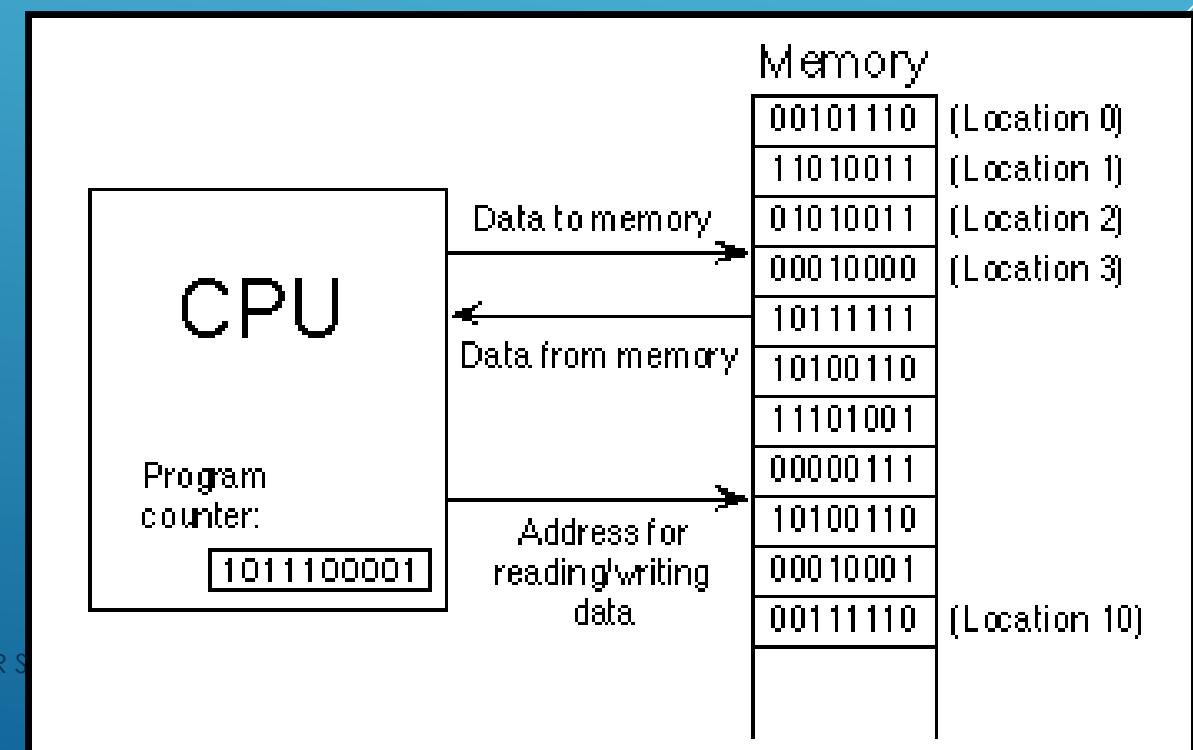
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MAKING CHIPS – NOT MAGIC, JUST ADVANCED PHOTOGRAPHY



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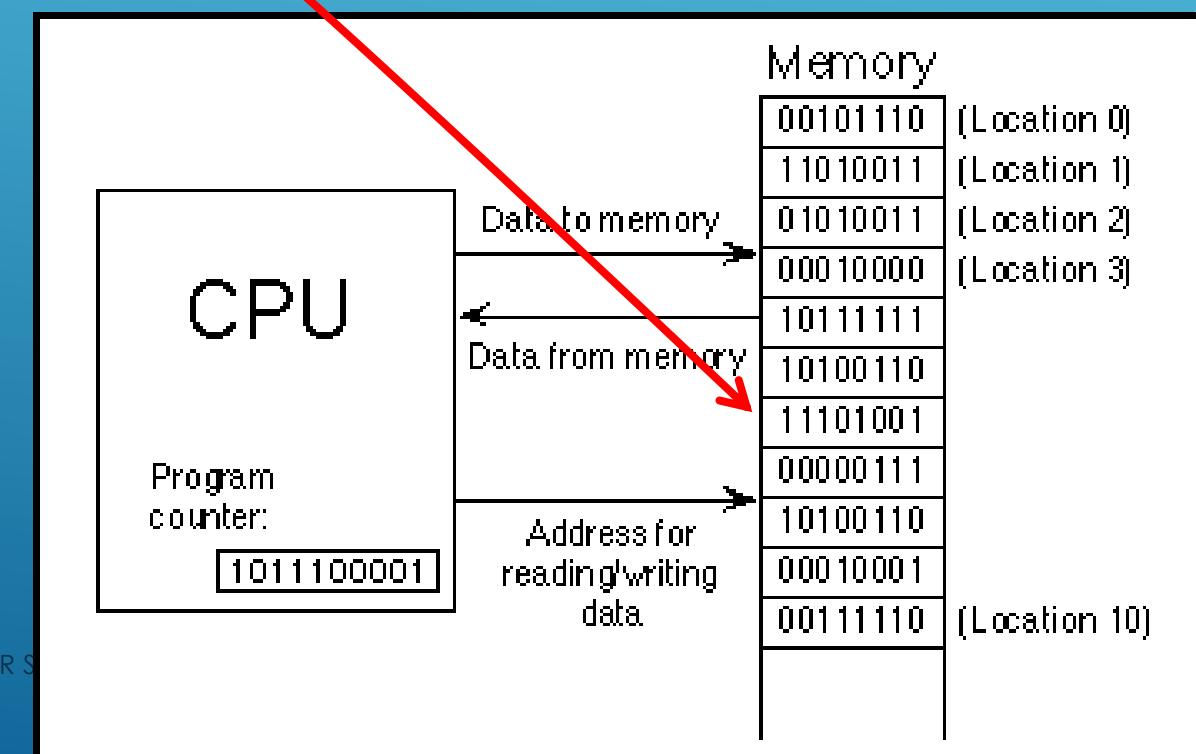
- START WITH MEMORY LOCATION 0
- 1'S AND 0'S INTO LOGIC CIRCUITS IN CPU
- CPU -- DO SOME SIMPLE OPERATION
 - EG, memory A > memory B? Yes, write a '1'
 - EG, Jump to memory location xx



SOME OF THE 1'S & 0'S ARE DATA, SOME OF THEM SPECIFY LOGIC OPERATIONS THE CPU IS SUPPOSED TO DO

EG, COMPARE TWO MEMORY LOCATIONS ALREADY LOADED IN THE CPU (EG, LOCATIONS 58 & 96)

-IF LOCATION 58 > LOCATION 96
THEN SET A MEMORY 'FLAG'
WHICH THEN NEXT STEP CAUSES
A JUMP TO MEMORY LOCATION
XX AND USE THIS AS THE NEXT
LOGIC OPERATION

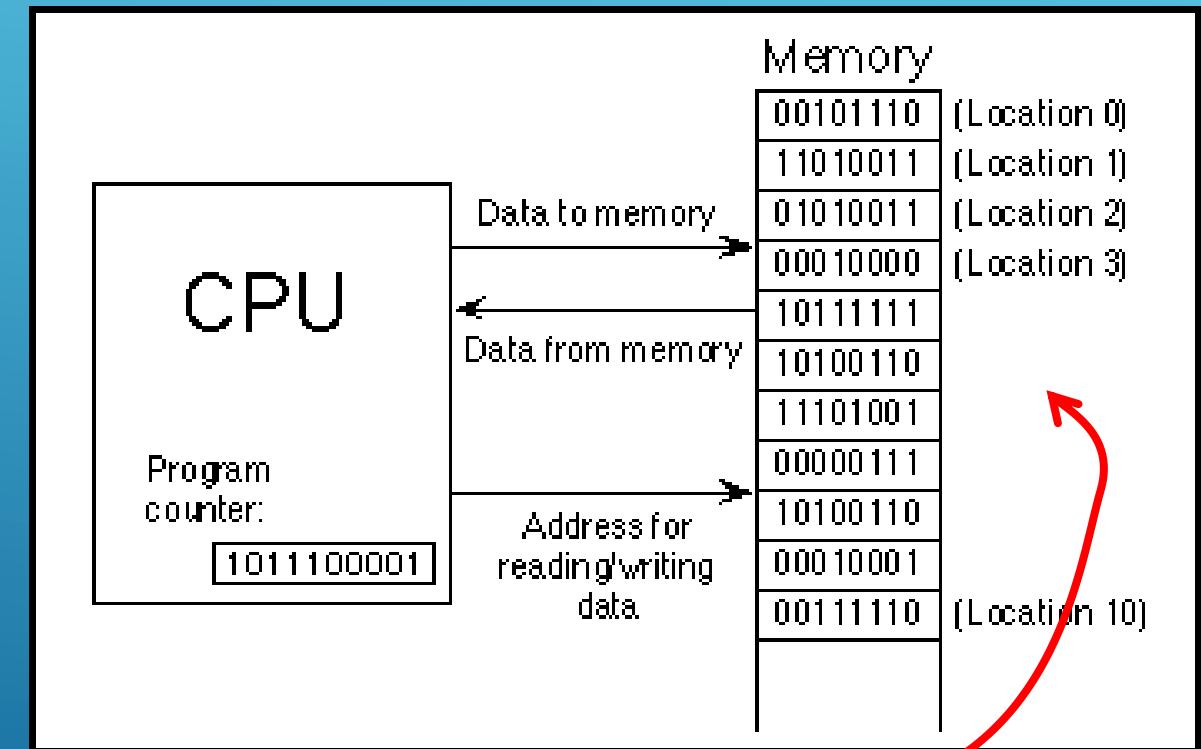


SYMBOLIC COMPUTER PROGRAM ('GOFAI') IS TURNED INTO 1'S AND 0'S AND CPU PROCESSES IT

King(John) \wedge Greedy(John) \Rightarrow Evil(John)

```
if king and greedy:  
    print(f'{x} is an evil king')  
else:  
    .....  
.....
```

PYTHON
COMPILER



QUIZ – QUESTION 1.

WHAT IS REINFORCEMENT LEARNING?

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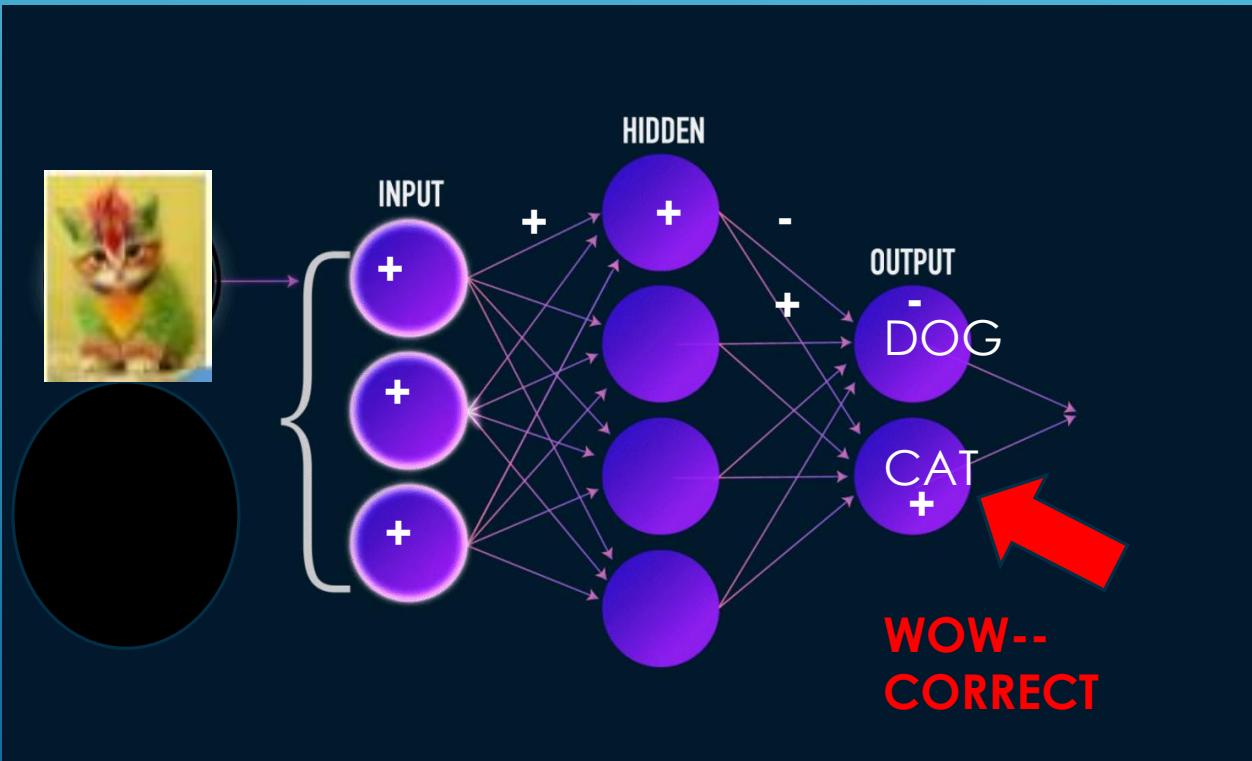
REINFORCEMENT LEARNING

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

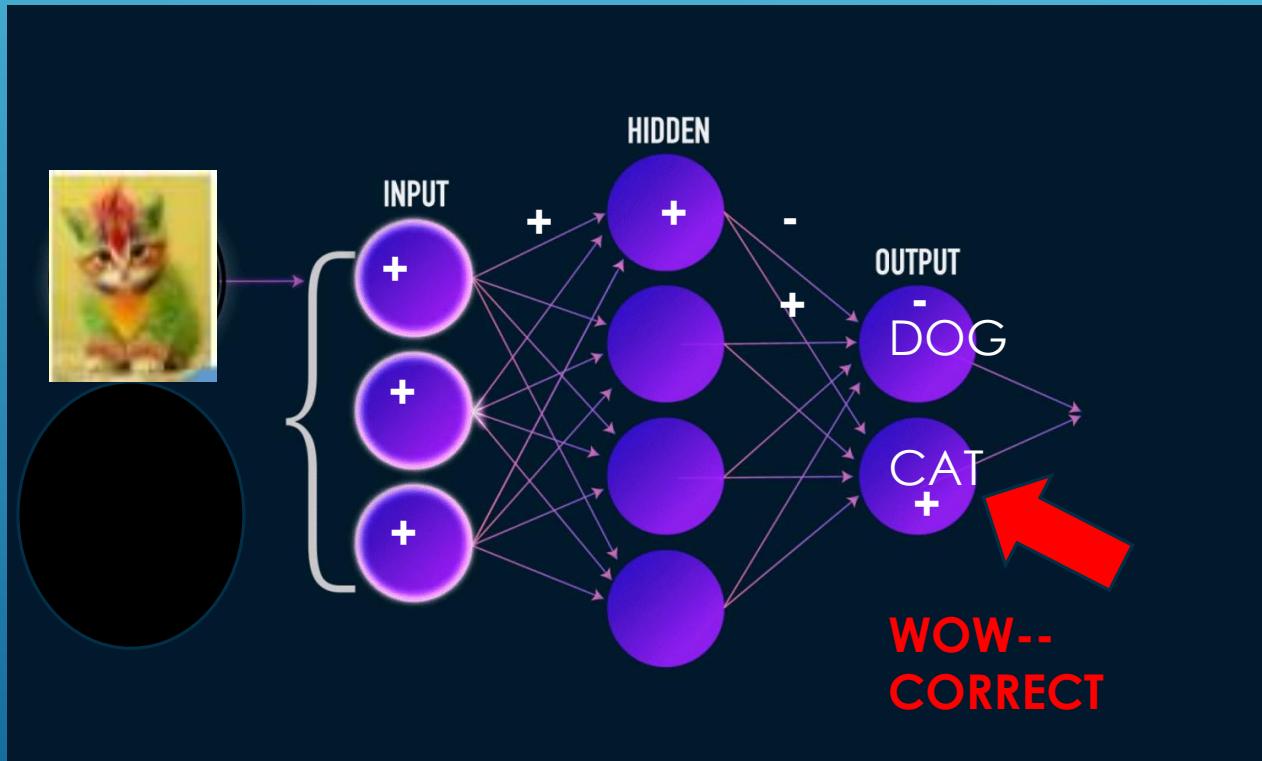


Deepmind 2017: Alphazero –
superhuman performance in
chess, shogi & go

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:

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

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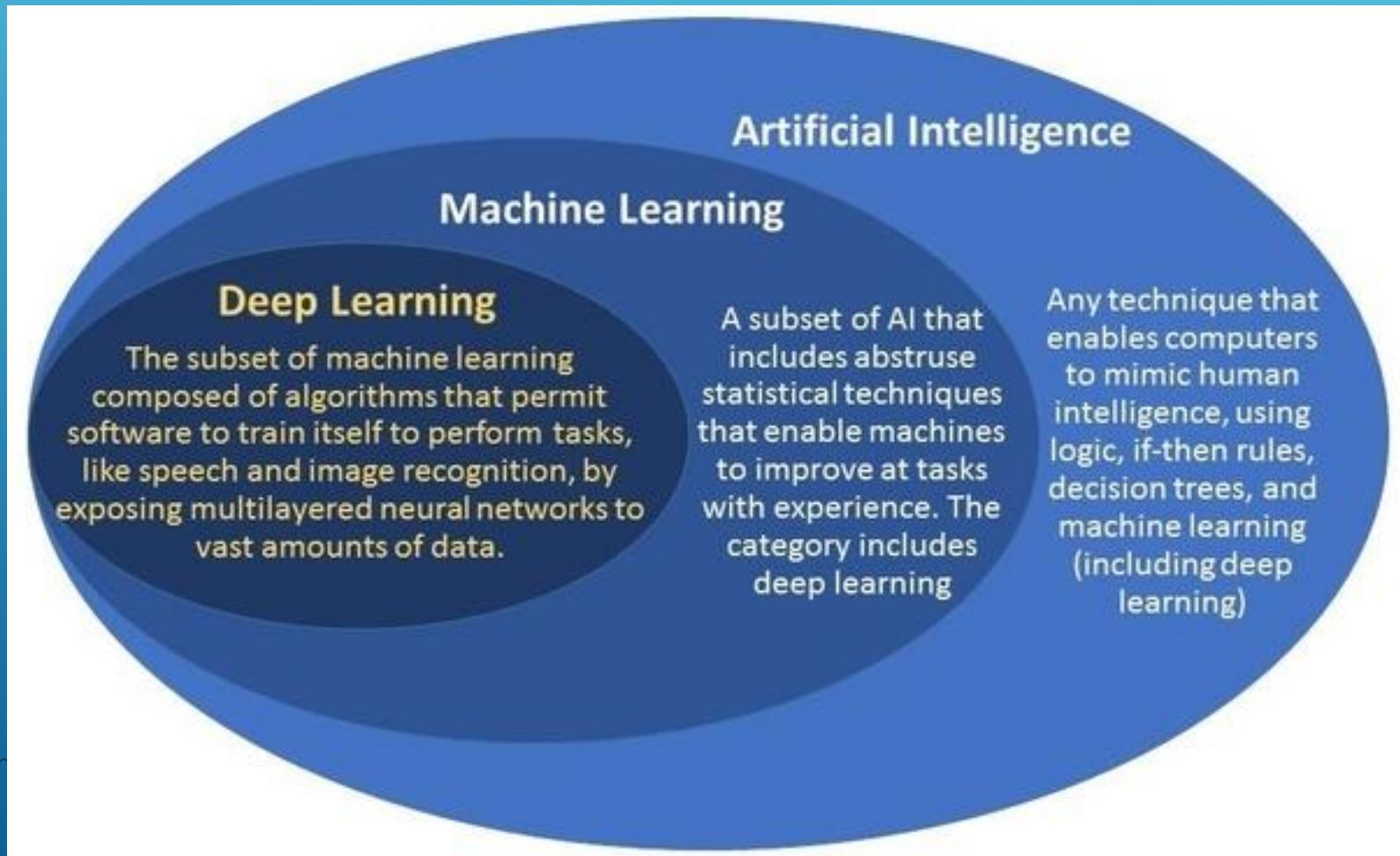
GOOD OLD FASHIONED ARTIFICIAL INTELLIGENCE “GOFAI” == “SYMBOLIC AI”

```
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
```

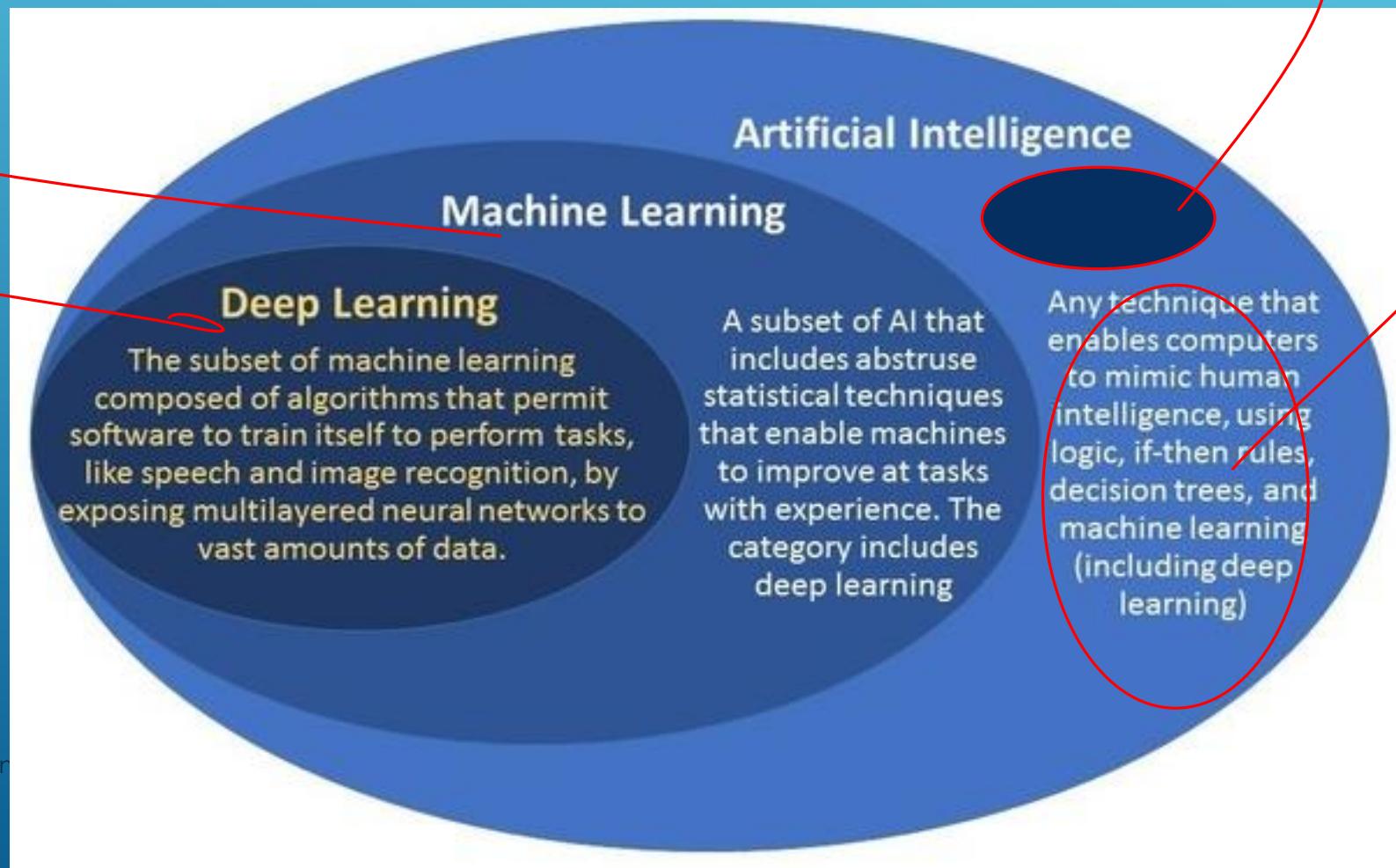
Quiz – question 4

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



Neural networks

Symbolic AI



LEARNING OBJECTIVES

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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!!

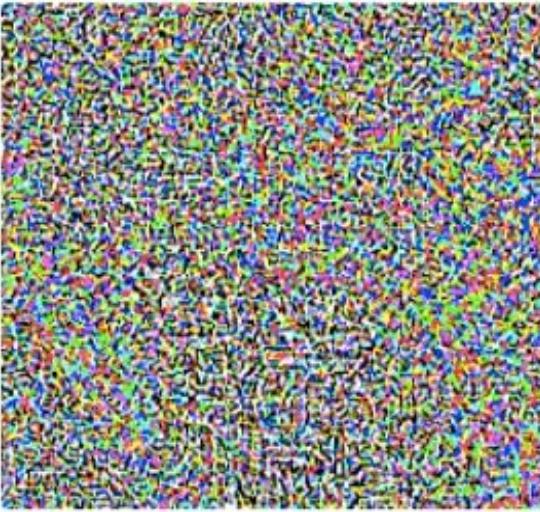
The Neural Symbolic Gap



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



+



=

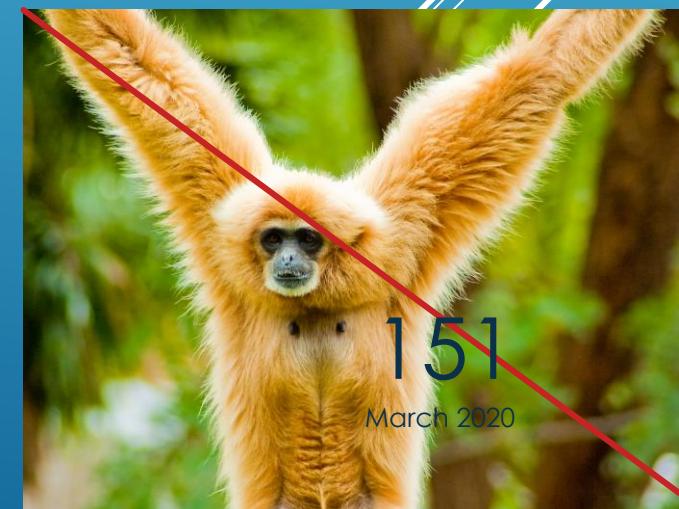


**“panda”
57.7% confidence**

**“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

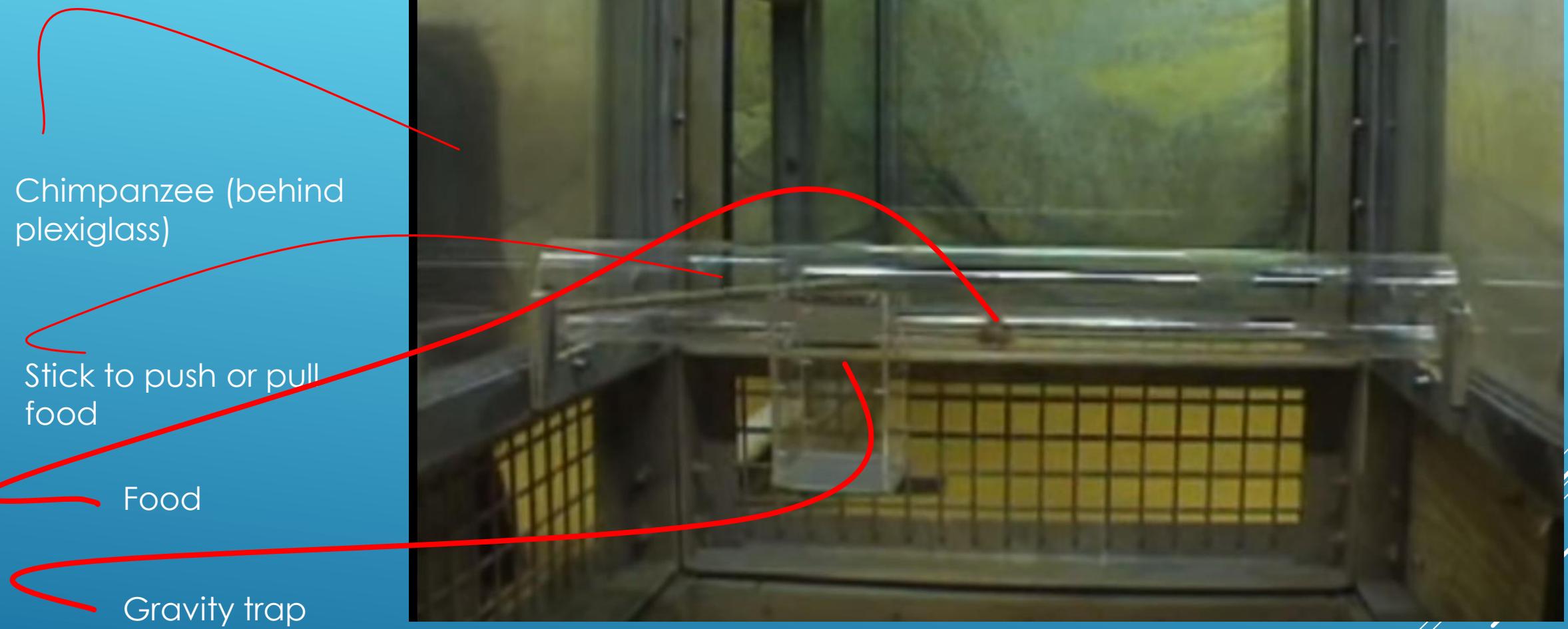
Need 1000's examples for learning

3 Year Old Human Child

Model Building +also Pattern Recognition
→Explain the World

A few examples enough

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Chimpanzees **do not** have full causality

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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

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**

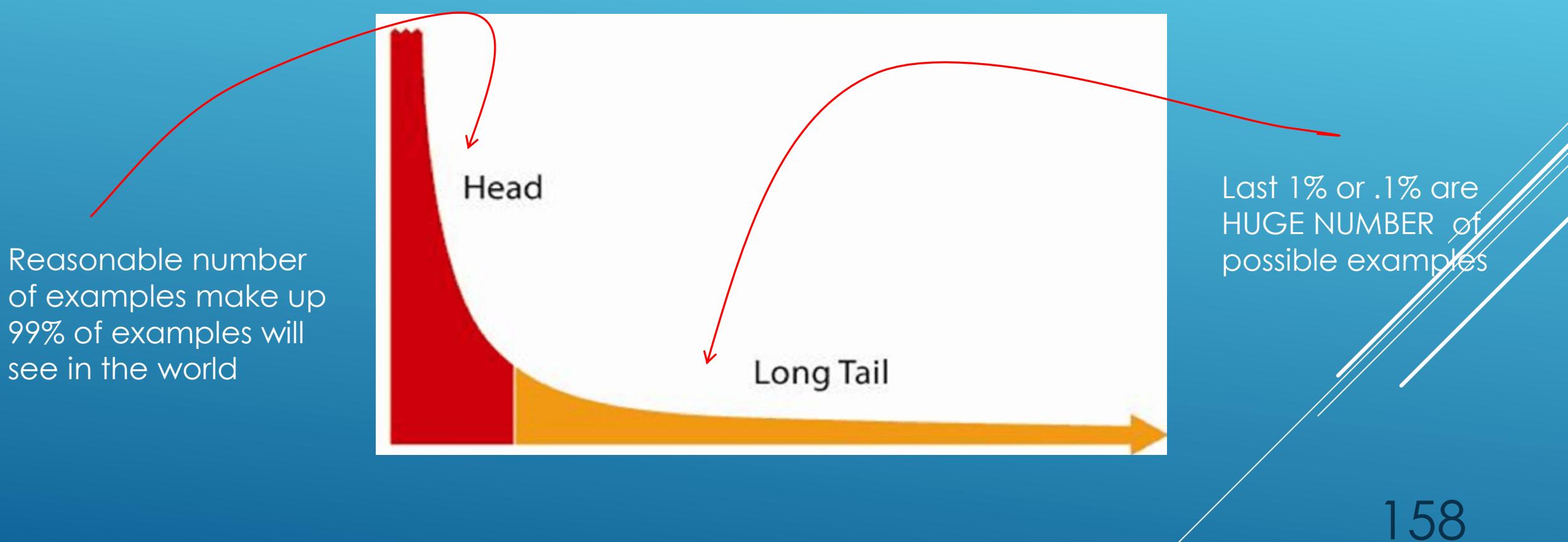
Eg, Tesla has about a billion miles of driving experience of its cars as training data now.

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

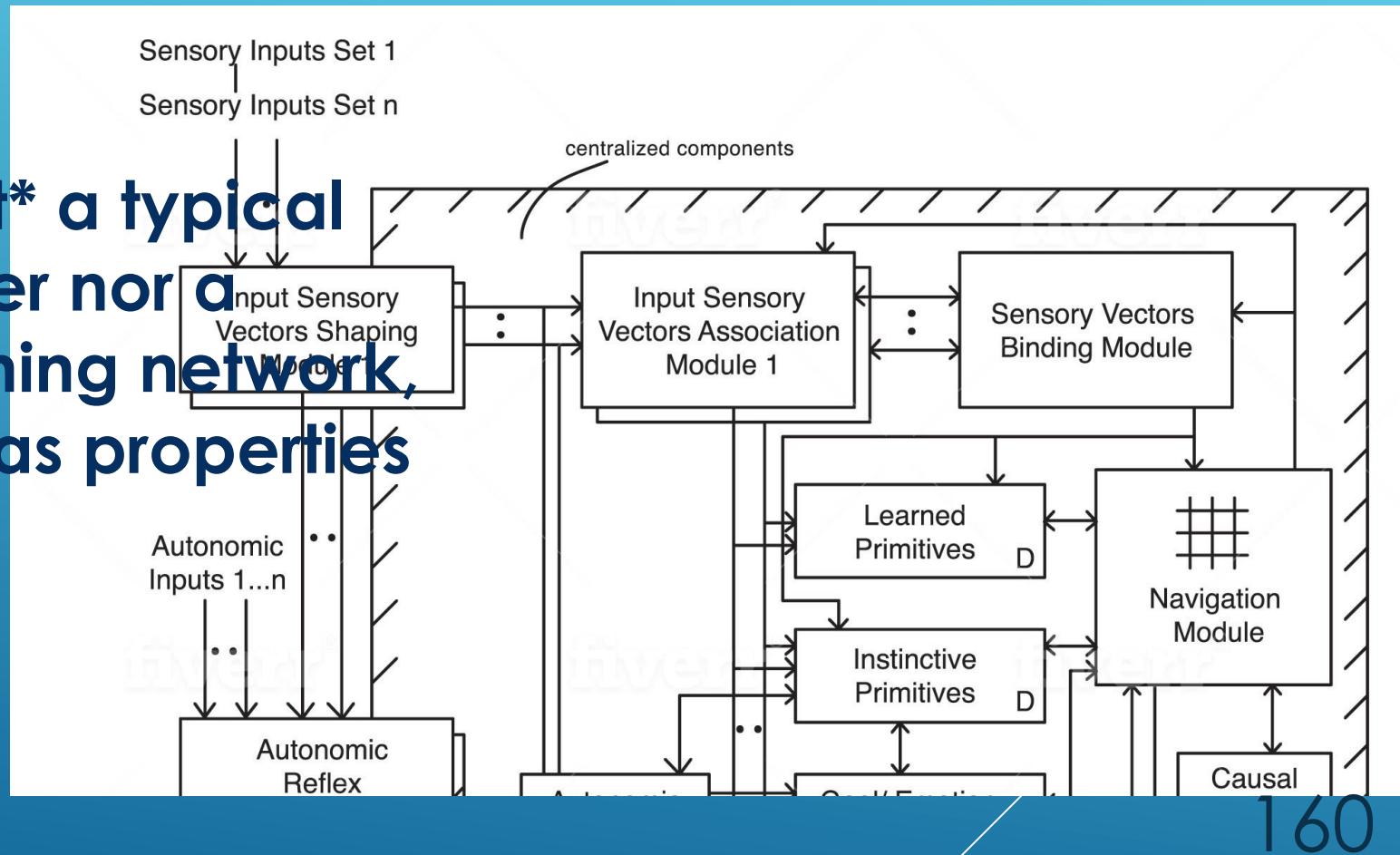
-Uber's system never had training with image of pedestrian pushing bike across the middle of the street
-Volvo normal system: did detect (6secs) but ignored



G**

CAUSAL COGNITIVE ARCHITECTURE 1 – SCHNEIDER (IN 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



1000+, Google



Fei-Fei Li (ImageNet)



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**



AI AND THE WORK OF THE FUTURE CONGRESS

2019 UNCONFERENCE REPORT

"SENSE OF POWERLESSNESS – WORRY..."
→ RECORD LEVELS OF INEQUALITY, LOWER SOCIAL
MOBILITY

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March 2020

-EVIDENCE –USA 500WORKER FACTORIES NOT USING
MANY ROBOTS BUT TROUBLE FINDING SPECIALIZED
WORKERS

“HYPE ABOUT ROBOTS”

“FOCUSED OUR ATTENTION IN THE WRONG PLACE”

-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
→**NEED TO FIX IMBALANCE** BETWEEN WORKERS HELPED
AND HURT BY **NEW ECONOMY**

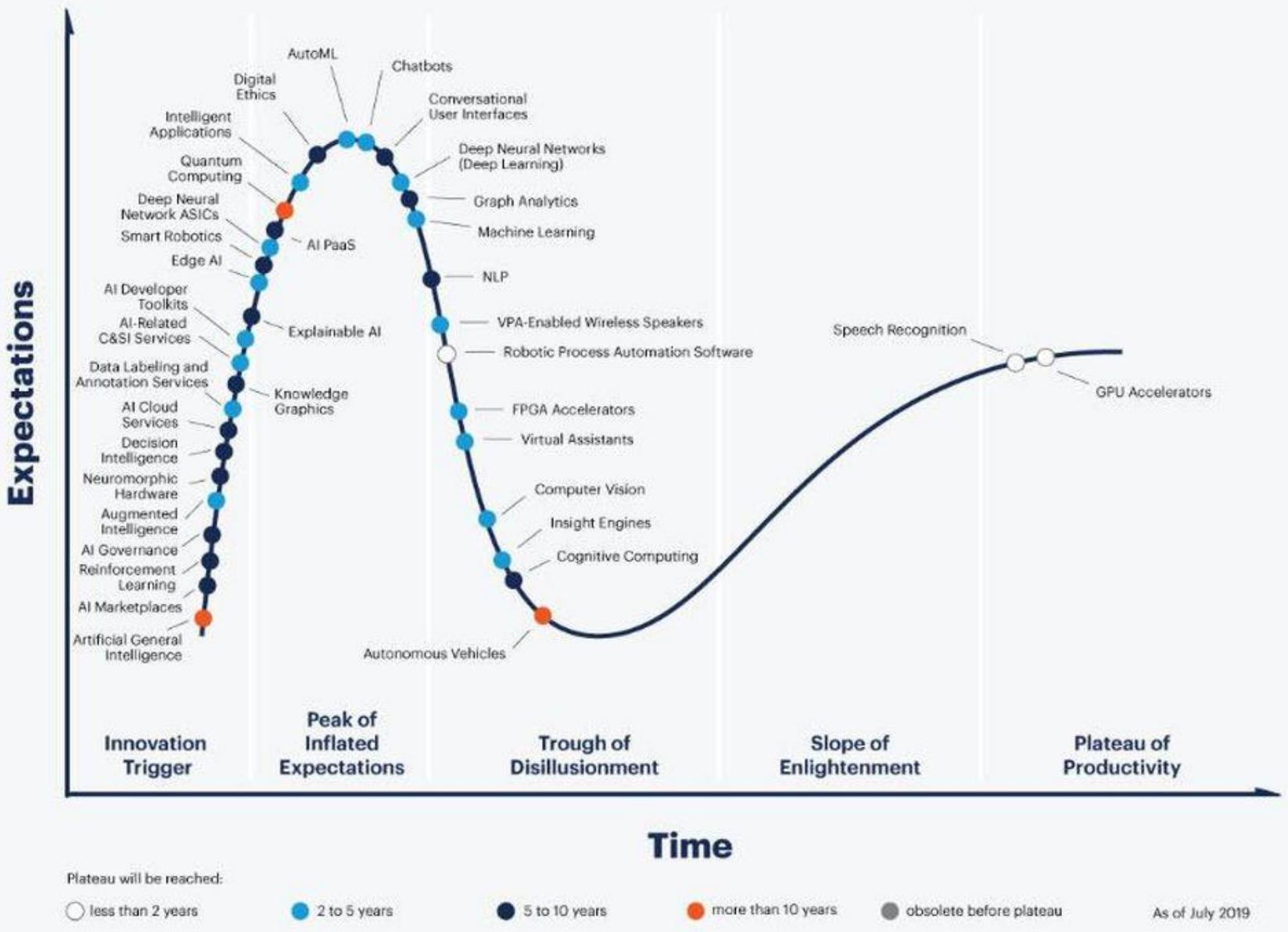
→ NOT REALLY DUE TO AI AT THIS POINT

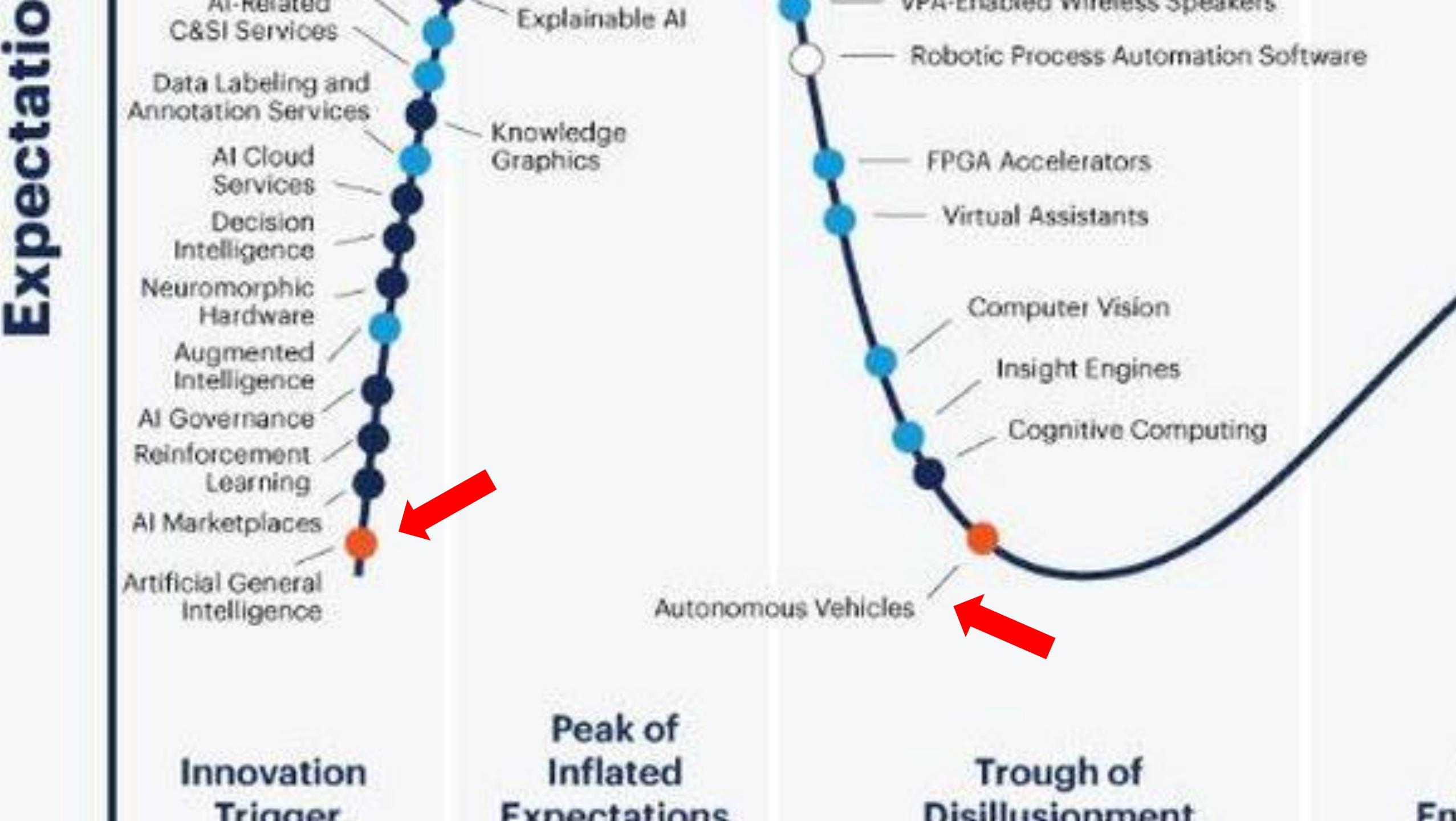
AI -- NEXT DECADE

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

--Yogi Berra

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**

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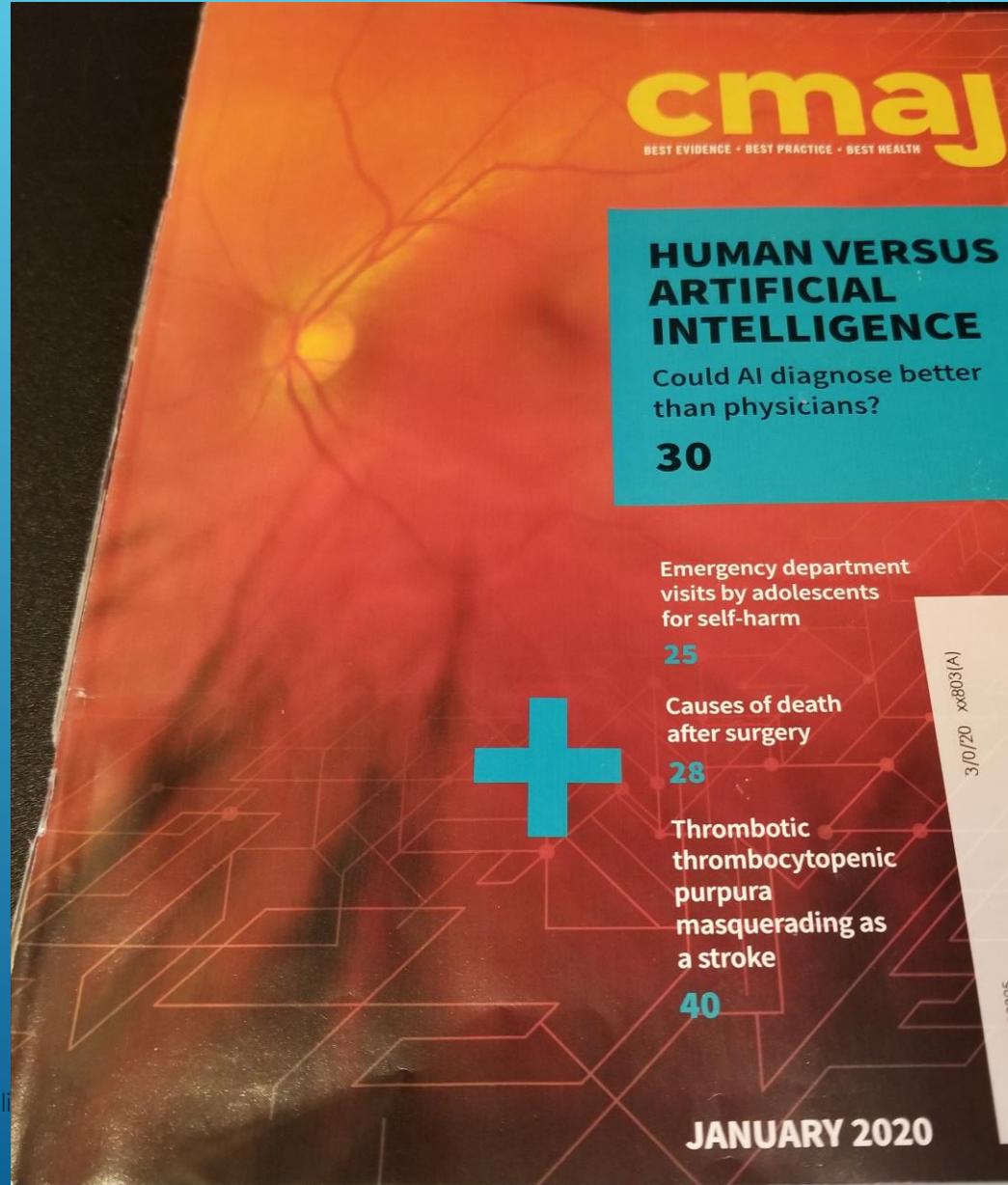
MEDICAL AI SYSTEMS

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



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COVER STORY OF JANUARY 2020 PRINT CMAJ



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March 2020

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

ANALYSIS+

“Because human and artificial intelligences are different and complementary, it is unlikely that AI will entirely replace the physician in the resolution of clinical problems.”

My view:

- current AI contains **no model** of the world, **no causal** reasoning
- instead functions as a **massive association machine**

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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

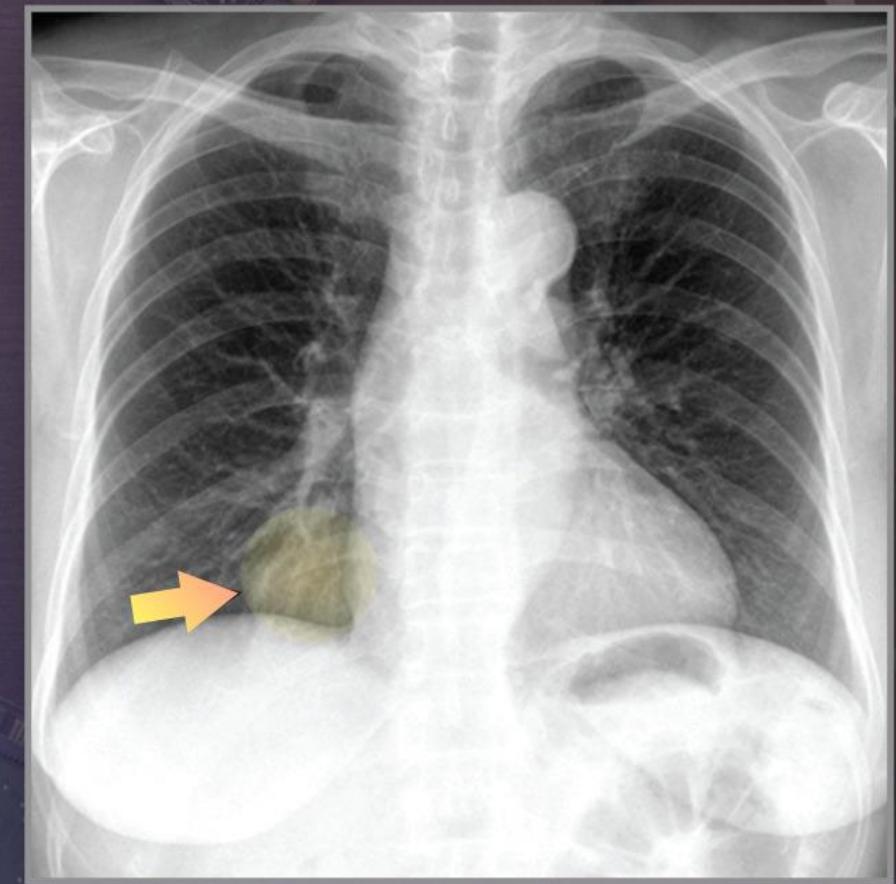
Human vs Machine: Lung Tumor

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

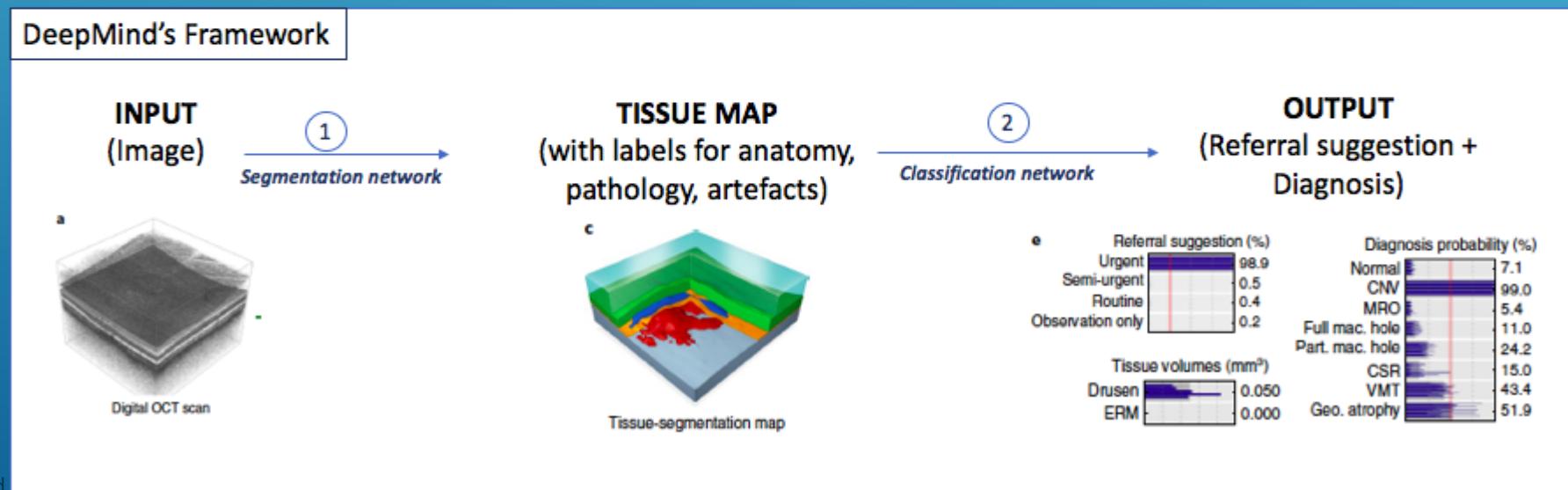
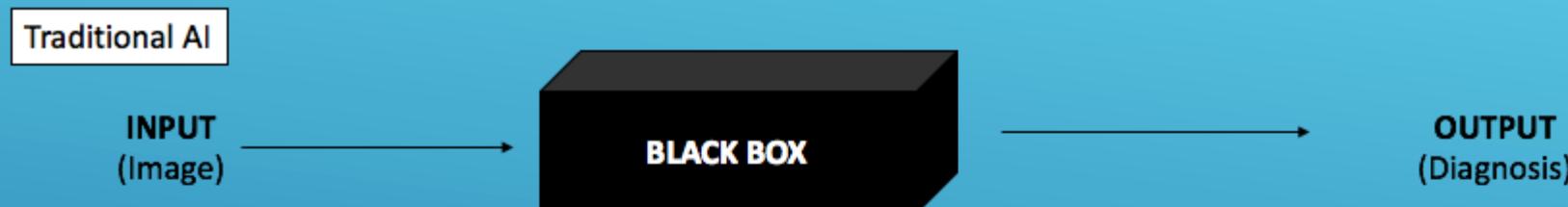
Example:
Lung Tumor

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

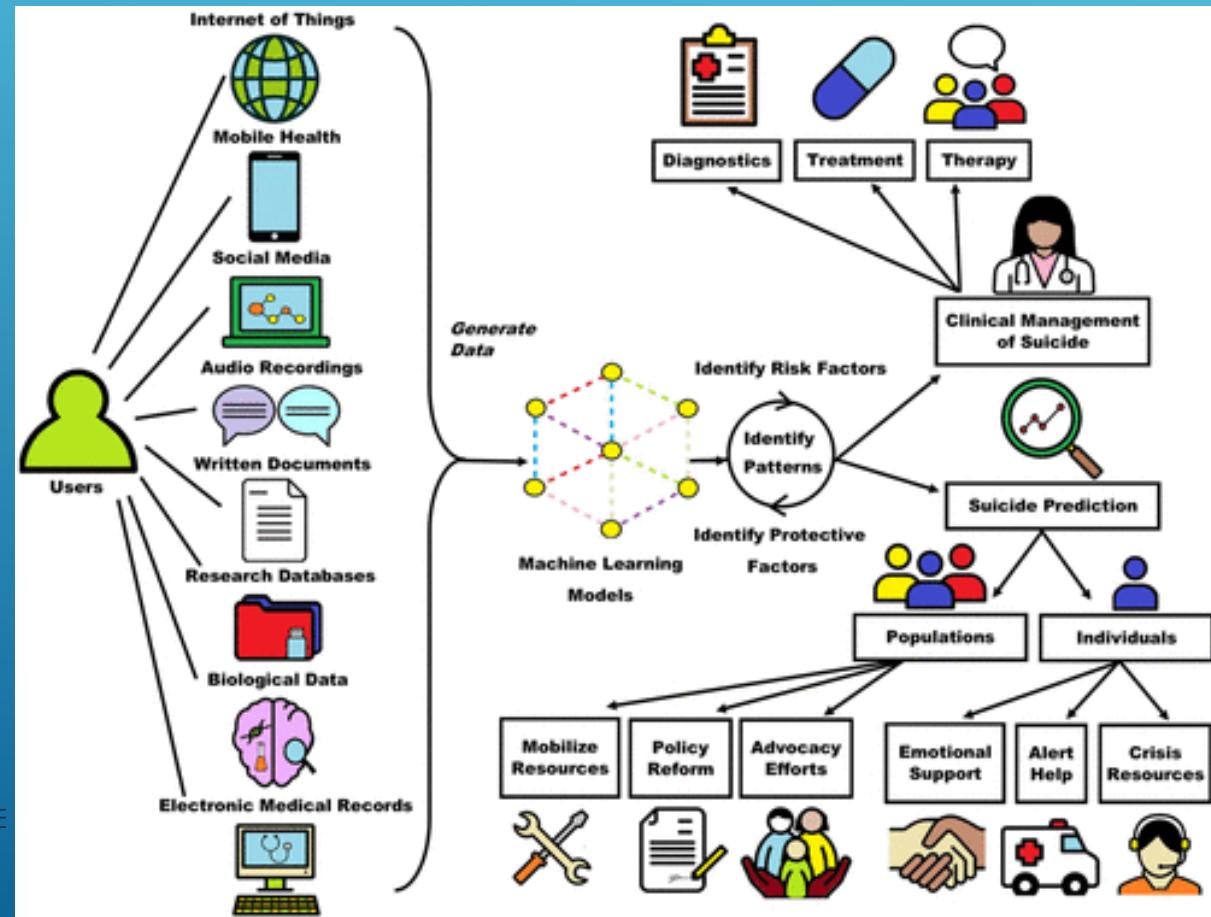
Ben-Israel and colleagues - Neurosurgery, University of Calgary

“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.”

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March 2020

Dr Sidney Kennedy, University of Toronto
Machine Learning in psychiatry
-predict escitalopram treatment outcome from EEG
-predict relapse, increased risk of suicidal behavior



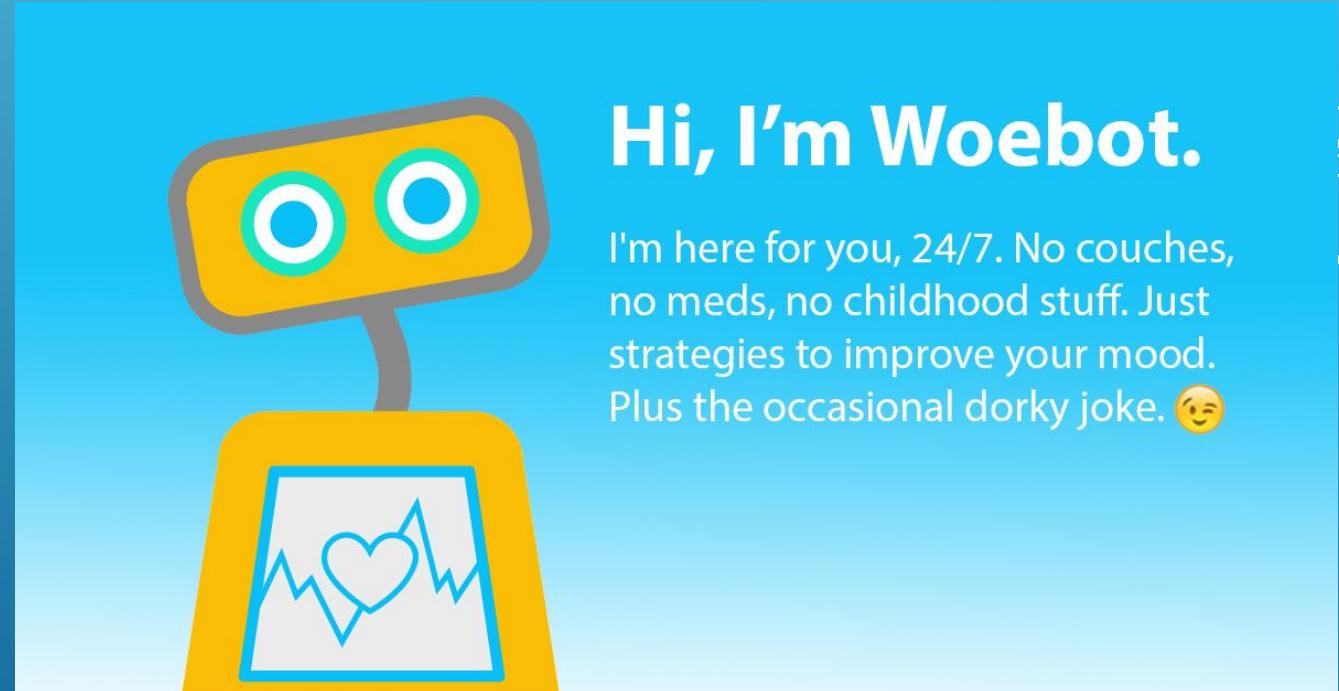
Brain activity can help predict who'll benefit from an antidepressant

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



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??)

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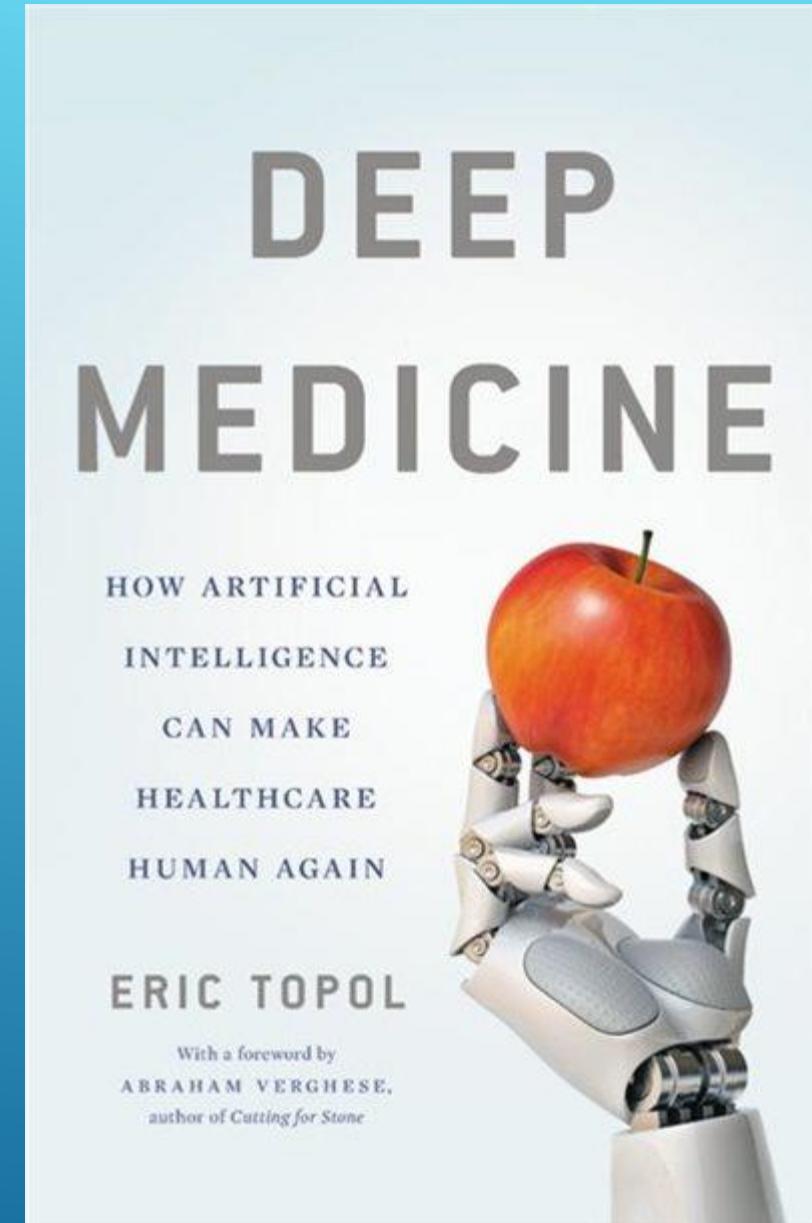
March 2020

→ 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

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NEXT DECADE (MY OPINION)

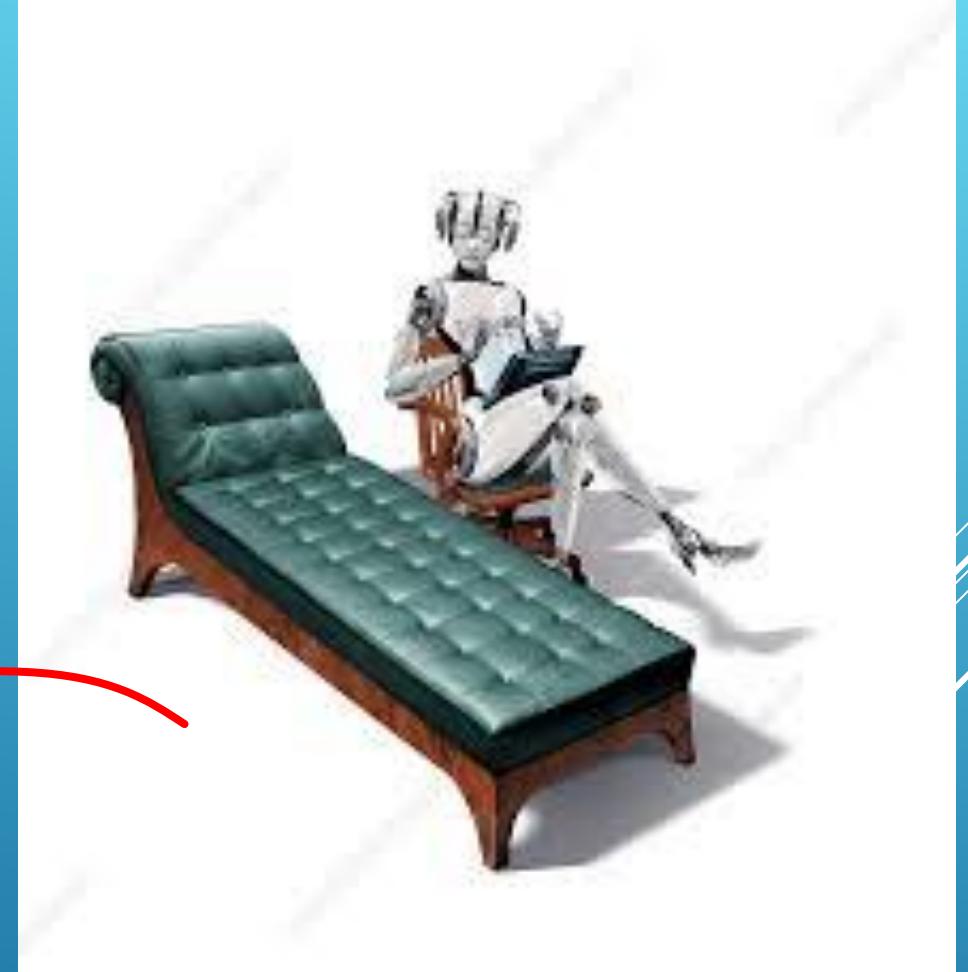
- ONCE THE **NEURO-SYMBOLIC GAP IS SOLVED**, AI SYSTEMS SHOULD BE ABLE TO DO THE WORK ALMOST ANY HEALTHCARE WORKER CAN DO
- HUMANS PROVIDE **OVERSIGHT** (FOR A WHILE....) OF AI HEALTH SYSTEMS

NEXT DECADE (MY OPINION)

HUMANS PROVIDE EMPATHIC &
EXISTENTIAL LIAISON TO AI HEALTH
SYSTEMS

→ THUS KEY FOR PSYCHOTHERAPY

Even if technology is
great, will this work?



LEARNING OBJECTIVES

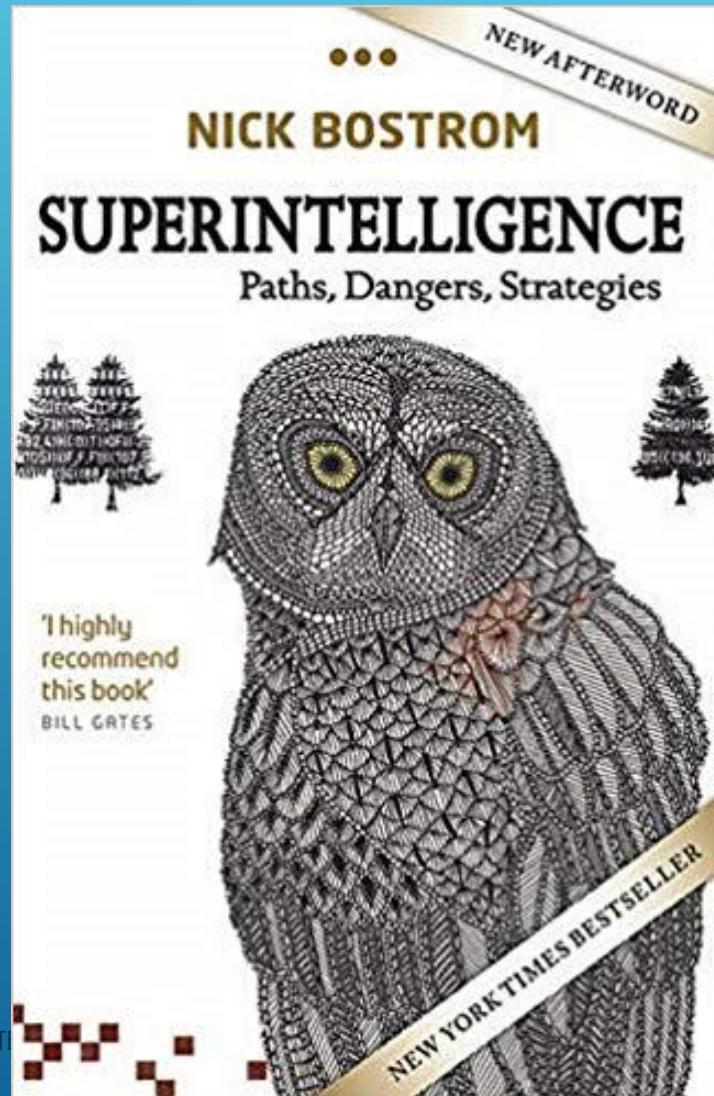
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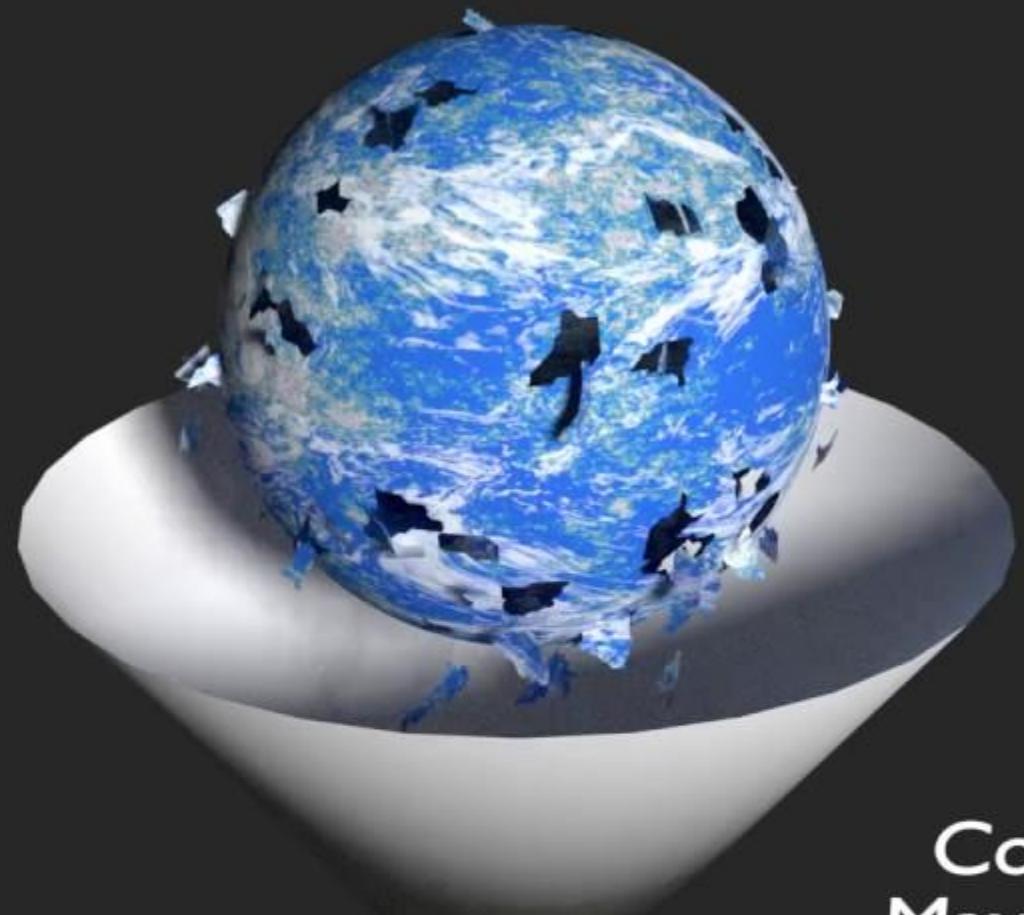
DEEP LEARNING ALL AROUND US NOW: LONDON POLICE SURVEILLANCE CAMERAS WITH FACIAL RECOGNITION

PSYCHOLOGY OF CONSTANT SURVEILLANCE??



Bostrom – SuperIntelligence

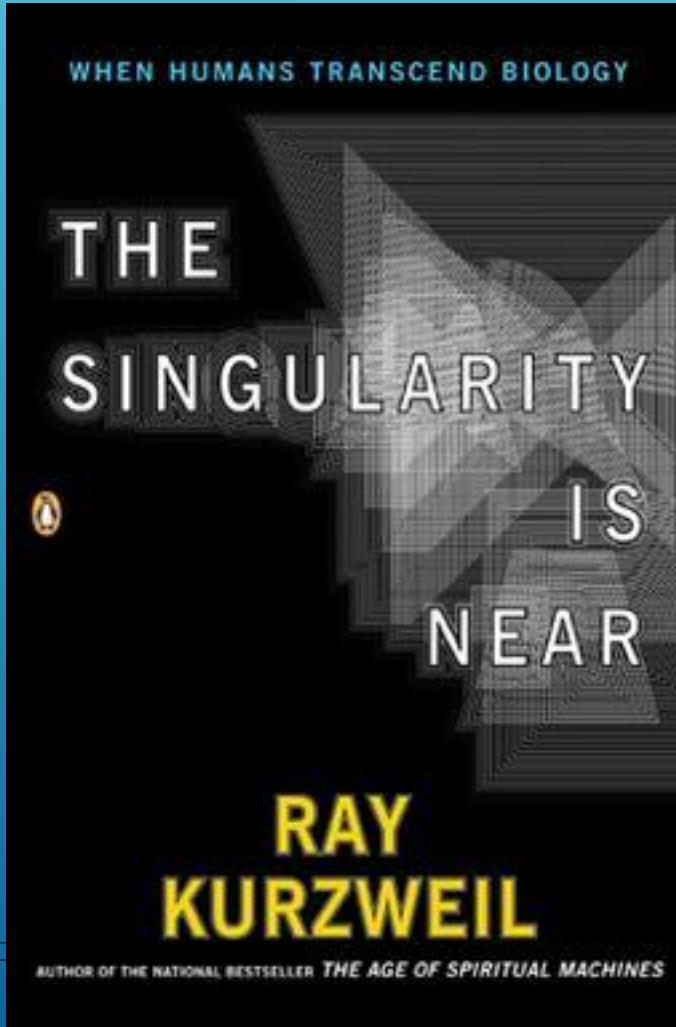




*Could an AI Paperclip
Maximizer machine turn
the earth into paperclips?*

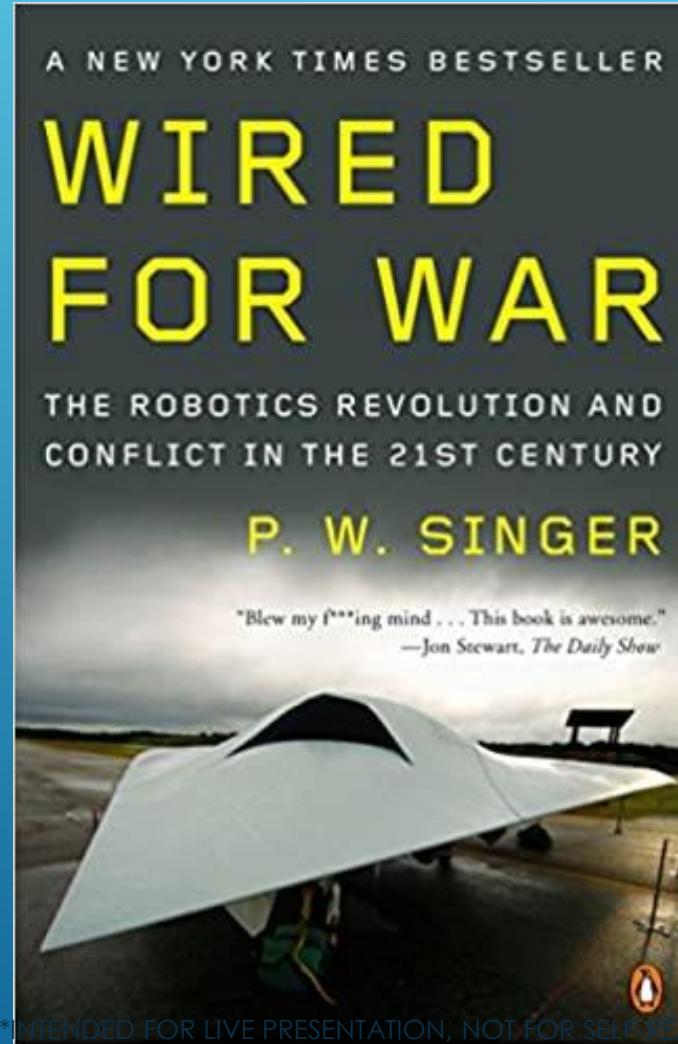
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Kurzweil – AI Exceeding Human Intelligence and Merging with Humans





SINGER'S 2009 BOOK – WIRED FOR WAR



2017 ASILOMAR AI PRINCIPLES

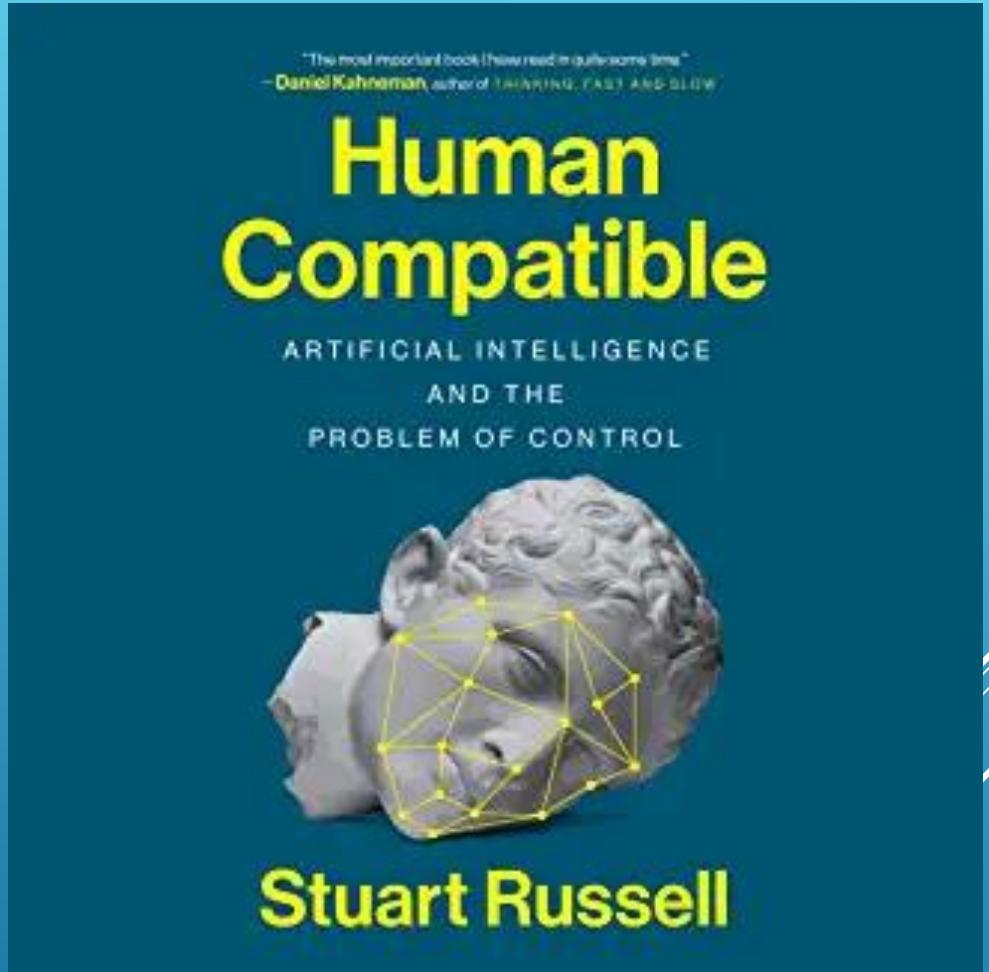


- #1- The goal of AI research should be to create not undirected intelligence, but **beneficial intelligence**.
- #6- AI systems should be **safe and secure.. verifiably so..**
- #23- **Superintelligence** should only be developed.. for the **benefit of all humanity** rather than one state.

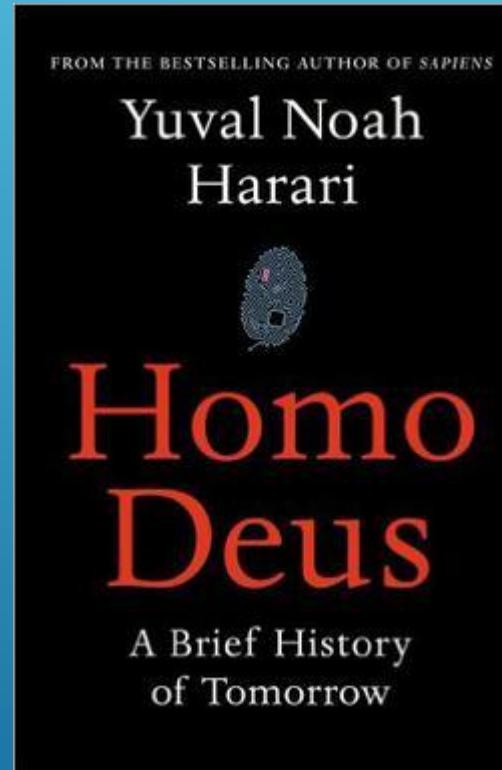
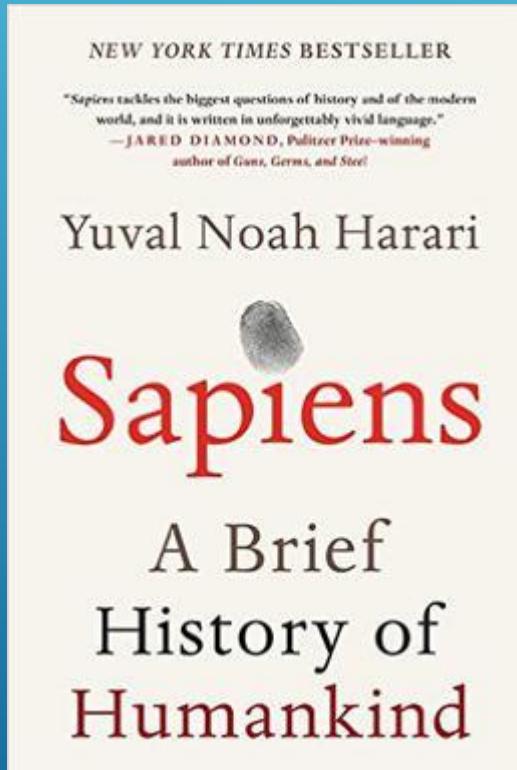
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Provably Beneficial AI

The only objective
of the machine is
human well being,
or the satisfaction
of human
preferences



- 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....



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March 2020

Artificial Intelligence and the Future of Medicine/Mankind

Thank You

howard.schneider@gmail.com