

# **AI: A taxing problem**

A deep-dive into the world of AI and its application in the tax world

Vikram. V

# Agenda

**Part 1. AI, ML, Deep Learning:** What is it all about? A deep dive

**Part 2. Tax and AI:** 360degree view

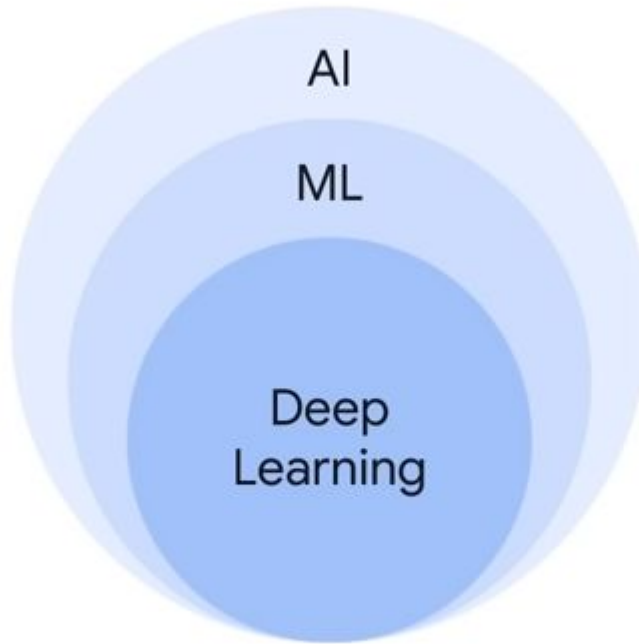
**Part 3. Walk the Talk:** My experiments with ChatGPT & Llama

# AI vs ML vs Deep Learning



Artificial Intelligence

is a discipline



Machine Learning

is a subfield

# ML: How does it work?

- AI is the theory and development of computer systems able to perform tasks normally requiring human intelligence.
- ML gives computer the ability to learn without explicit programming
  - It is a sub-field which is a program or system that trains a model from input data. Then the trained model can make useful predictions from new data.

# ML: How does it work?

- **Training**

- Analyze a bunch of sample or training data for feature or pattern extraction
- Data can be images, videos, numbers etc

- **Inference**

- Output of Machine learning stage is a **model** which encapsulates the algorithm that has *learnt* the dataset
- Now we can query the Model with new data not in the training data set and it infers the answer

# ML: Methods

- Supervised learning
- Unsupervised learning
- Reinforcement learning

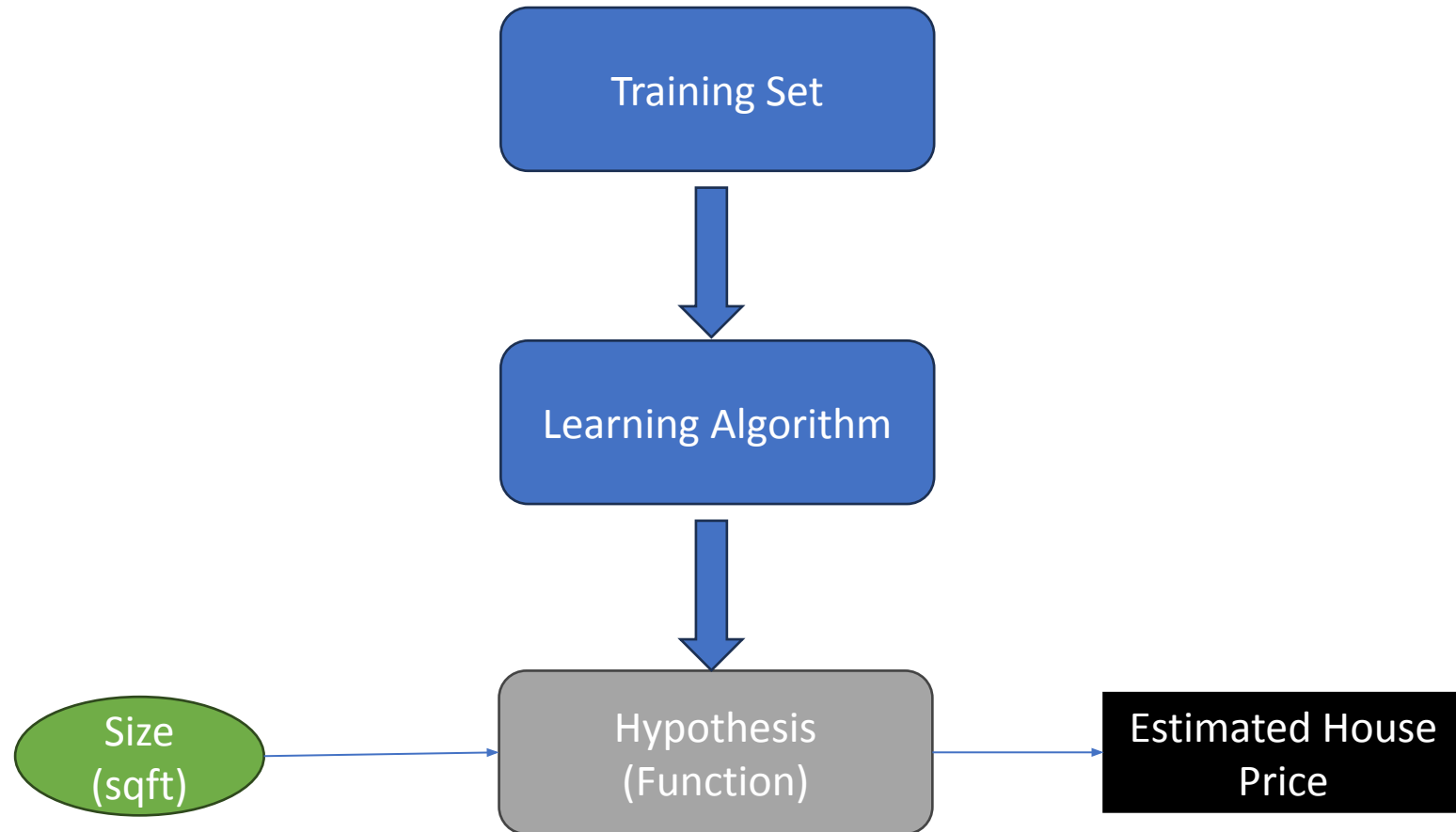
# ML: Supervised Learning: Linear Regression

- **LR: Simplest supervised learning algorithm**
- **Let's say you want to estimate or predict the prices of houses**
  - The way you build the learning algorithm is start by collecting a dataset of houses and their prices

Size (sqft)	Price (\$1000s)
2104	400
1416	232
1534	315
852	178

Fit a straight line to the data (size x-axis vs price y-axis)

# ML: Linear Regression (contd)





# ML: Linear Regression: Features, parameters

- Need to add more features...? Number of bedrooms.

- $h(X) = \theta_0 + \theta_1 * X_1 + \theta_2 * X_2$

- $X_1$  = size of house

- $X_2$  = # of bedrooms

$$h(X) = \sum \theta_j X_j \text{ where } X_0 = 1$$

Size (sqft)	# of bedrooms	Price (\$1000s)
2104	3	400
1416	2	232
1534	3	315
852	2	178
...	...	...

$\theta$	$X$
$\theta_0$	$X_0$
$\theta_1$	$X_1$
$\theta_2$	$X_2$

$\Theta$  - Parameters vector

$X$  - Features vector

**Job of the learning algorithm is to make choices of  $\theta$  that allows you to make good predictions about your prices of houses, right?**

# ML: Features, parameters

- Need to add more features...? Number of bedrooms.

- $h(X) = \theta_0 + \theta_1 * X_1 + \theta_2 * X_2$

- $X_1$  = size of house

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$\theta$	$X$
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$\theta_1$	$X_1$
$\theta_2$	$X_2$

$\Theta$  - Parameters vector

$X$  - Features vector

$N$  features,  $N+1$  dimensional vectors

**Job of the learning algorithm is to make choices of  $\theta$  that allows you to make good predictions about your prices of houses, right?**

- **Quiz time: Suggest some more features!**

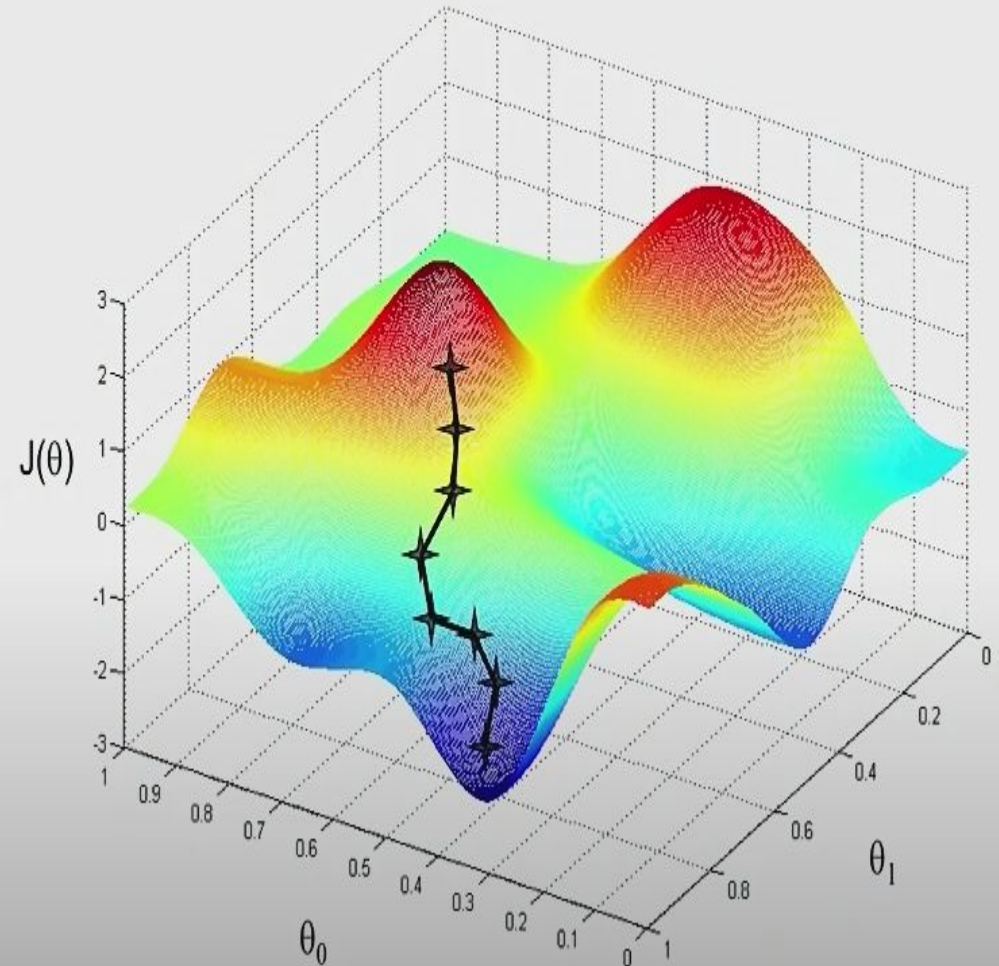
# ML: Least-squares linear regression

- $X$  = “inputs” / features
- $Y$  = output, target
- $m$  = # of training samples
- $x^i, y^i$  =  $i$ th training example
- Choose  $\Theta$  such that  $\mathbf{h}(\mathbf{x}) \approx \mathbf{y}$  for the training samples
- Cost function:  $J(\Theta) = \frac{1}{2} \sum_{i=1}^m (\mathbf{h}_{\Theta}(\mathbf{x}^{(i)}) - \mathbf{y}^{(i)})^2$
- Find parameters  $\Theta$  to minimize the cost function  $J(\Theta)$

# ML: Gradient descent

- **Algorithm** to find  $\Theta$  that minimizes  $J(\Theta)$
- Start with some value of  $\Theta$ , could be a zero vector.
- Keep changing  $\Theta$  to reduce  $J(\Theta)$
- Find values for  $\Theta_0$  and  $\Theta_1$  (in our example  $\Theta_1$  and  $\Theta_2$ ) that minimizes the height of the surface  $J(\Theta)$
- Depends on where you start...initial values?

## Gradient Descent



# ML: Supervised learning – Example #2

Supervised learning implies the data is already labeled

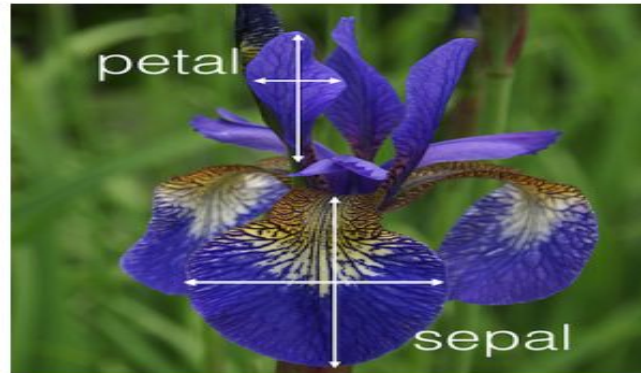
In supervised learning we are learning from past examples to predict future values.



# ML: Supervised learning –Example #3

- Remember we train “machines” using labelled data
- Data can be image, text, video
- Example: Iris dataset

About Iris dataset



- The iris dataset contains the following data
  - 50 samples of 3 different species of iris (150 samples total)
  - Measurements: sepal length, sepal width, petal length, petal width
- The format for the data: (sepal length, sepal width, petal length, petal width)

# Iris dataset

	sepal length	sepal width	petal length	petal width	Target
1	5.1	3.5	1.4	0.2	0 (Setosa)
2	6.4	3.1	4.5	1.2	1 (Versicolor)
3	5.9	3.0	5.0	1.8	2 (Virginica)
...					
150	4.9	3.0	1.4	0.2	0 (Setosa)

Quiz time: How many features are there, how many training data samples?





## Training Data

**Features**      **Target**

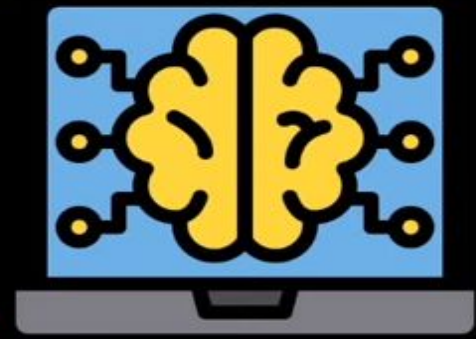
5.1 3.5 1.4 0.2 0

6.4 3.1 4.5 1.2 1

5.9 3.0 5.0 1.8 2

...

4.9 3.0 1.4 0.2 0



# Training...



5.3 3.7 1.4 0.3 ?

Predict the species of an iris with the new measurements



# ML: Supervised learning

Typically, Classification and regression

- **Regression** makes sense when relationship is between two or more variables and change in one is associated with change in another
- **Classification** makes sense when output variable is categorical  
example: yes/no, true/false
  - New observations are recognized and separated

# ML: Supervised learning algorithms

- Linear Regression
- Logistic Regression
- Support Vector Machines [Classification]
- K Nearest Neighbor [Classification]
- Decision Tree [Classification]

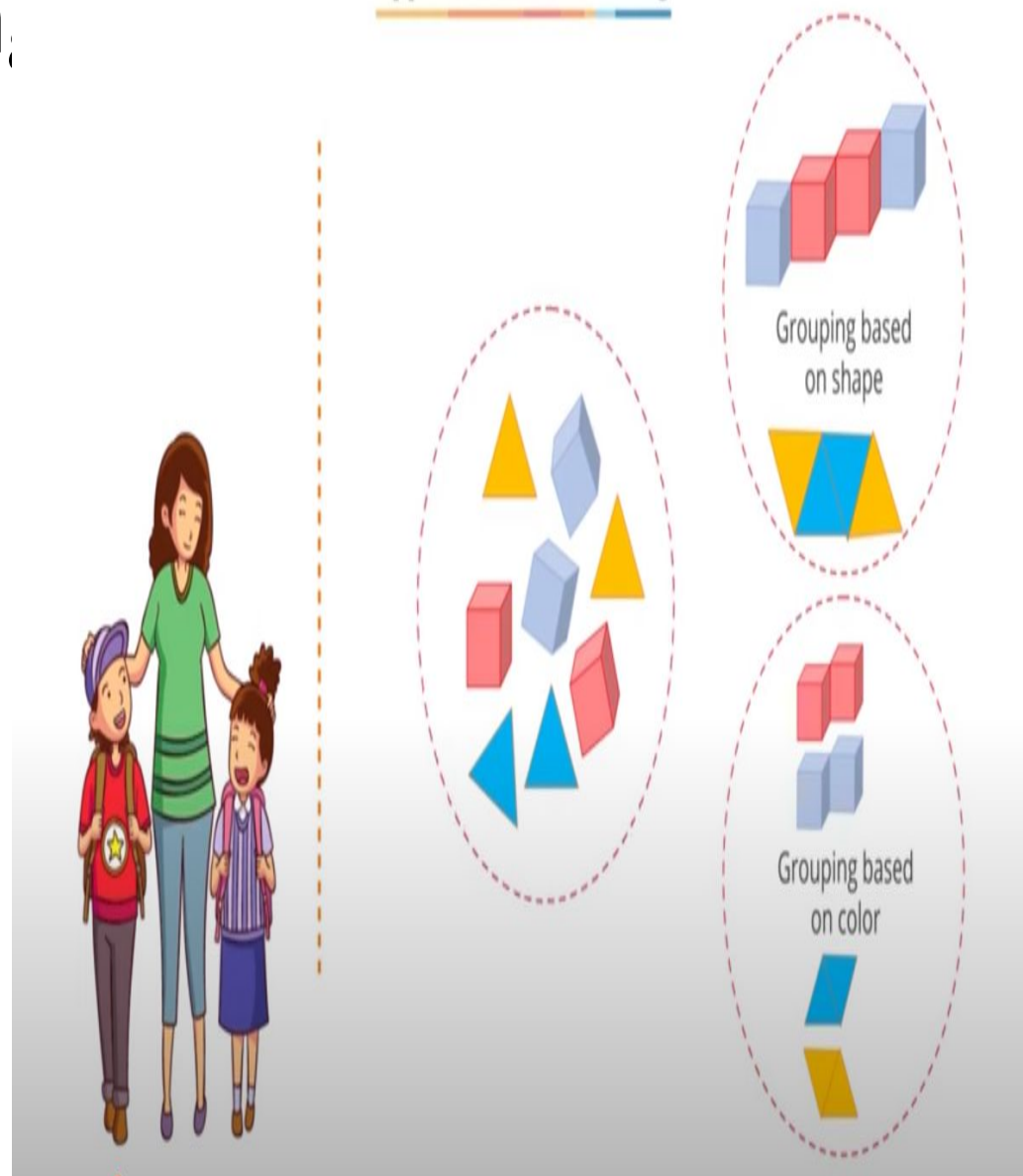
**Bottomline: Typically, Classification and regression**

# ML: Supervised Learning: Pros & Cons

- Image Recognition, Predictive Analysis, Customer Sentiment Analysis, Spam detection
- Advantages
  - Real world applications
  - Predict output using past experiences
  - Reusable data
  - Optimization
- Disadvantages:
  - Computation time/Running time
  - Need updates
  - Pre-processing of data

# ML: Unsupervised learning

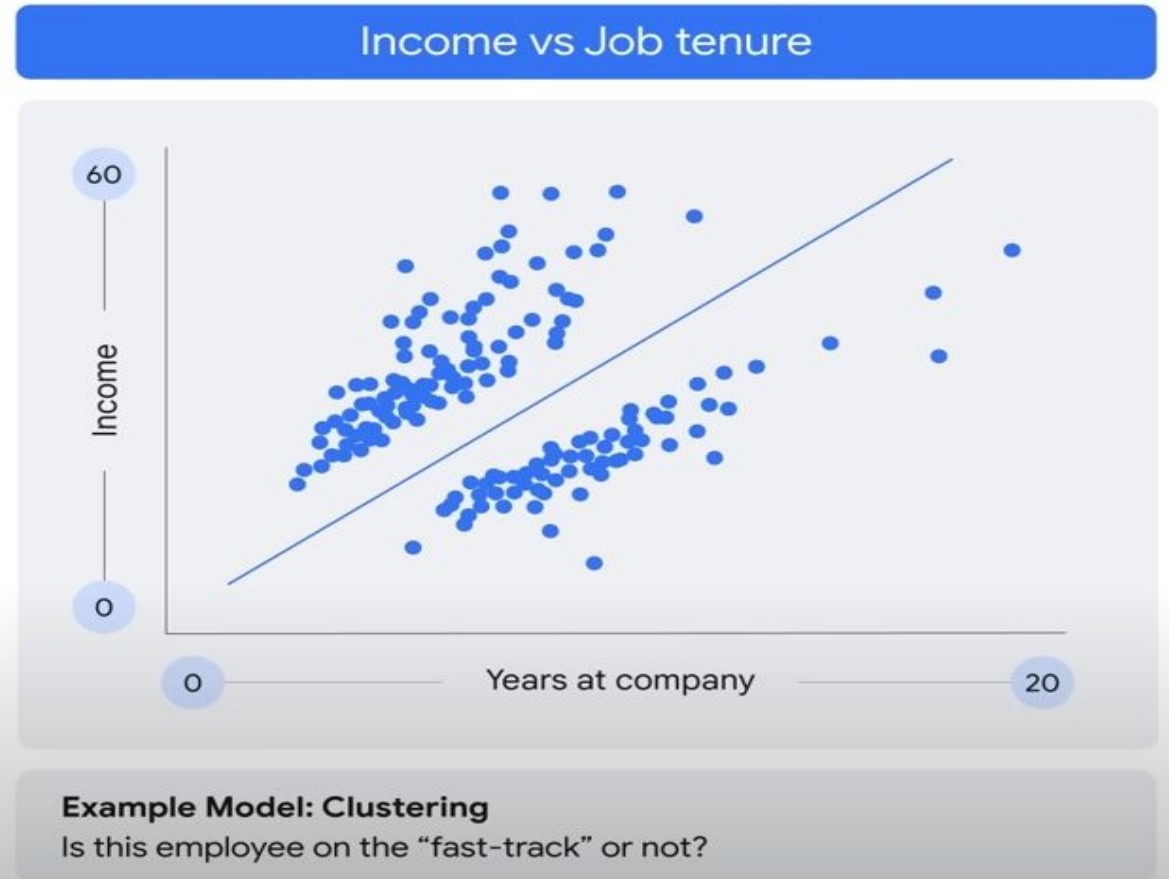
- Child is shown images without labels; does not anything beforehand
- Will the child identify bird or animal? Likely will classify:
  - Groups with wings
  - Groups with legs: two legs, four legs
- Types of clustering
  - Hierarchical: Agglomerative, Divisive
  - Partitional: K-means, Fuzzy C-means



# ML: Unsupervised learning

Unsupervised learning implies the data is **not labeled**

Unsupervised problems are all about looking at the raw data, and seeing if it naturally falls into groups



# ML: Unsupervised learning

- K Means Clustering
- Hierarchical Clustering
- DBSCAN
- Principal Component Analysis

Bottomline: Typically, Clustering & association based

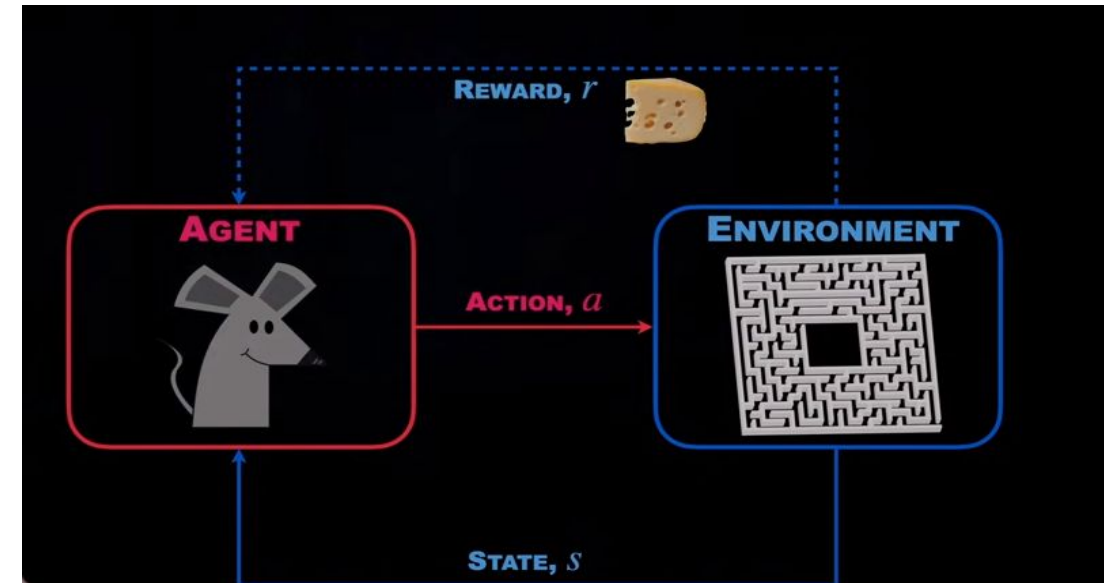
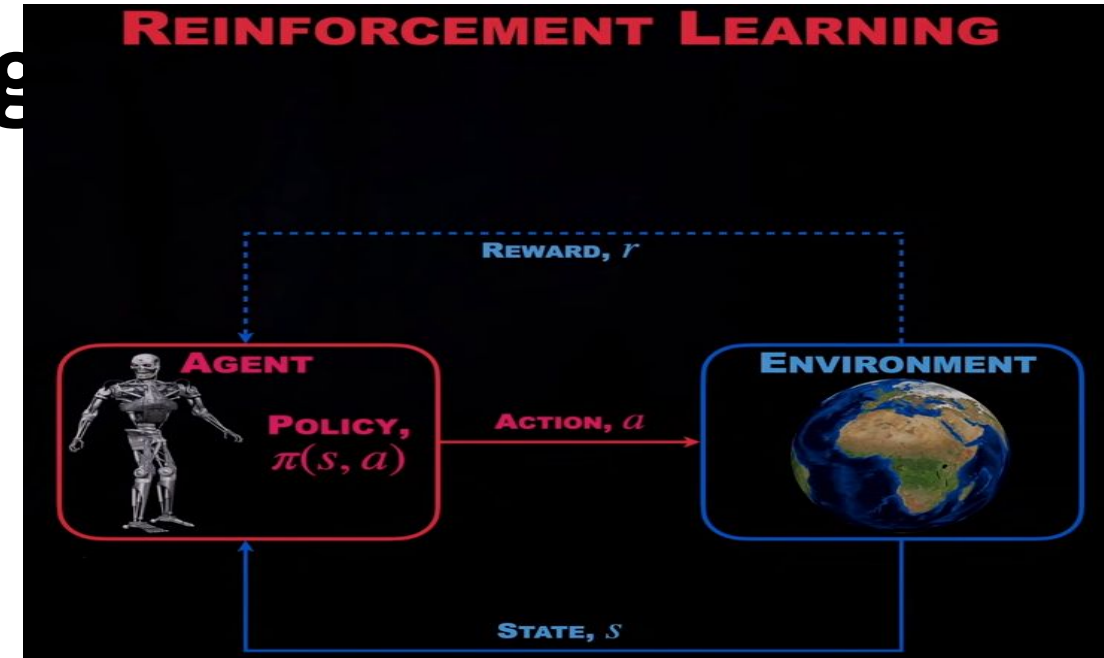
# ML: Reinforcement learning

- Uses an agent and an environment to produce actions and rewards
- Framework for learning how to interact with the environment from experience
- Very biologically inspired isn't it . Animals do this through trial and error, through experience, through positive rewards and feedback
- Design a **policy** to, given a State  $S$ , to maximize the chance of getting a future reward  $r$

**Example 1:** Mouse (agent), Environment (maze)

- Mouse may not know full state
- It takes an **Action** (turn right, left, forward)
- Only at the end of maze, Mouse gets a **Reward**. (Sparse rewards)

Quiz time: What kind of learning is Reinforcement Learning - supervised, unsupervised...or what?



# ML: Reinforcement learning: What is it?

- **Semi-supervised learning:**

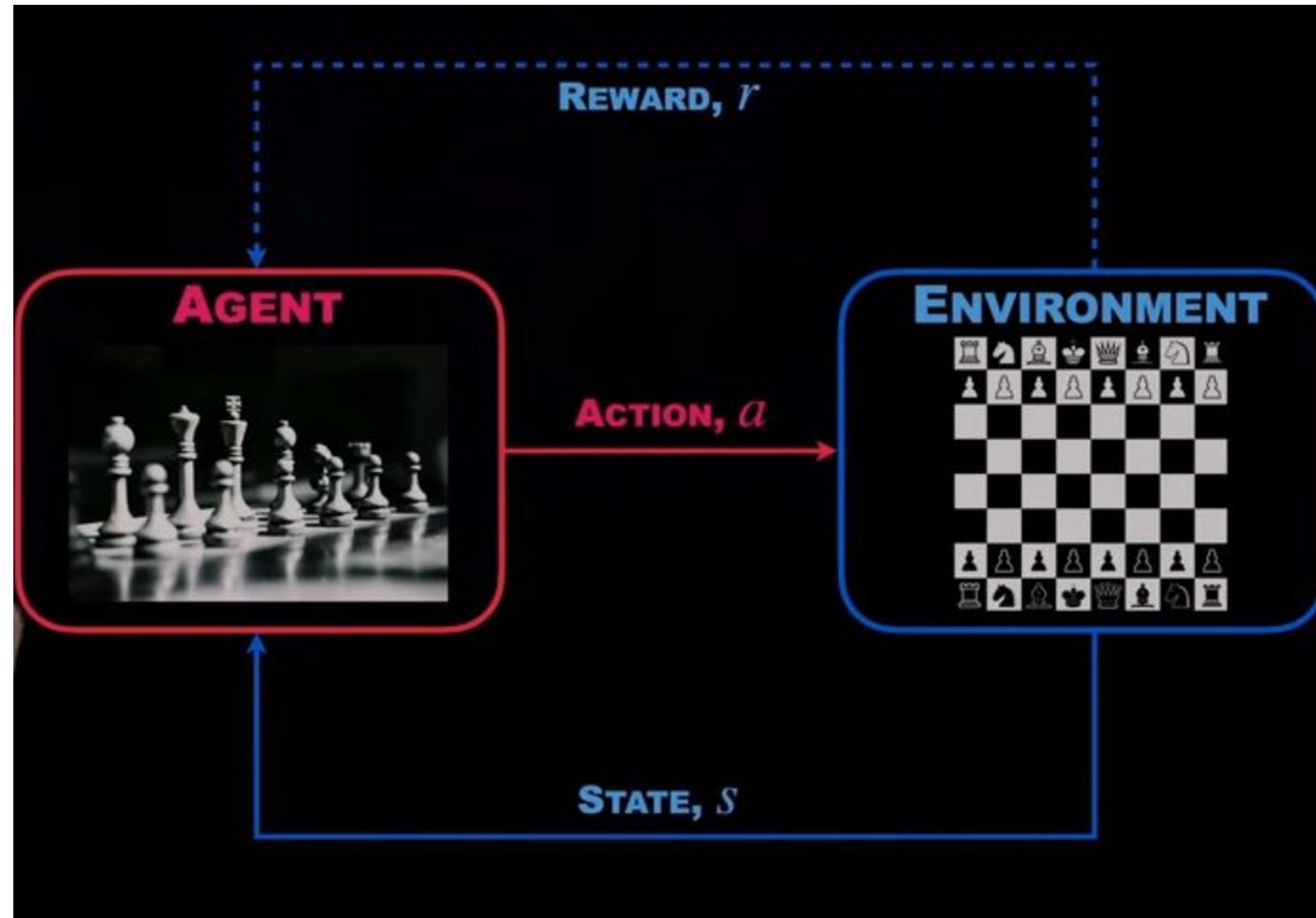
- Every correct turn it got a piece of cheese its regular supervised learning, rewards are labels.
- Time delayed label = Reward makes it semi-supervised
- Still supervised as there is supervisory feedback



# ML: Reinforcement learning

## Example 2:

- Adversarial active player in the environment
- Games are great examples for use of RL
- Probabilistic Policy to explore and optimize rewards  
 $\pi(s,a) = \Pr(a = a \mid s=s)$



## ML: Reinforcement learning : AlphaGo vs Lee Sedol



# ML: Reinforcement Learning: Go vs Chess

Mathematician I.J.Good in 1965:

*“Go on a computer? – In order to program a computer to play a reasonable game of Go, rather than merely a legal game – it is necessary to formalise the principles of good strategy, or to design a learning program. The principles are more qualitative and mysterious than in chess, and depend more on judgement. So, I think it will be even more difficult to program a computer to play a reasonable game of Go than of chess.”*

- 19x19 grid
- Prior to 2015, Go programs reached Amateur Dan level
- Lee was ranked 9-Dan. One of the strongest players in history of Go.

# ML: Reinforcement learning : AlphaGo

<https://www.youtube.com/watch?v=WXuK6gekU1Y>

*“On March 9, 2016, the worlds of Go and artificial intelligence collided in South Korea for an extraordinary best-of-five-game competition, coined The DeepMind Challenge Match. Hundreds of millions of people around the world watched as a legendary Go master took on an unproven AI challenger for the first time in history.”*

<https://jonathan-hui.medium.com/alphago-how-it-works-technical-ly-26ddcc085319>

- Deep Learning classifier composes of **13 layers** containing alternative convolutional filters followed by a softmax classifier.
- To train, AlphaGo collects moves for **30 million board positions**. Then it applies the backpropagation to train model parameters.
- AlphaGo uses 50 GPUs to train the network and it takes 3 weeks. The SL policy network achieves a 57% accuracy.
- **AlphaGo's original training dataset started with games of strong amateur players from internet Go servers, after which it trained by playing against itself for tens of millions of games**
- Training done and RLE used to create:
  - *a policy network that tells what moves are promising, and*
  - *a value network that tells how good a board position is.*
- Finally, complement both networks to get best move.

# ML: Reinforcement learning : AlphaGo

1<sup>st</sup> 3 games Lee lost

4<sup>th</sup> game. Lee went God Mode:

- Lee chose to play a type of extreme strategy, known as **amashi**, in response to AlphaGo's apparent preference for **Souba Go** (attempting to win by many small gains when the opportunity arises), taking territory at the perimeter rather than the center.
- By doing so, his apparent aim was to force an "all or nothing" style of situation – a possible weakness for an opponent strong at negotiation types of play, and one which might make AlphaGo's capability of deciding slim advantages largely irrelevant

5<sup>th</sup> game Alpha Go won

**Bottomline: Alpha Go vs Lee Sedol : 4/5**

# ML: Reinforcement learning

- Q-Learning
- SARSA
- Monte Carlo
- Deep Q Network

Bottomline: Typically, Reward based

## ML: Quiz Time (to make sure you aren't asleep...)

**Scenario 1:** Facebook recognizes your friend in a picture from an album of tagged photographs

**Scenario 2:** Recommending new songs based on someone's past music choices

**Scenario 3:** Analyze bank data for suspicious looking transactions and flag the fraud transactions



# Applications

## Supervised Learning



Weather Prediction



Sales Forecast



Stock Price Analysis

## Unsupervised Learning



Customer Segmentation



Churn Analysis

## Reinforcement Learning



Building Games

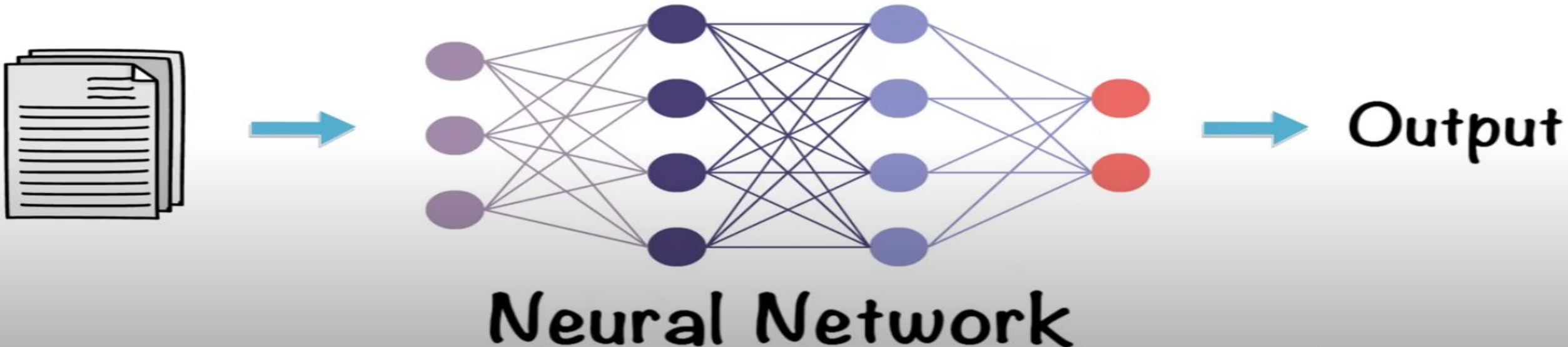


Training Robots

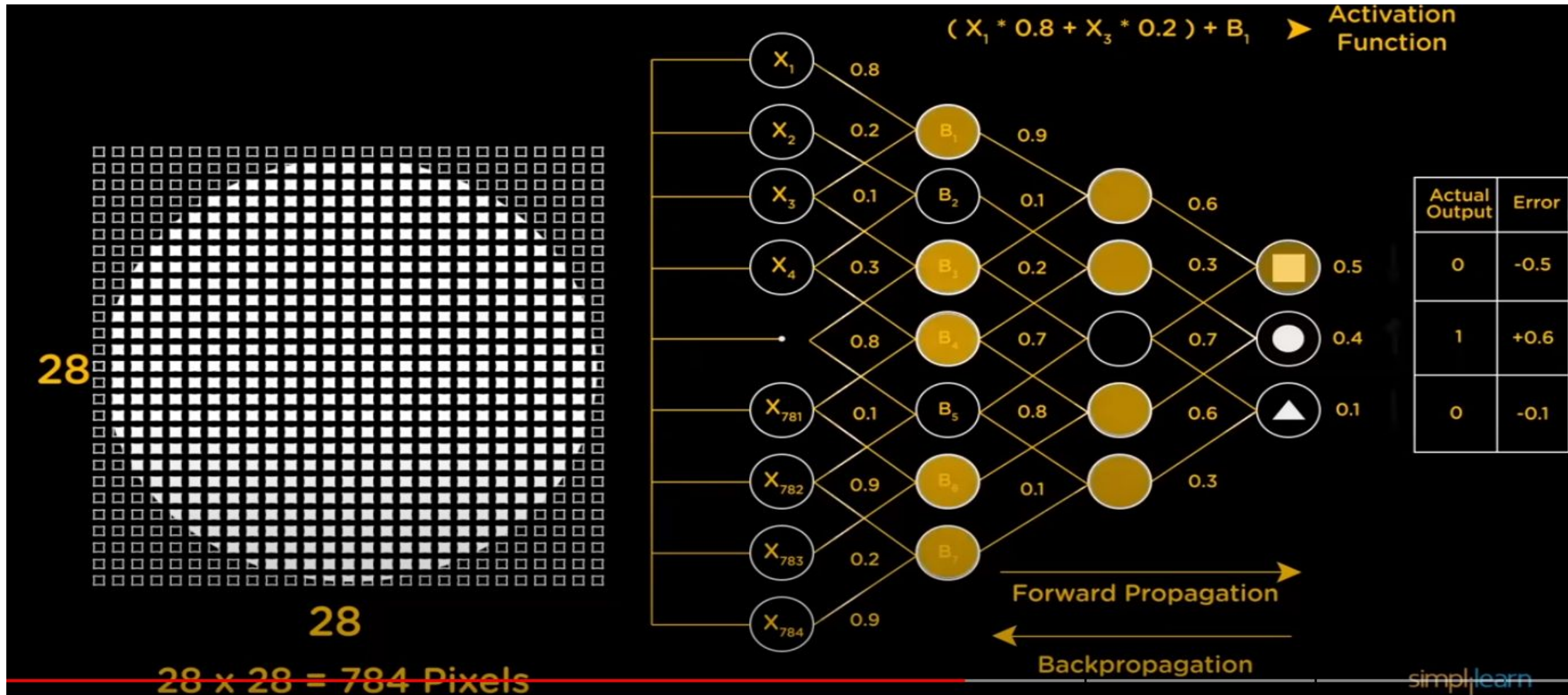


# Deep Learning: Neural Networks

- DL is a sub-field of ML where the algorithms are inspired by how the human brain functions i.e., neurons
- Uses Artificial Neural Networks allowing them to process more complex patterns than traditional ML:
  1. NN's take in data,
  2. Train themselves to recognize patterns
  3. Predict the output for similar data



# Deep Learning: How do Neural Networks work?



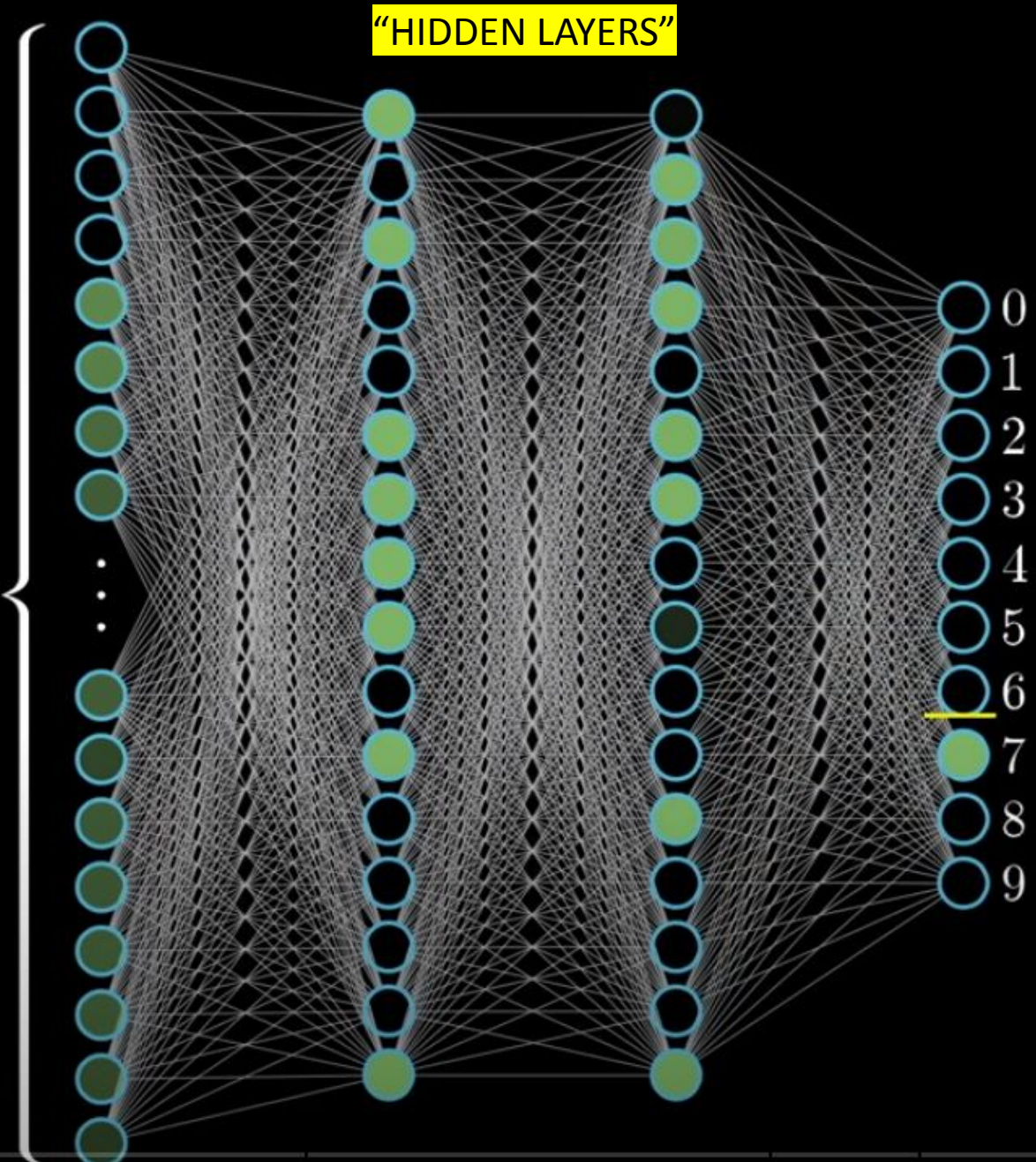




**Initial layer:** Network starts with 784 neurons; each one of these holds a number that represents the grayscale value of the pixel ranging from 0 to 1

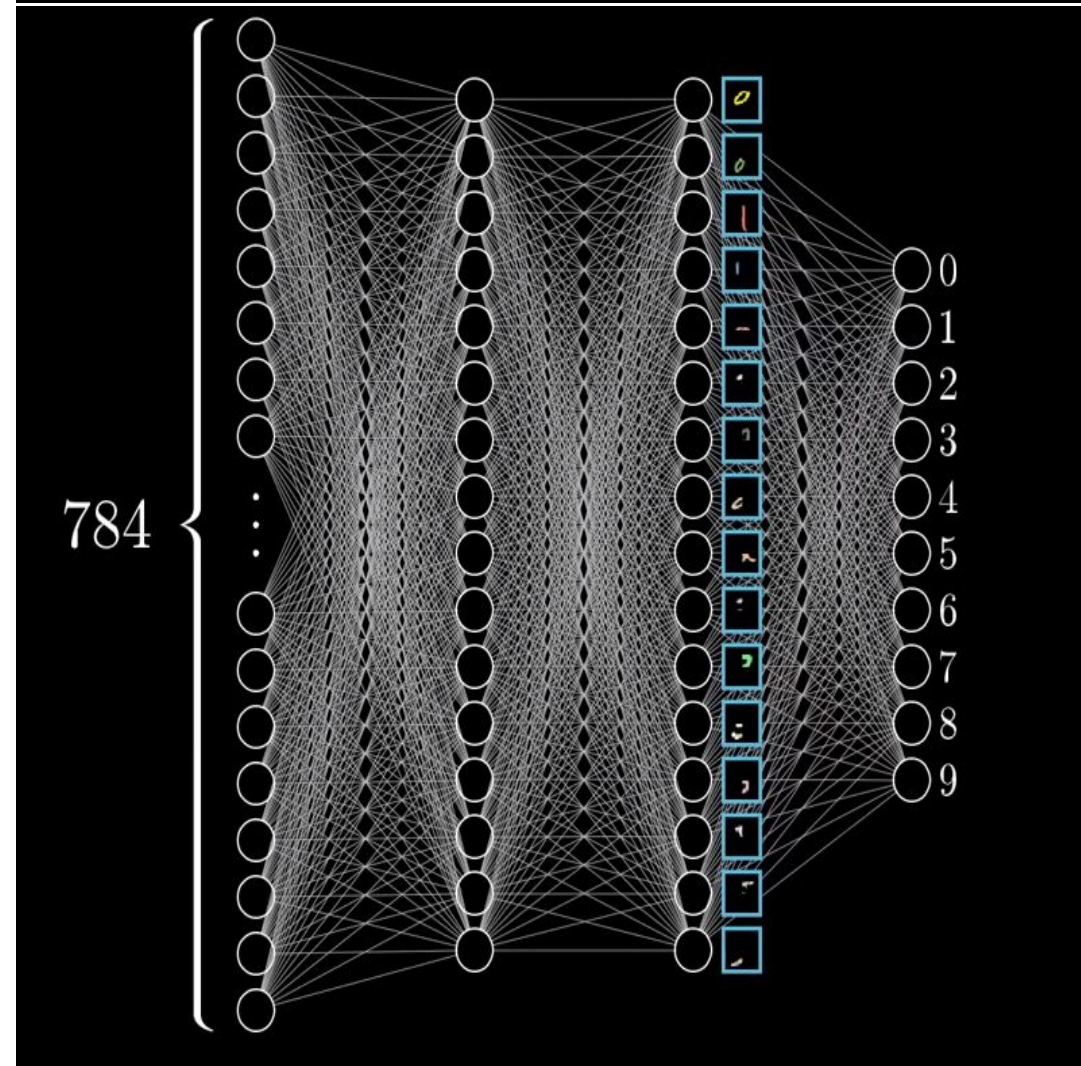
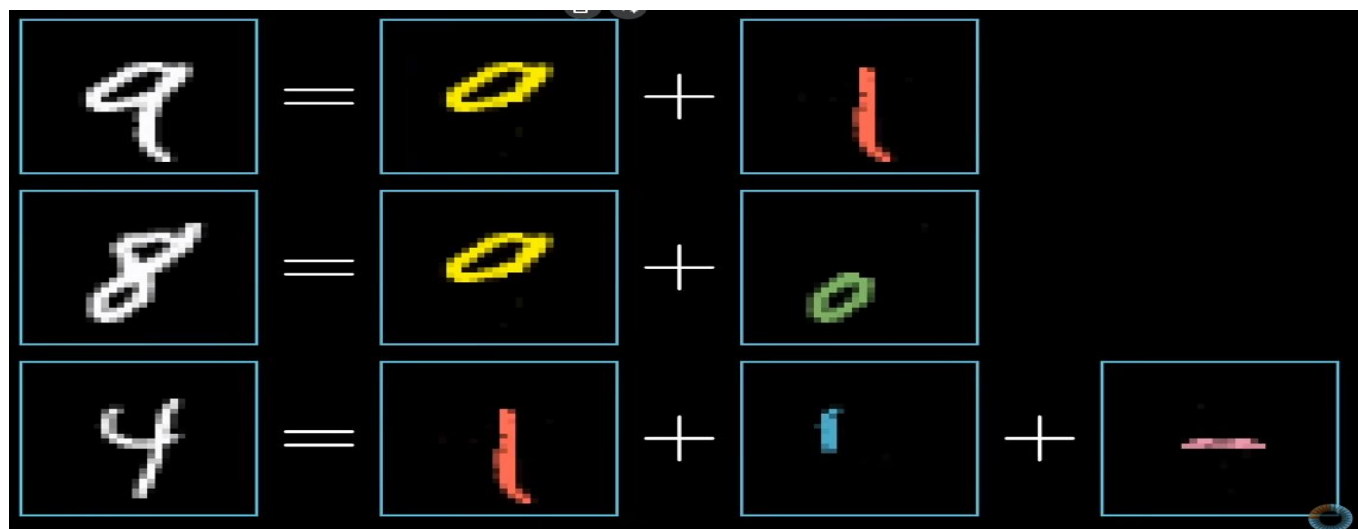
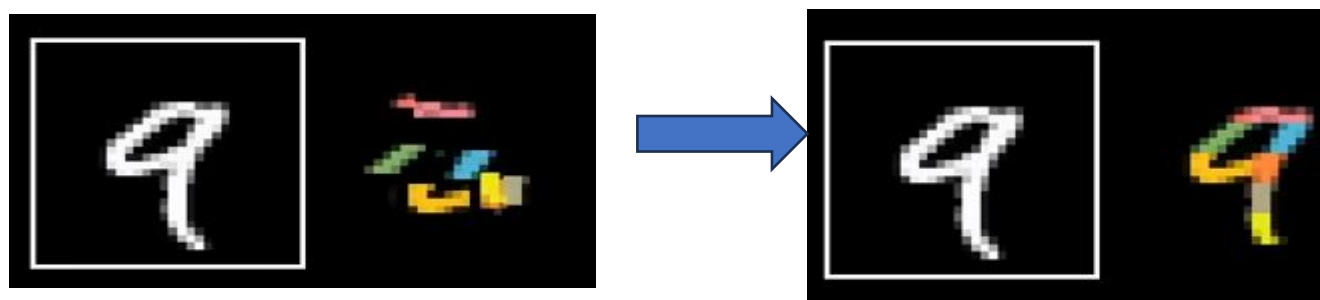
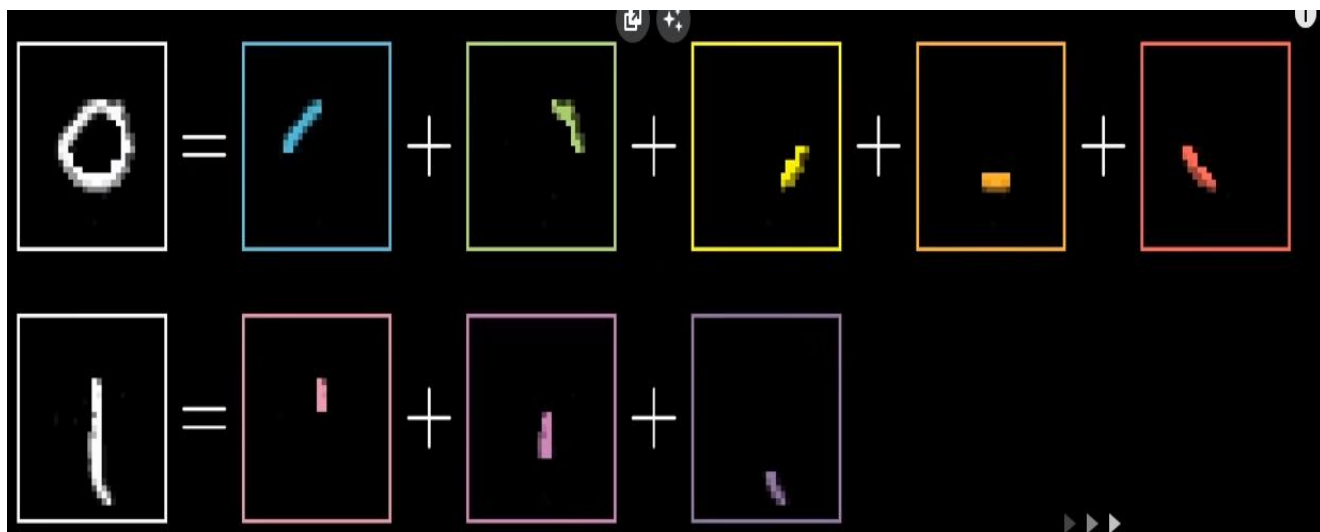
This number inside the neuron is called the activation

784



**Last layer** has 10 neurons each representing one of the digits.

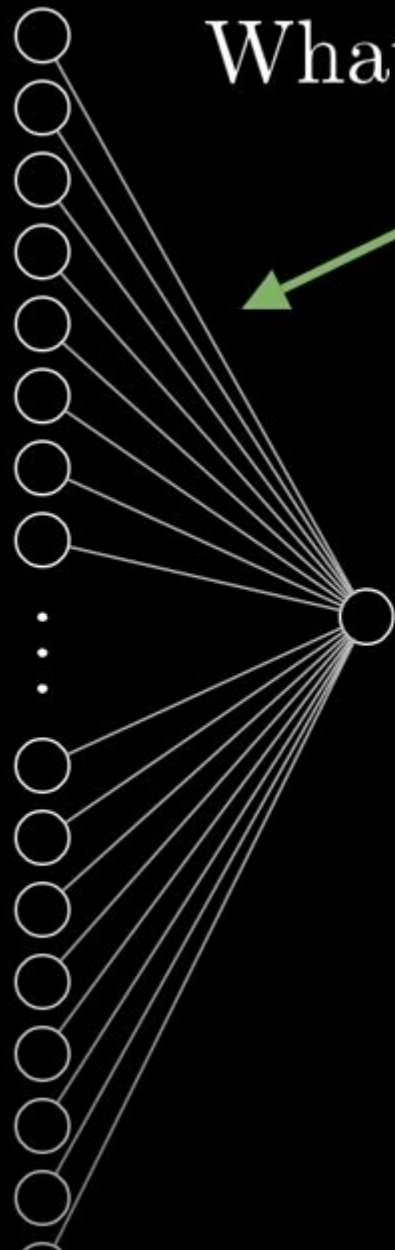
The activation in these neurons again is between 0-1 represents how much the system thinks that a given image corresponds with the given digit





What parameters should exist?

784



$p_1: 0.00$

$p_2: 0.00$

$p_3: 0.00$

$p_4: 0.00$

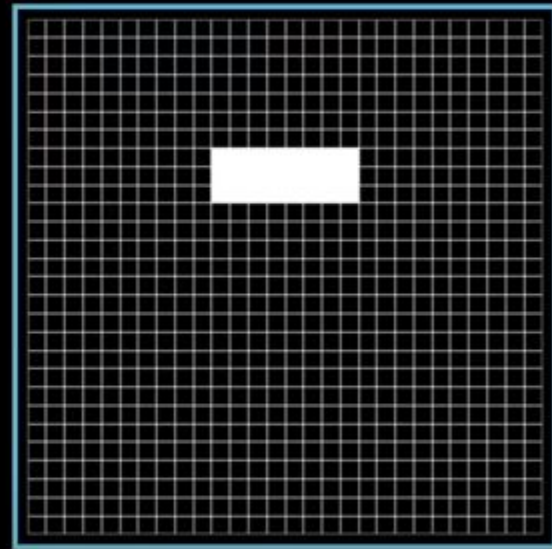
$p_5: 0.00$

$p_6: 0.00$

$p_7: 0.00$

$p_8: 0.00$

$\vdots$



Sigmoid



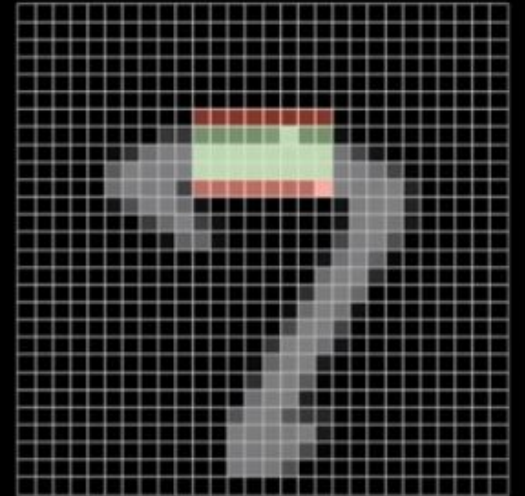
How positive is this?

$$\sigma(w_1 a_1 + w_2 a_2 + w_3 a_3 + \cdots + w_n a_n \boxed{-10})$$

“bias”

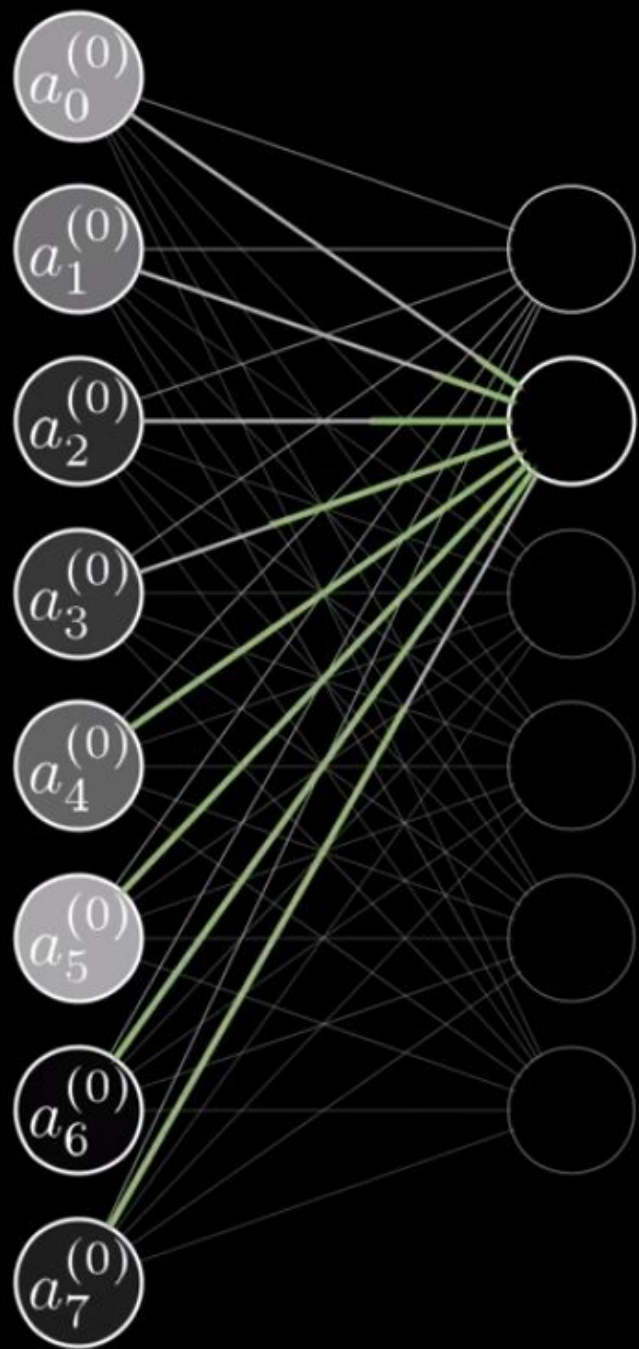
Only activate meaningfully  
when **weighted sum**  $> 10$

- Activations in one layer determine activations in the next layer.
- Pattern of activations causes some specific pattern in the next layer which causes patterns in the one after it which finally gives some pattern in the output layer.
- Brightest neuron in output layer is the choice of the system for what the image represents



784





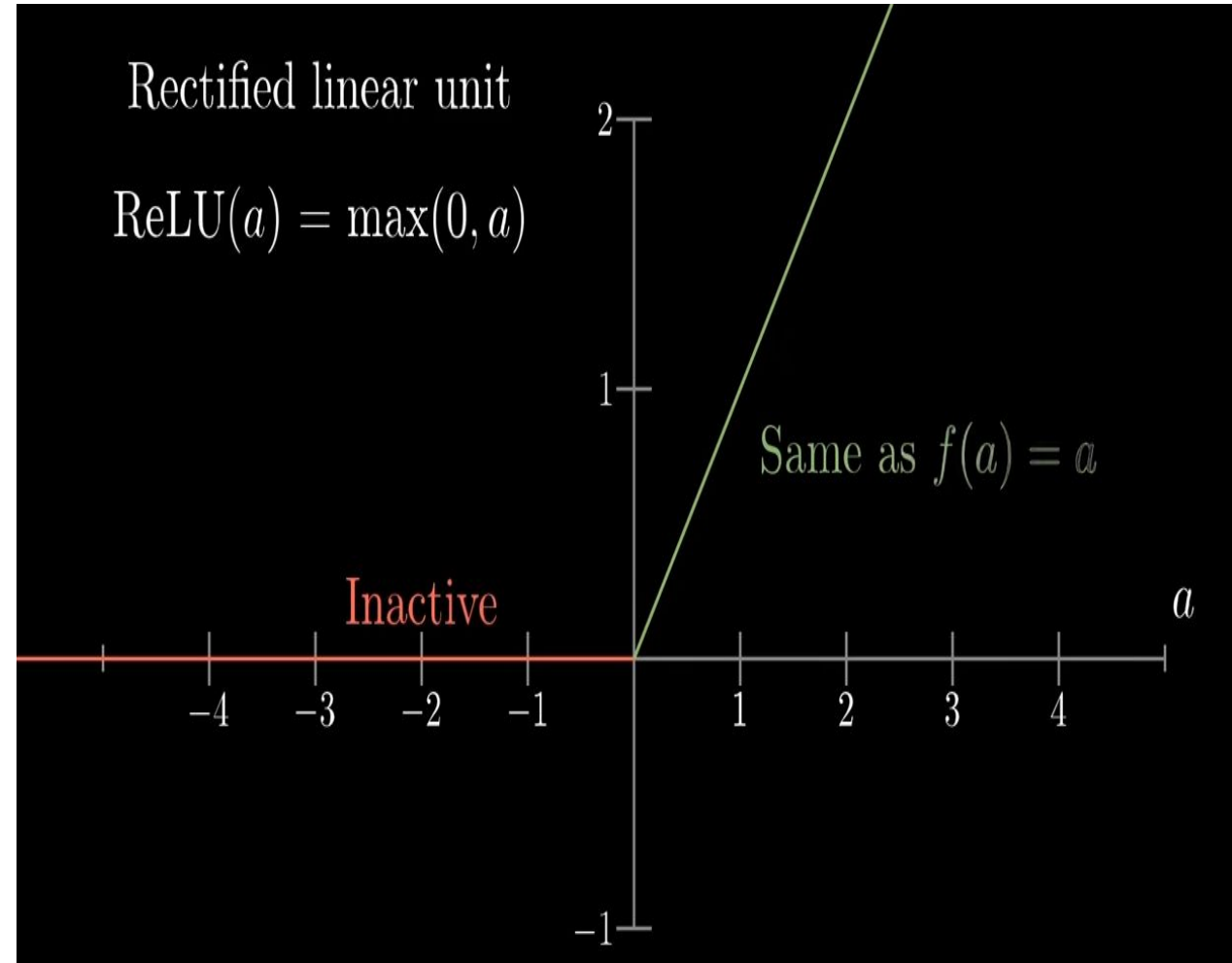
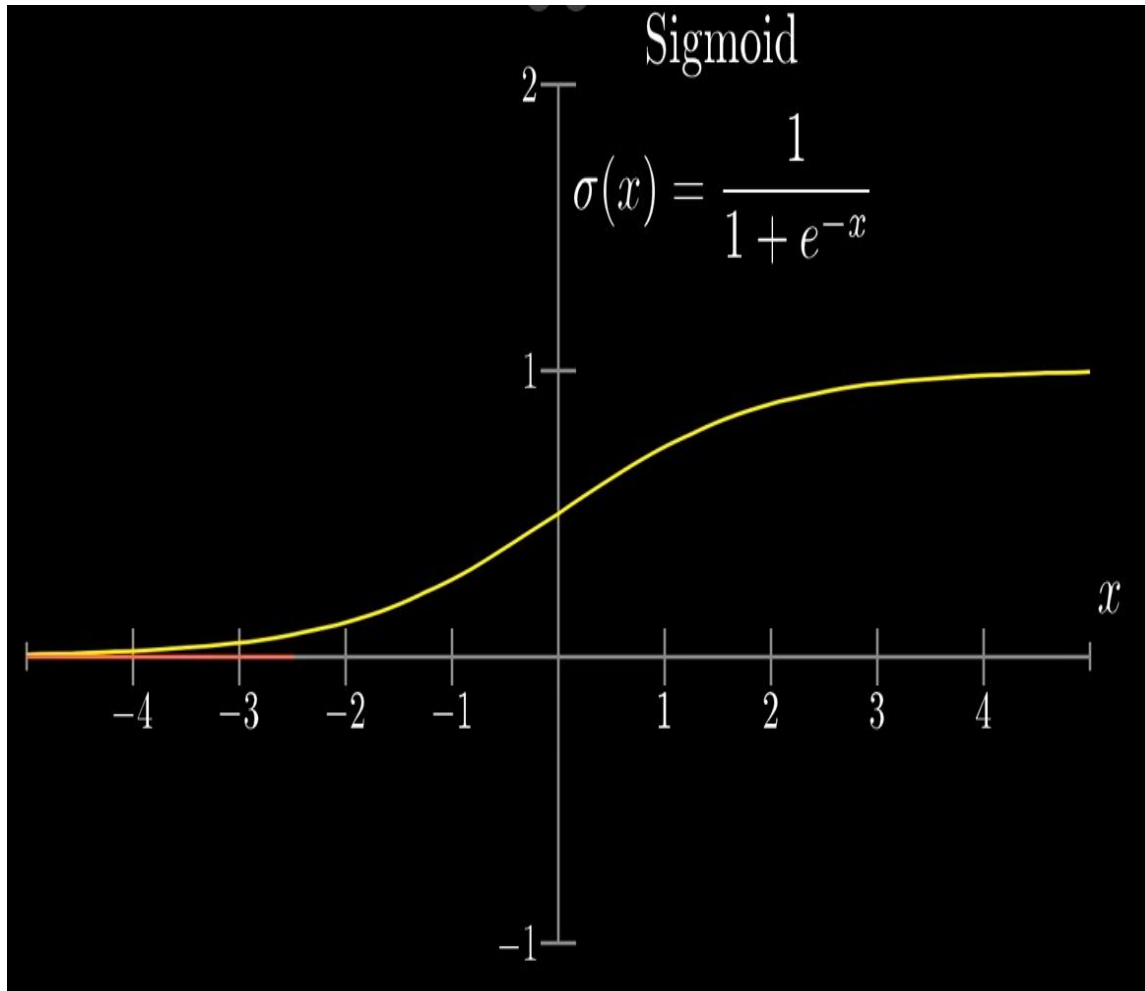
Sigmoid

$$a_0^{(1)} = \sigma \left( w_{0,0} a_0^{(0)} + w_{0,1} a_1^{(0)} + \dots + w_{0,n} a_n^{(0)} + b_0 \right)$$

$\uparrow$   
Bias

$$\begin{bmatrix} w_{0,0} & w_{0,1} & \dots & w_{0,n} \\ w_{1,0} & w_{1,1} & \dots & w_{1,n} \\ \vdots & \vdots & \ddots & \vdots \\ w_{k,0} & w_{k,1} & \dots & w_{k,n} \end{bmatrix}
 \begin{bmatrix} a_0^{(0)} \\ a_1^{(0)} \\ \vdots \\ a_n^{(0)} \end{bmatrix}
 =
 \begin{bmatrix} ? \\ ? \\ \vdots \\ ? \end{bmatrix}$$

# Sigmoid (or) ReLU – “squishification”



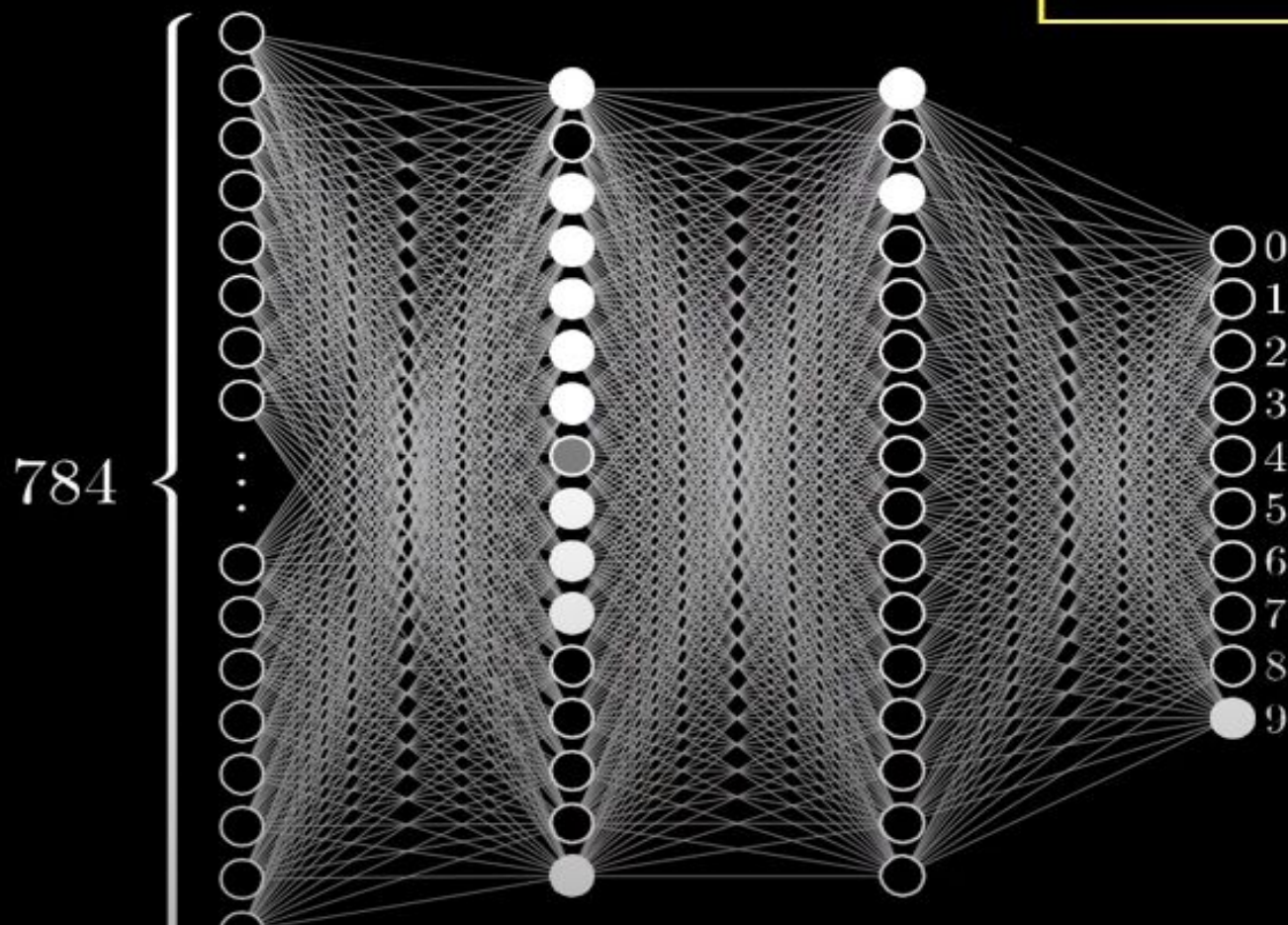




$784 \times 16 + 16 \times 16 + 16 \times 10$   
weights

$16 + 16 + 10$   
biases

13,002



Learning = Finding the  
right weights and biases



# DL: Neural Networks

- Show a whole bunch of images of handwritten numbers with the number it represents – training data
- Initialize weights, biases randomly[!]
- **Average cost of all training data.** How lousy is the network? 😊
- **Backpropagation is where the magic happens.** Propagate the adjustment of the weights and biases layer by layer to get to desired lower cost function.
  - **13k dimensions!**

What's the "cost" of this difference?

Cost of 3

Utter trash

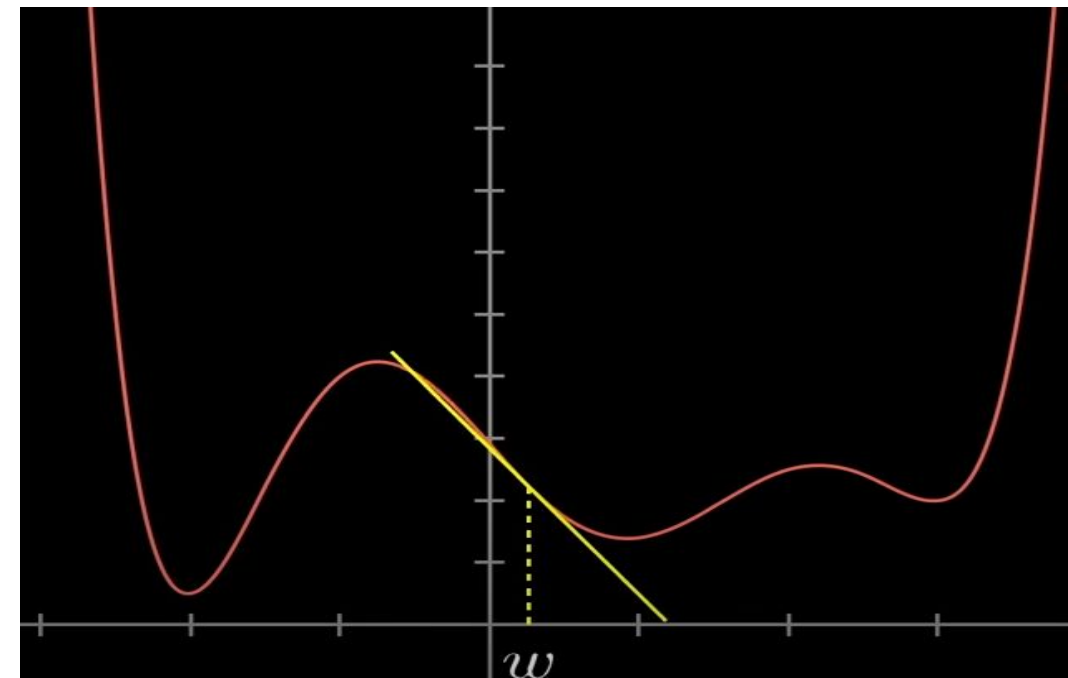
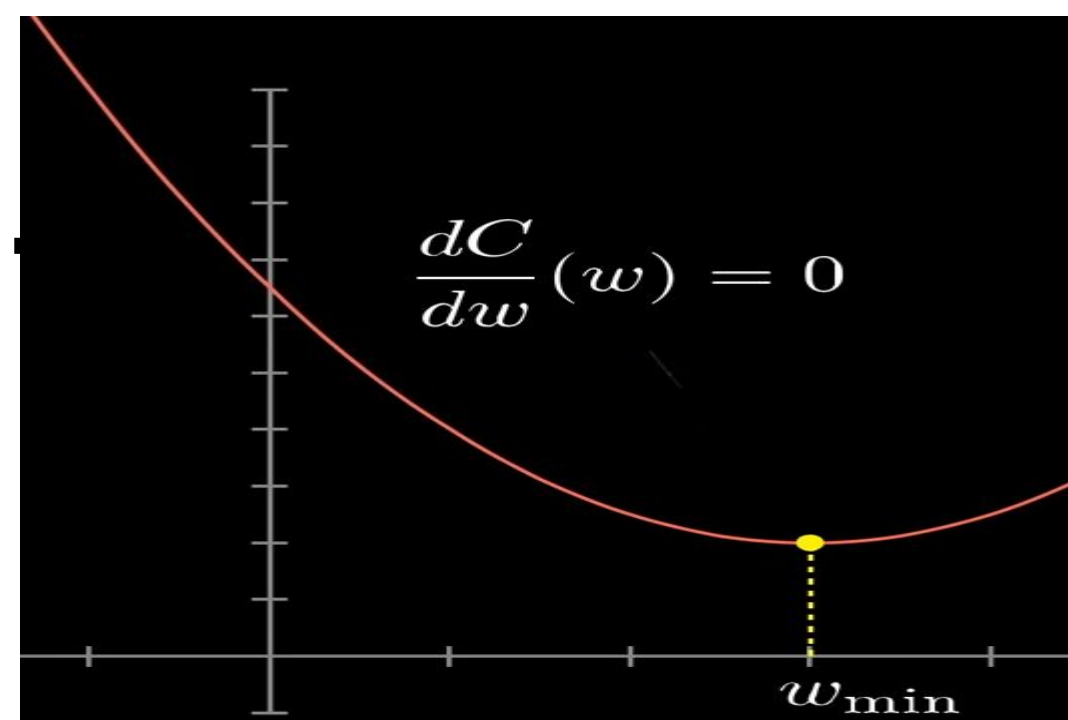
0 0  
1 1  
2 2  
3 3  
4 4  
5 5  
6 6  
7 7  
8 8  
9 9

$(0.43 - 0.00)^2 +$   
 $(0.28 - 0.00)^2 +$   
 $(0.19 - 0.00)^2 +$   
 $(0.88 - 1.00)^2 +$   
 $(0.72 - 0.00)^2 +$   
 $(0.01 - 0.00)^2 +$   
 $(0.64 - 0.00)^2 +$   
 $(0.86 - 0.00)^2 +$   
 $(0.99 - 0.00)^2 +$   
 $(0.63 - 0.00)^2$

Digit	Cost
0	$(0.43 - 0.00)^2$
1	$(0.28 - 0.00)^2$
2	$(0.19 - 0.00)^2$
3	$(0.88 - 1.00)^2$
4	$(0.72 - 0.00)^2$
5	$(0.01 - 0.00)^2$
6	$(0.64 - 0.00)^2$
7	$(0.86 - 0.00)^2$
8	$(0.99 - 0.00)^2$
9	$(0.63 - 0.00)^2$

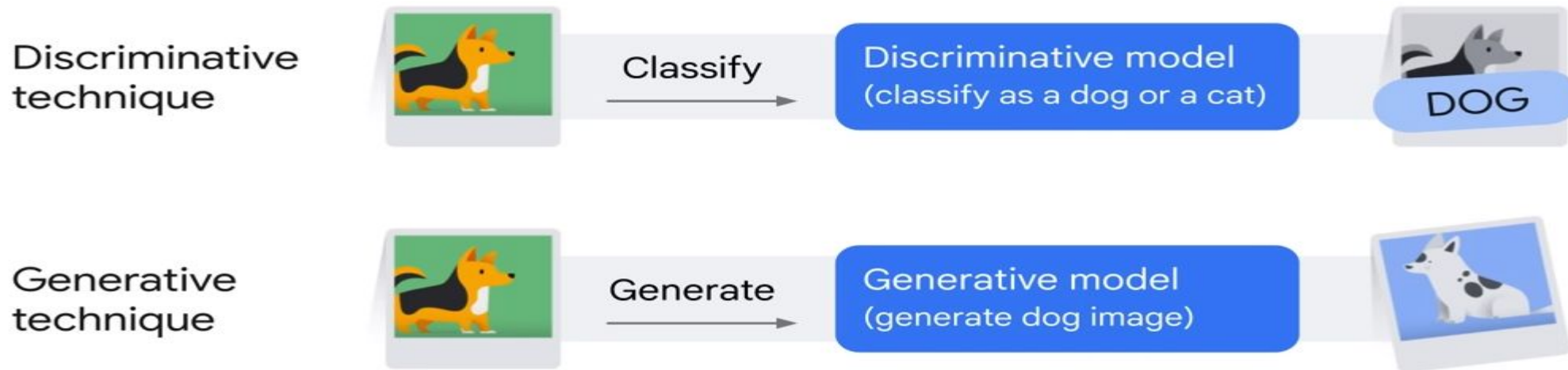
# DL: NN: Questions & more.

- Initialize weights randomly?
- Number of layers in NN?
- Each layer transforms data it receives
  - Example in image processing lower layers might identify edges, higher may identify digits or letters
- Calculate “cost”, Minimize cost function
  - Can use Gradient descent!



# Generative AI

- Can produce various types of text , audio, video – synthetic data
- Subset of Deep Learning
- GenAI model learns patterns in **unstructured data**
- Output is Natural Language, Speech/Text, Audio, Image
- Creates new content based on what it has learned from existing content.  
Statistical model used to predict what an expected response would be and thereby creates new content





# Generative AI: A walk down memory lane

## 2011: Computer Vision

- .....everything was shitty with AI (?!) .
- Every sub-field of AI was terribly different and lot of interesting ideas but hotch-potch and didn't work well
- Learning was essentially a bunch of rules, descriptions, bandages



# 2012

then this happened...



Steven Feng

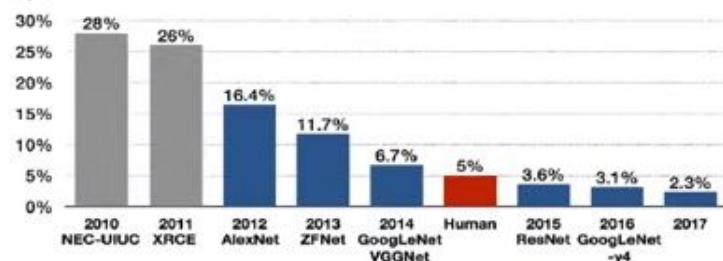
## ImageNet Classification with Deep Convolutional Neural Networks

Alex Krizhevsky  
University of Toronto  
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Geoffrey E. Hinton  
University of Toronto  
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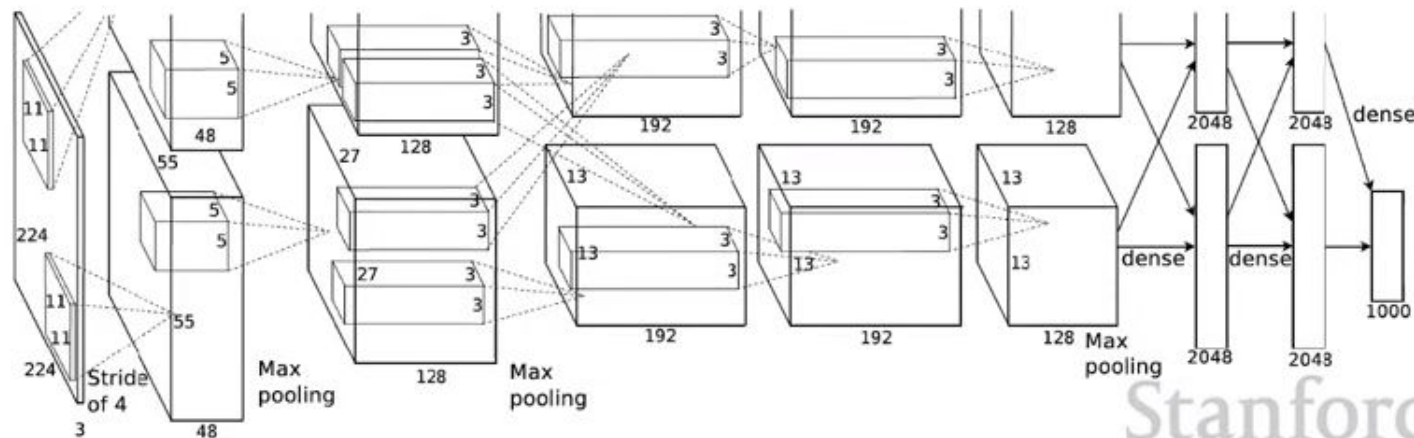
Top-5 error



## ImageNet Challenge

IMAGENET

- 1,000 object classes (categories).
- Images:
  - 1.2 M train
  - 100k test.



Stanford



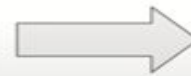
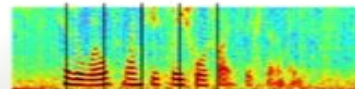
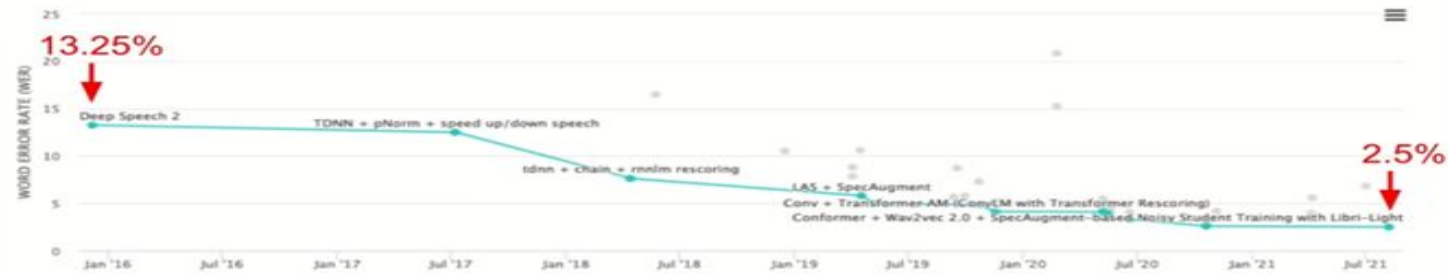
## Image Classification on ImageNet



"Leopard"

Source: <https://paperswithcode.com/sota/image-classification-on-imagenet>

## Speech Recognition on LibriSpeech test-other



"How cold is it outside?"

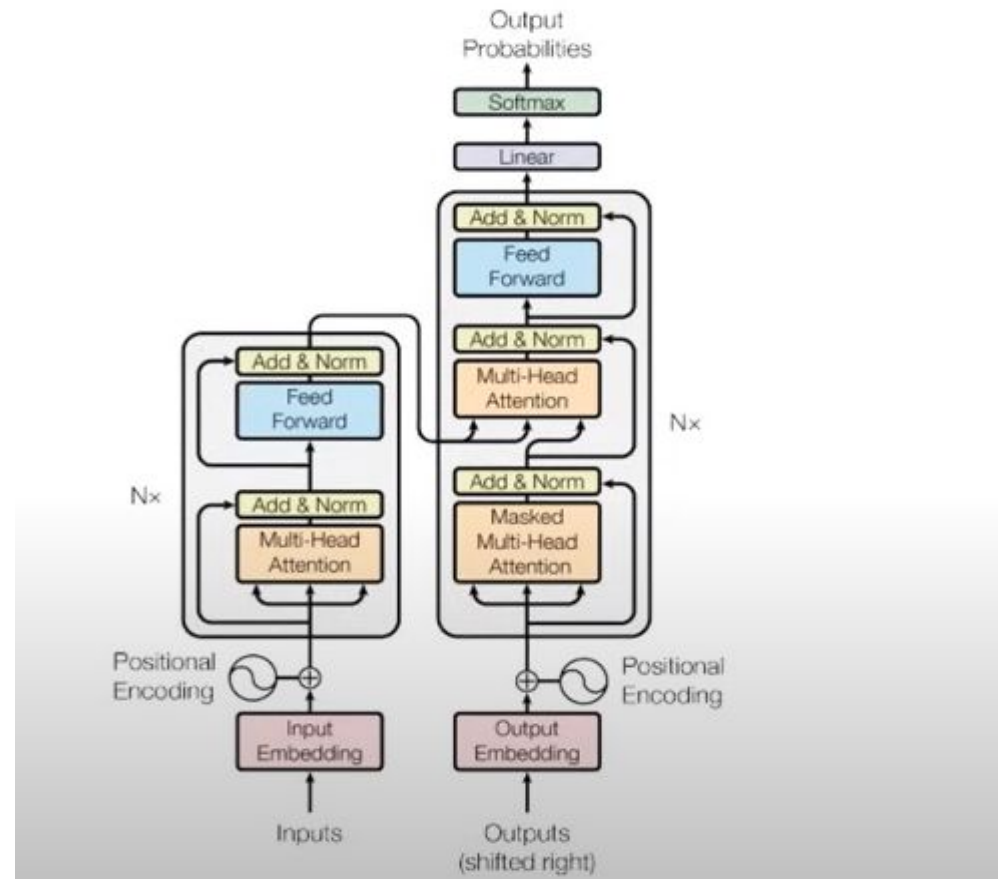
Source: <https://paperswithcode.com/sota/speech-recognition-on-librispeech-test-other>



# (2017) AI: Transformer architecture – Attention is all you need

## Attention Is All You Need

Ashish Vaswani, Noam Shazeer, Niki Parmar, Jakob Uszkoreit, Llion Jones, Aidan N. Gomez, Lukasz Kaiser, Illia Polosukhin





# Transformers : 3 main innovations

- **Positional encoding**

- “I love dogs”

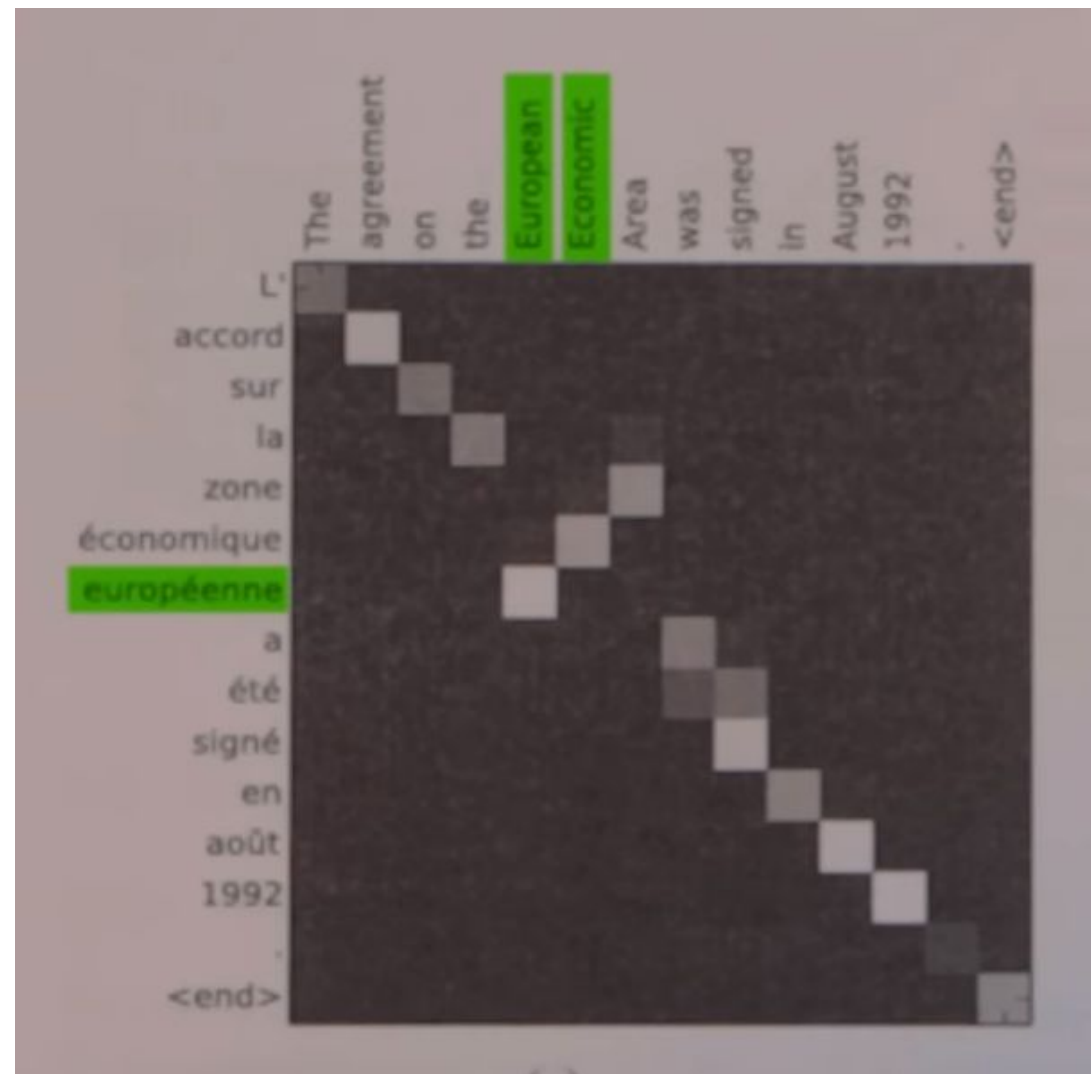
- 1 2 3

- Store information on word order in the data itself
  - Train the network on a lot of text data, it learns how to interpret positional encodings; learns importance of word order.

# Transformers : 3 main innovations

- **Attention**

- NN which allows the text model to look at every single word in the original sentence while making decision to translate to output sentence
- How does the model know which words it should be attending to? Learnt over time
- **“the European Economic Area” -> “la zone économique européenne”**



# Transformers : 3 main innovations

- **Self-Attention**

- Understand a word in the context of the words around it.

“Server, can I have a **cheque**?”  
“Looks like I just **crashed** the **server**”

- Model processes word *Server* in first line maybe attending to the word *cheque* which helps it disambiguate.

“I arrived at the bank after crossing the river”

- To determine *bank* refers to the shore of a river and not financial institution, the Transformer can learn to immediately attend to the word *river*

- Coreference resolution:

The animal didn't cross the street because **it** was too tired.  
L'animal n'a pas traversé la rue parce qu'**il** était trop fatigué.

The animal didn't cross the street because **it** was too wide.  
L'animal n'a pas traversé la rue parce qu'**elle** était trop large.

# Transformers : Revolutionary Scalable Architecture

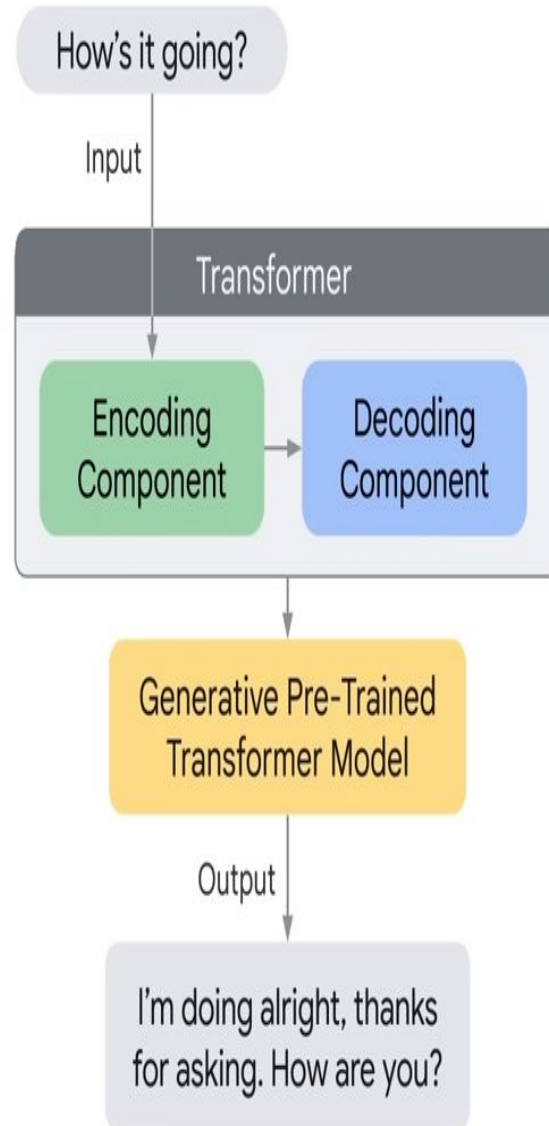
- **Do not process data in order** – Attention mechanism
- Tries to give context in each word in sequence
- **Run multiple sequences in parallel – speeds up training times tremendously**
- **Internals:**
  - **Consists of two parts: Encoder & Decoder**, Encoder works on the input sequence; Decoder works on the target output sequence
  - **Sequence to sequence learning** – takes a sequence of tokens in input and predict next word
  - Encoder generates encodings that define which part of the input sequence are relevant to each other and passes it to the next encoder layer
  - Decoder takes all of these encodings and uses their derived context
- **Semi-supervised learning**
  - Pre-trained in an unsupervised manner
  - Fine-tuned using supervised training

# Generative AI

## How it Works

### Pre-Training:

- Large amount of Data
- Billions of parameters
- Unsupervised learning



## Summary: how to train your ChatGPT



every  
~year

### Stage 1: Pretraining

1. Download ~10TB of text.
2. Get a cluster of ~6,000 GPUs.
3. Compress the text into a neural network, pay ~\$2M, wait ~12 days.
4. Obtain **base model**.

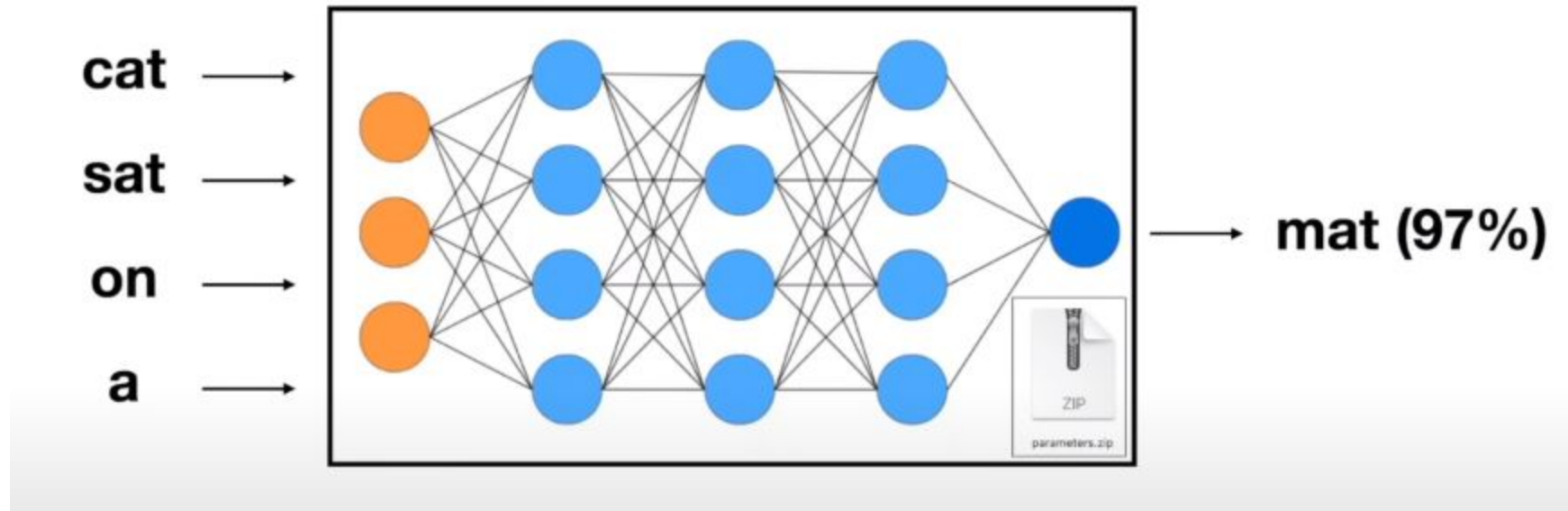


every  
~week

### Stage 2: Finetuning

1. Write labeling instructions
2. Hire people (or use [scale.ai](https://scale.ai)), collect 100K high quality ideal Q&A responses, and/or comparisons.
3. Finetune base model on this data, wait ~1 day.
4. Obtain **assistant model**.
5. Run a lot of evaluations.
6. Deploy.
7. Monitor, collect misbehaviors, go to step 1.

# LLM: Neural Network: Predict the next word in a sentence



Inference based on the training documents up documents mimicking the training dataset

## Point to ponder:

For next word prediction, model needs to learn a lot more info about the words and their context. **Is it similar to human thinking when we fully complete a sentence....**

# LLM: Large Language Models

- Chat-GPT (OpenAi)
  - Model architecture is not released. No access to the model
- LLama2
  - Open-source model (Meta/FB)
  - Parameters : 70billion. 2 bytes each parameter.  $70 \times 2 = 140\text{GB}$
  - Code: ~500 lines of C code [!!!!]

And many more...!

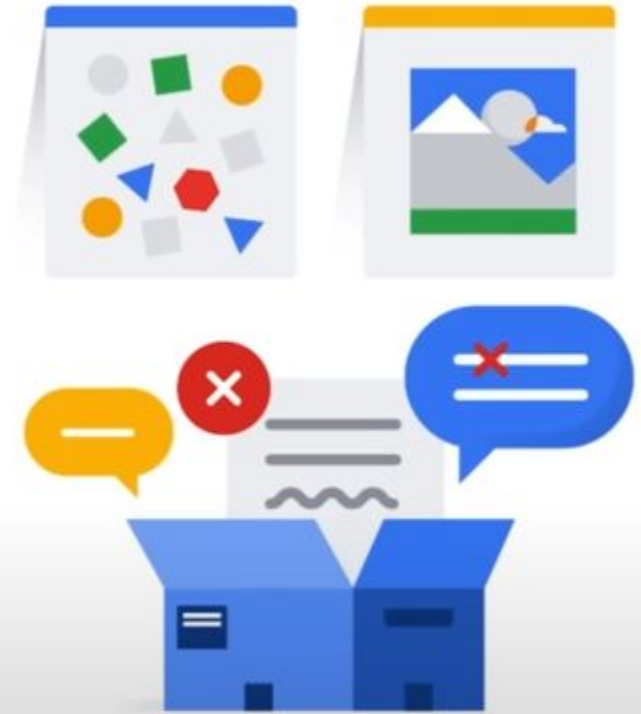
## Llama2:

- Chunk of internet ~10TB of text
- 6000 GPUs, 12 days, ~2million\$
- 140GB
- **Compress the internet : Andrej Karpathy**
  - **Lossy. Gestalt**

# Hallucinations

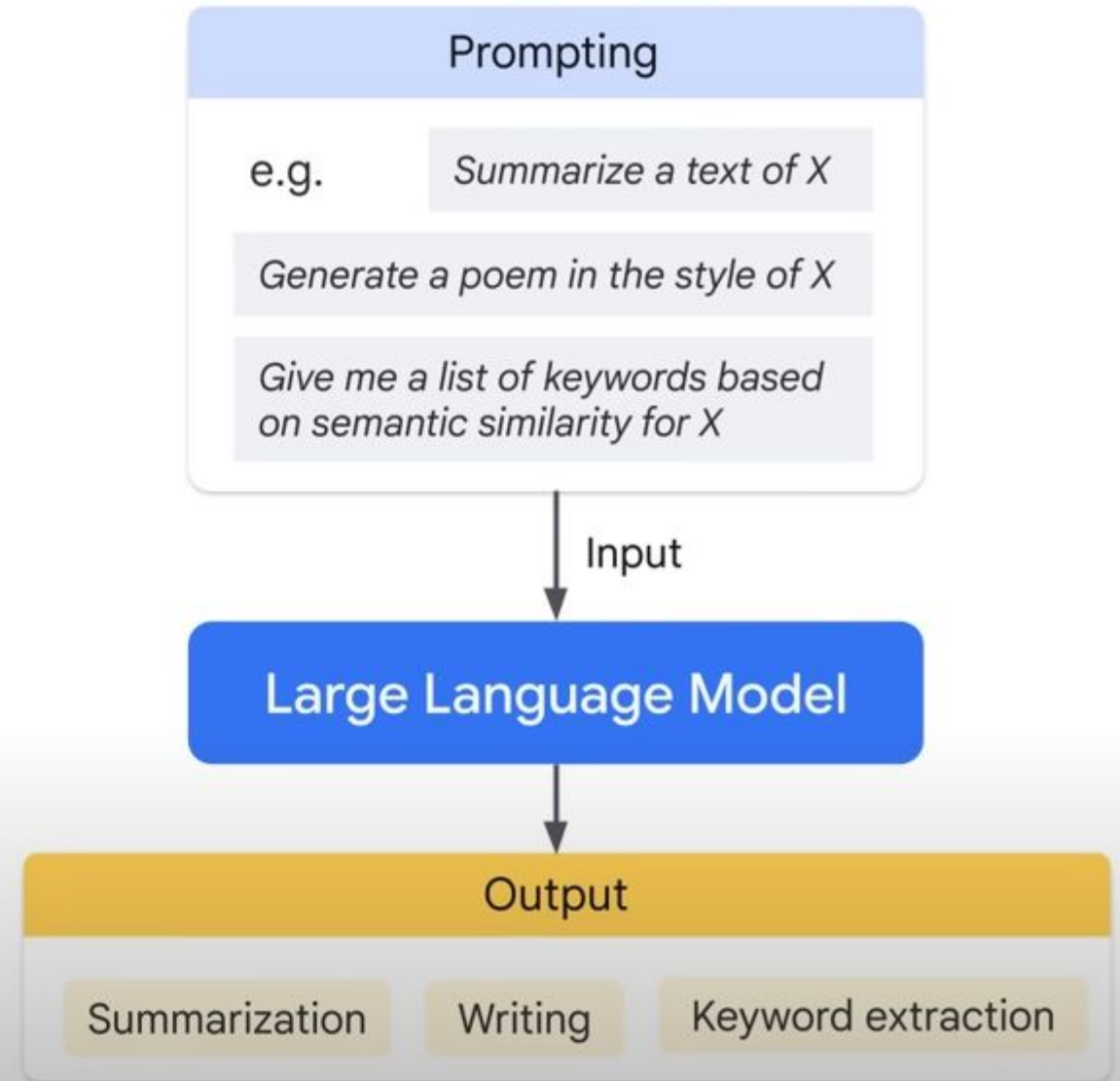
## Challenges

- ❗ The model is not trained on enough data
- ❗ The model is trained on noisy or dirty data
- ❗ The model is not given enough context
- ❗ The model is not given enough constraints



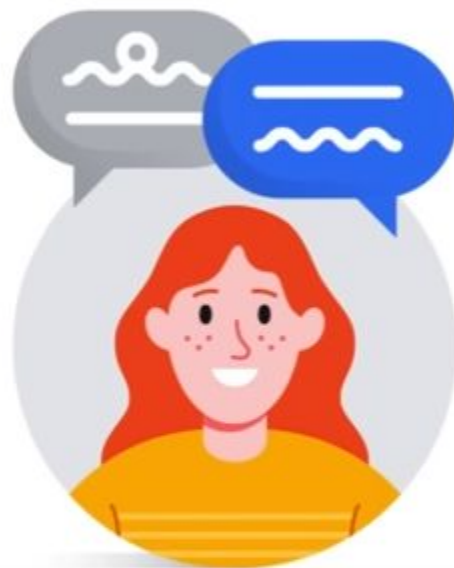


**Prompt Design:**  
the quality of the  
input **determines the**  
**quality of the output.**





Forming a Database



Inputting a Prompt



Generating content



# LLM Scoreboard: Proprietary vs Open

LMSYS [Chatbot Arena](#) is a crowdsourced open platform for LLM evals. We've collected over 200,000 human preference votes to rank LLMs with the Elo ranking system.

Arena Elo

Full Leaderboard

Total #models: 64. Total #votes: 299816. Last updated: Feb 15, 2024.

Contribute your vote 🗳 at [chat.lmsys.org](#)! Find more analysis in the [notebook](#).

Rank ▲	🤖 Model ▲	★ Arena Elo ▲	📊 95% CI ▲	🗳 Votes ▲	Organization ▲	License ▲	Knowledge Cutoff ▲
1	<a href="#">GPT-4-1106-preview</a>	1254	+5/-5	38745	OpenAI	Proprietary	2023/4
2	<a href="#">GPT-4-0125-preview</a>	1253	+10/-8	6308	OpenAI	Proprietary	2023/4
3	<a href="#">Bard...(Gemini..Pro)</a>	1218	+8/-7	10313	Google	Proprietary	Online
4	<a href="#">GPT-4-0314</a>	1191	+6/-6	20430	OpenAI	Proprietary	2021/9
5	<a href="#">GPT-4-0613</a>	1164	+5/-6	32941	OpenAI	Proprietary	2021/9
6	<a href="#">Mistral..Medium</a>	1152	+5/-7	17847	Mistral	Proprietary	Unknown
7	<a href="#">Claude-1</a>	1150	+7/-5	19017	Anthropic	Proprietary	Unknown
8	<a href="#">Qwen1.5-72B-Chat</a>	1147	+8/-8	5204	Alibaba	Qianwen LICENSE	2024/2
9	<a href="#">Claude-2.0</a>	1132	+6/-8	12753	Anthropic	Proprietary	Unknown
10	<a href="#">Gemini..Pro...(Dev..API)</a>	1122	+7/-7	9024	Google	Proprietary	2023/4
11	<a href="#">Claude-2.1</a>	1120	+6/-4	27723	Anthropic	Proprietary	Unknown
12	<a href="#">Mixtral-8x7b-Instruct-v0.1</a>	1120	+5/-6	18410	Mistral	Apache 2.0	2023/12
13	<a href="#">GPT-3.5-Turbo-0613</a>	1118	+5/-5	36704	OpenAI	Proprietary	2021/9
14	<a href="#">Gemini..Pro</a>	1115	+9/-9	6958	Google	Proprietary	2023/4
15	<a href="#">Yi-34B-Chat</a>	1111	+7/-8	7734	01 AI	Yi License	2023/6

# AGI: Ultimate goal....

- General intelligence
- Learning and reasoning
- Understanding and reasoning
- Consciousness and self-awareness!!!

# **Part 2**

## **Tax and AI**

#tacs

# The AI Tax Tool Landscape

January 2024

## AI Tax Research & analysis

blueJ

tod

TAX GPT



Taxy.io



THOMSON REUTERS

Bloomberg Tax



CPA Pilot  
AI Tax Assistant

taxHOL.ai  
By Traditional Tax, Inc.

## AI Tax Compliance Platform

## AI Tax Filing Software

AI.TaxAssist



Reconcile

april

TaxstudioAI

Intuit Assist

stripe



Chetu

Integra  
Global  
Solutions

## AI based Tax/VAT Reclaim

keeper



taxaroo

evollux

yokoy

Prosaic

VATAI

Heru

## AI Tools for Small Businesses

FLYFIN  
Fly through your Taxes

Bizway

## AI Personal income tax tools

VAT@reclaim

vatu

KEYNS

EY

K1X

taxly

CanTax

## AI Sales Tax Tools

Kintsugi

Avalara

TaxJar  
a stripe company

prophit

## AI Transfer Pricing Tools



ARKK



TAXMODEL

qu be  
TP  
transfer pricing  
quality benchmarks

Keep up with tacs on the go.

Download the App

Google Play

App Store



<https://tacs.community>

# Tax & AI Tools: A bird's-eye view

**Tax filing / Personal Tax powered by AI:** Simplifies complex process of tax preparation, connects to user's financial accounts and uses AI to analyze and generate accurate tax estimates customized to individual circumstances. Personalized strategies to maximize tax savings (identifying deductions, credits, and strategies specific to needs and goals)

**Tax Compliance helped by AI:** Compliance at lower cost for TP, R&D Tax Credits and Tax Provisions [Exactera]

**TP helped by AI:** Operational TP, TNMM and CPM Benchmarks enhanced by AI.

**VAT reclaim** processes streamlined by AI

**Sales tax life cycle** automated using AI entirely across all of sales channels — from calculations and nexus tracking to reporting and filing.

**Tax Planning and Forecasting:** AI algorithms can analyze historical tax data and financial information to provide insights for tax planning and forecasting. This can help businesses optimize their tax strategies and minimize tax liabilities within the bounds of the law.

# Tax & AI Tools: Tax Research tools

- Validate tax positions not just based on provisions but on judgments and their interpretation
- Leverage existing API's (chat-gpt).....updatation problem?
- Build own models for provisions and judgments?
- This is a hard problem and the cutting edge of Generative AI use in tax



# Tax & AI Tools: Tax Research tools – Example\*

## ***Gregory v. Helvering, 293 U.S. 465 (1935)***

For a business reorganization to affect tax liability, the reorganization must have economic substance, not be merely an attempt to reduce tax.

**2010 IRC. § 7701(o)** provides that a transaction shall be treated as having economic substance only if:

1. The transaction changes in a meaningful way (apart from Federal income tax effects) the taxpayer's economic position, and
2. The taxpayer has a substantial purpose (apart from Federal income tax effects) for entering into such transaction.

**Differing judgments on this principle:** Can AI understand and apply the relevant ratio?

1. *Austin v. Commissioner* (T.C., 2017) - Creation of multiple entities with sale and repurchase of stock
2. *Gregg v. Department of Revenue* (Or. Tax, 2017) - Two individuals' venture to be considered a business?
3. *DTDV, LLC v. Commissioner* (T.C., 2018) – Legitimacy of partnership interest

\* [BlueJ ML multifactorial analysis](#)

## Tax & AI Tools: Tax Research tools – Quantify Risk\*

- Consider a situation in which a taxpayer wishes to assign income he earned to a different but related taxpayer so that the income is taxed in the hands of the related taxpayer.
- Although it appears on paper that related taxpayer earned the income, the Courts will look to who controls the products, services, and funds at issue to identify true earner of the income, and tax it in the hands of that true earner.
- A tax practitioner faced with a similar fact pattern based on case laws **would be able to quantify the risk of an assignment of income** and communicate it to their client in the following ways:
  - that the likelihood that Dept or Courts will disallow the assignment of income with this particular proposed structure is > 94% based on a comprehensive analysis of 300+ rulings in which the assignment of income was an issue;
  - that in general only ~6% of the court decisions involving an assignment of income for services have found that the income was appropriately assigned to another taxpayer; and
  - that significant changes will need to be made to the business arrangement for it to come close to successfully assigning the income to the related corporation,

## Tax & AI Tools: Tax Research tools – Insights galore\*

- **Optimize Business/Tax strategy:** Build an ML model for worker classification which predicts in similar situation as the Petitioner would be 23% more likely to be classified as an independent contractor than they would have been before the change. *Example: Uber*
- **Uncover blind spots:** Deduct from taxable income money paid to shareholders as “management fees.” Required to show under S.162(a)(1), the fees paid to the shareholders were for ordinary and necessary services performed for company by or on behalf of the shareholders and were reasonable in their amounts. *ML Model suggests use of independent analysis for deductibility of fees for different services.*
- **Optimize litigation strategy:** Identify the significant factors in determining the case for the taxpayer to bring focus on the same and understand litigation changes.

# Tax & AI: Avengers assemble!

[IRS USA](#)

**[Sep 2023]**

*IRS to use AI to crack down on millionaires and large business partnerships that owe back taxes. The effort will focus on 1,600 taxpayers who have incomes above \$1 million that have more than \$250,000 in tax debt and large, complex business partnerships that have more than \$10 billion in assets that owe the government large sums.*

**[January 9, 2024]:** *“This tax filing season, the IRS is implementing the use of artificial intelligence (AI) and other improved technology with funding from the Inflation Reduction Act of 2022 in its audit processes to help compliance teams better detect tax avoidance issues in certain areas where audit coverage has declined, including large partnerships, large corporations, and employment tax returns.”*

# Tax & AI: Avengers assemble!

[Indian Tax Department](#) [Dec 2023]

*The technology used by the department is a mix of generative AI, advanced AI and machine learning, which is customised for the department and continuously updated every quarter.*

*"There is a specially designed, automated and enhanced artificial intelligence software program (AI) for scrutinising income tax returns (ITR)," the official said without giving details.*

*The department receives a lot of information about taxpayers in the form of data from banks, digital financial transaction , stock market and various other financial instruments attached with bank accounts and PANs.*

*With so much data available on a single platform, the department is using AI to build regression models to identify deviations and errors in tax filing and separate those deviations for further assessment.*

*In case a deviation is found, the data is further scrutinised by officials and if they suspect any shortfall in tax payment, an intimation is sent to the taxpayer.j*

# Tax & AI: Tax Assistants across the World

TA – COUNTRY	MAIN FUNCTIONALITIES
CRA -Canada	“CHARLIE” was launched in March 2020 to answer questions from taxpayers, especially to make tax returns. During the first year he answered 5 million questions.
ATO- Australia	“ALEX” was launched in 2016 to deal with queries related to taxes, property rights, income and deductions and filing of returns and taxes. He had 1.4 million conversations between July 1, 2020 and March 23, 2021.
HMRC – United Kingdom	“RUTH” answers simple questions and provides links to TA websites.
VERO – Finland	“VEROBOT” provides all the information related to business taxes and labor income in the country.
STA – Sweden	“SKATTI” answers questions about population registration and personal taxes 24 hours a day, all year round. It can understand questions within other areas of expertise and with link to the website. As of October 2019, Skatti has had more than 320,000 conversations, including about 800,000 questions.
REVENUE – Ireland	The virtual AV answers tax-related questions and can also be operated by voice.
FTS- Russia	“TAXIK” is integrated with the following online services: appointments with inspection; transportation tax calculator; insurance premium calculator; and property and territorial tax calculator.
STA- China	“ROBOTCHAT” provides answers about taxes and allows to direct more complicated questions to human experts.



**IRAS – Singapore**

“ASK JAMIE” helps with the presentation of income tax return to taxi drivers and entrepreneurs engaged in private car rental. It is available at all government agencies. In 5 years of launch it has already answered more than 15 million questions from citizens.

**OSS – Latvia**

“TOM” has been answering since January 2020 about opening hours and locations of offices, registering a company, how to use the electronic filing system, annual filing of tax returns and deductible expenses.

**EMTA- Estonia**

The Virtual Assistant was launched in 2020 helps to promote Estonia globally. It provides information from location to population, nature, taxes, etc. in multiple languages.

**SAT – Mexico**

“ORIENTASAT” launched in 2020, is aimed especially for individuals to fundamentally help in the preparation of the income tax return. It uses a knowledge base consisting of 1,149 standard answers and 17,776 question variants.

**AEAT – Spain**

VA VAT for the execution of the SII, foreign trade VAT, deadline calculator, census declaration, conduct of the self-assessment form 303 (VAT) for property lessors and other functionalities, for example, recently, access to real estate auctions. In 2020, there have been more than 1,100,000 queries resolved by the VA.

**SAT – Guatemala**

“RITA”, implemented in 2019, answers questions of the Vehicle Circulation Tax, the Unified Tax Registry, Online Electronic Invoice, Tax Solvency, Receipt of Complaints, customs concepts and the opening hours of the agencies. In 2020, it received 798 thousand inquiries, with 75% of satisfactory comments.



# Accounting & AI: Basic analysis is easy....



I am going to share with you the profit and loss account for this year and the previous year. I want you to act as my accountant and tell me whether there are any potential errors and also tell me whether there is anything about the numbers that gives you cause for concern. Here is the profit and loss account:

Share Prompt



2015    2016  
££   ££

Turnover    450,000    550,000

## Cost of sales

Opening stock	15,000	0
Purchases	179,000	206,500
Direct wages and salaries	126,000	160,000
Closing stock	0	0
	320,000	366,500
Gross profit	130,000	183,500

## Overheads

Wages and salaries	0	0
Directors' remuneration	15,000	20,000
Rent and rates	25,000	25,000
Advertising	10,000	12,000
Printing, postage and stationery	11,000	13,000
Telephone	3,000	3,500
Motor expenses	15,750	22,500
Sundries	4,500	5,000
Legal and professional	5,000	

Regenerate response

the following observations:

1. The company's turnover has increased from £450,000 in 2015 to £550,000 in 2016, which is a positive sign.
2. The cost of sales has increased from £320,000 in 2015 to £366,500 in 2016. This increase can be attributed to higher purchases and direct wages and salaries. However, the closing stock for both years is listed as zero, which could be a potential error. It is highly unlikely that the company did not have any stock at the end of the year.
3. The gross profit has increased from £130,000 in 2015 to £183,500 in 2016, which is a positive sign.
4. The overheads have increased from £114,500 in 2015 to £134,500 in 2016. This increase can be attributed to higher directors' remuneration, legal and professional fees, and motor expenses. The interest paid has decreased, which is a positive sign.
5. The other operating income has remained almost the same for both years.
6. The operating profit has increased from £15,750 in 2015 to £49,200 in 2016, which is a positive sign.
7. The other income (rent received) has remained the same for both years.
8. The net profit before tax has increased from £16,750 in 2015 to £50,200 in 2016, which is a significant increase.
9. The taxation has increased from £750 in 2015 to £4,000 in 2016, which is a significant increase. This increase could be due to a change in the tax laws or regulations.
10. The retained profit has increased from £16,000 in 2015 to £46,200 in 2016, which is a positive sign.

Overall, the profit and loss account

Regenerate response

th an increase in turnover, gross

# Accounting & AI: Forensic Accounting++

- Fraud detection and prevention
  - Real-time monitoring of transactions, flagging fraud/bogus ones
  - Anomaly detection – ML is excellent at this!
- Digital forensics
  - Tracing digital transactions
- Risk assessment & predictive modelling
  - Evaluate historical data to predict risks
  - Use of ML models to learn from analysis of previous frauds to identify new fraud schemes
- NLP for unstructured data:
  - Evaluate unstructured , multimodal data sources with the help of natural language processing (NLP), extract essential features / info and discover insights that are tough to glean manually.
- **AI/ML superpower: Data processing and pattern recognition at scale**

# Accounting & AI: Forensic Accounting++

An [artificial intelligence \(AI\)](#) system trained to detect signs of accounting manipulation has flagged 16 Kiwi companies at risk of collapse.

The AI, from [Singapore-based company Transparently.ai](#), detected the companies as part of a world-wide audit.

The AI works a bit like an automated forensic accountant and was trained on thousands of company accounts and designed to look for common signs that someone was cooking the books.

Transparently.ai chief executive Hamish Macalister, a Kiwi himself, said the 16 companies could be described as “deeply concerning” after they scored above 50% on the system’s manipulation risk score.

# Accounting & AI: Anomaly Detection in Accounts Payable

- Take a company with a large volume of txns in accounts payable department, responsible for vendor invoice processing and payments.
- **An AI-powered fraud detection system can analyze these transactions to identify anomalies**
- **Data Collection:** Collects data from various sources, including invoices, payment records, vendor contracts, historical txn data.
- **Feature Extraction:** It extracts relevant features from data, such as invoice amounts, payment dates, vendor information, and txn frequencies.
- **Model Training:** The system is trained using machine learning algorithms on a labelled dataset that includes examples of both fraudulent and legitimate transactions. The algorithms learn to recognize patterns and relationships in the data that distinguish between normal and fraudulent behaviour.
- **Anomaly Detection: Once trained, the AI system can analyse new transactions in real-time or periodically to detect anomalies. It flags transactions that deviate significantly from expected patterns or exhibit suspicious characteristics:**
  - ✓ **Invoice Amount Discrepancies:** Identifies invoices with unusually high/low amounts compared to historical avgs or similar transactions.
  - ✓ **Duplicate Invoices:** It flags invoices that appear to be duplicates/near-duplicates, which may indicate attempts to double-bill the company.
  - ✓ **Unusual Payment Patterns:** Detects payments to vendors outside of normal payment cycles or to new vendors with no prior txn history.
  - ✓ **Vendor Collusion:** By analyzing relationships between vendors and patterns of transactions, the system can identify potential collusion schemes where multiple vendors may be involved in fraudulent activities.
- **Alerts and Investigation:** Generates alerts for further investigation by the company's internal audit or fraud detection team.
- **Continuous Learning:** System continuously learns from new data and feedback from investigators, adapts algorithms over time, stays ahead.

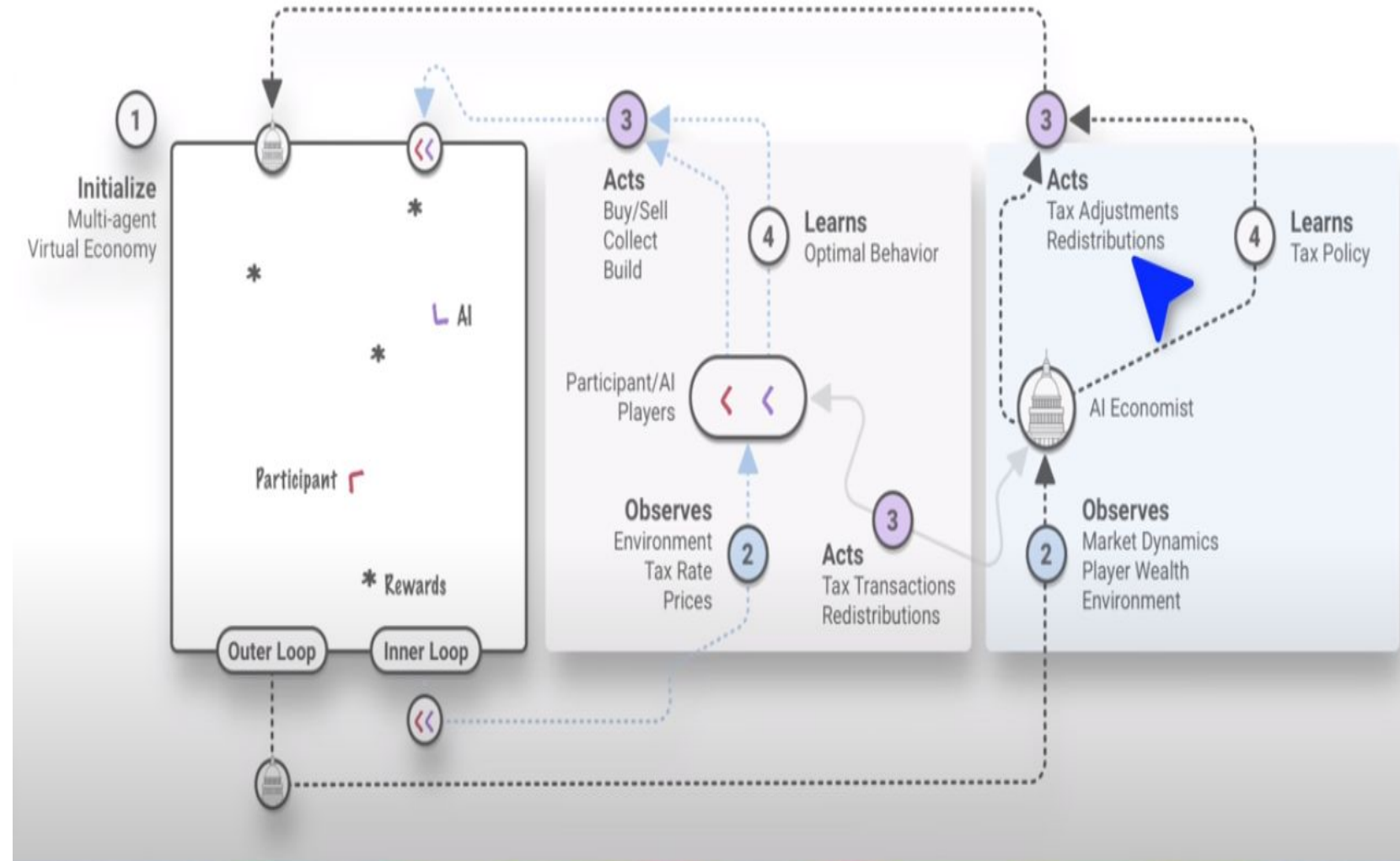
# Accounting & AI: Creditworthiness

- **Multiple Data Points:** Aggregate and analyze vast data from diverse sources, including credit reports, bank statements, transaction history, social media profiles, and alternative data sources.
- **Predictive Modeling:** ML can be used to build predictive models that assess the likelihood of a borrower defaulting on a loan or credit obligation. Analyze historical data to identify patterns and correlations that predict credit risk.
- **Alternative Credit Scoring:** AI enables incorporation of alternative data sources, such as utility bill payments, rental history, and even social media activity, into credit scoring models.
- **Real-Time Monitoring:** AI systems can continuously monitor borrowers' financial behavior and external factors that may impact their creditworthiness, such as changes in income, spending habits, or economic conditions.
- **Fraud Detection:** Analyze patterns and anomalies in application data, transaction history, and behavioral signals
- **Personalized Risk Assessment:** Use “Features” such as income stability, employment history, debt-to-income ratio, and asset ownership
- 100's of startups like ZestFinance, Kreditech, Lingxi, Cleo, Upstart



# Economics & AI : “The AI Economist: Improving Equality and Productivity with AI-Driven Tax Economist”

- Zhen & Trott  
2020, Harvard
  - Simulate policy X in virtual world and see if it works as promised
  - Workers are reinforcement learning agents
  - Learn to maximize well-being given the tax system



# Law & AI: A wider perspective

Broadly the areas of *legaltech* can be divided into:

1. **Research and Analysis** includes technology that enables the process of researching information necessary to support legal work and argument development.
2. **Document Processing/Contracting** is a wide category covering technology that helps lawyers draft complex legal documents, such as term sheets, contracts, briefs, and more.
3. **Litigation** : Software that governs matter management, conflict management, and e-discovery, assistive tools that support lawyers in the construction of arguments used in litigation.
4. **Legal Operations**:
  - Time and Billing is technology that captures, records all billable activity and expenses often with intuitive UI/UX, credit card capability, and ease of integration with accounting systems.
  - Legal Operations includes legal project management, calendaring/docketing, legal financial management, legal process automation

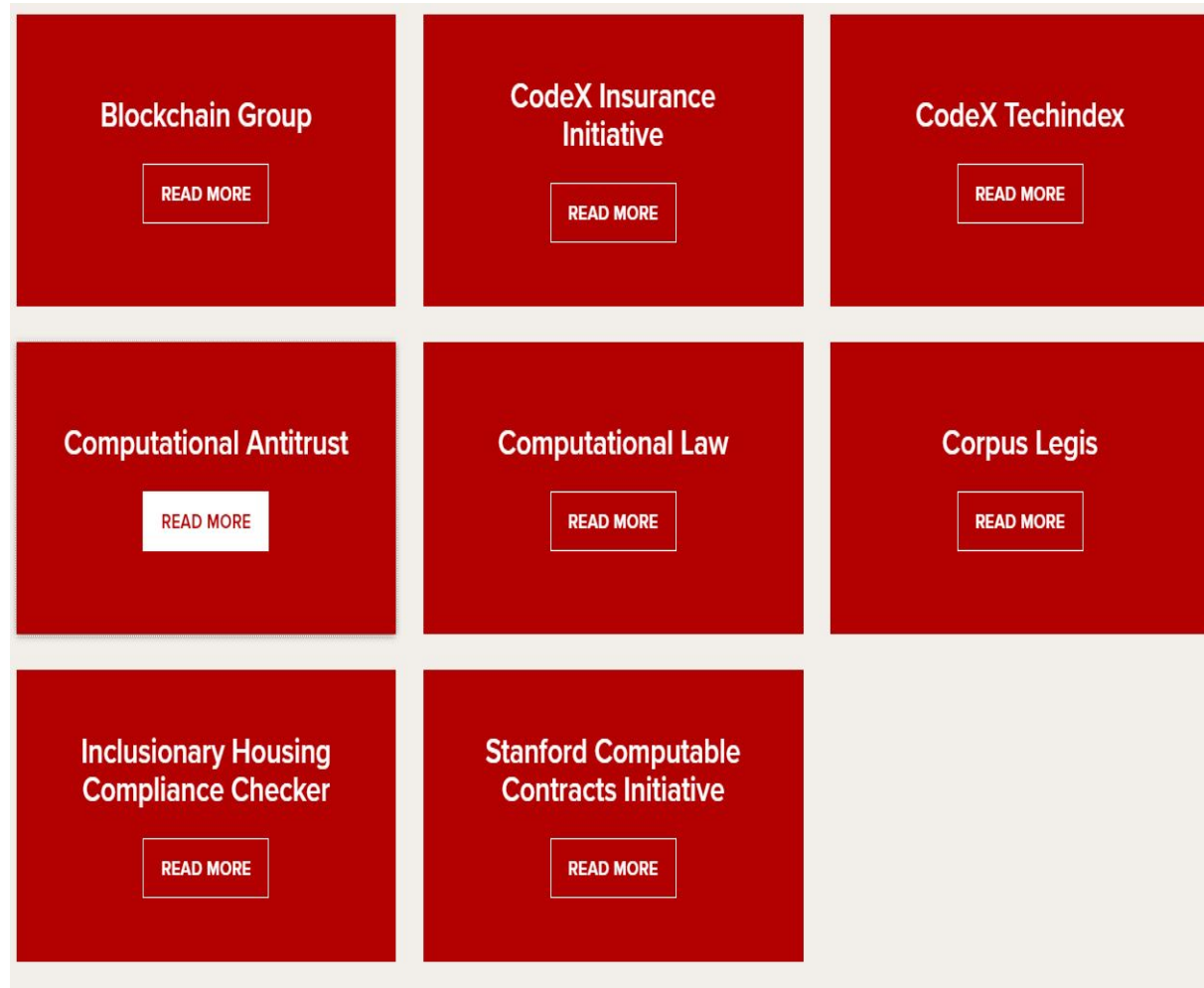
Perhaps most intractable was the fundamental problem that legal knowledge and practices are encased in natural language, specifically a subset (or even dialect) known as legal language.



# Law & AI: Legal Startups. What is your idea?

Name	What they do
Harvey (\$80M, Series B)	Harvey leverages large language models to both understand users' intent and to generate the correct output. Answers questions like, <i>"Tell me what the differences are between an employee and independent contractor in the Fourth Circuit,"</i> and <i>"Tell me if this clause in a lease is in violation of California law, and if so, rewrite it so it is no longer in violation."</i>
EvenUp (\$50M, Series B)	EvenUp's team of injury experts use AI to craft demand packages, freeing up time for your case managers and attorneys to focus on case strategy.
Masstro(\$43M, Series A),	Masstro aggregates, analyzes and reports total net worth; ingests structured and unstructured data including illiquid and liquid investments, liabilities and passion assets in every currency, in every region.
Darrow	Find your next big case. Every day, countless legal violations slip through the cracks. It's not humanly possible for lawyers to sift through endless amounts of data to detect every potential case. Darrow sifts through publicly available information, such as consumer complaints, administrative documents, SEC filings and more, and connects relevant data points to detect legal violations, predict their outcomes, and assess their financial impact, streamlining business development for litigation teams [!!!!]
Spellbook (\$27M, Series A),	Uses GPT-4 and other LLMs to review and suggest terms for contracts

# Law & AI: Cutting edge research – codex.Stanford.edu



*“Perhaps most intractable was the fundamental problem that legal knowledge and practices are encased in natural language, specifically a subset (or even dialect) known as legal language. ”*

Corpus Legis: tools for browsing regulations, scenario-based search, evaluating hypothetical scenarios, and **evaluating hypothetical changes to the regulations.**

Computational Law: enabling automation to achieve better usability and efficiency of tasks involving legal reasoning. Potential to bring legal understanding and tools to everyone in society, not just lawyers.

Computable Contracts: When **contract terms and conditions are represented in highly structured data**, computers can process them automatically with accuracy, reducing costs and other host of benefits.

Insurance Initiative: It is possible to **codify the terms of contracts in computable form**, to make it available to all parties in an online contract ecosystem and to use this ecosystem to provide all users with answers to real and hypothetical questions about the terms of these

# **Part 3: Walk the Talk**

# Walk the talk:

## My technical experiments with Tax & AI

- Various approaches:

1. Use **chatgpt-API** to answer Indian Income Tax queries
2. Use open source Llama2 70B to answer Indian Income Tax queries
3. Using **Keras & TensorFlow** to build my own model to answer Indian Income Tax queries [😞]
4. **GPT-4 Plugin** [😞]

## ChatGPT API

### Step 1. Background:

- Using **OpenAI Embeddings api**, we create embeddings for each Section of the IT Act and DTAA's and store them in a Chromadb collection.
- For each Section, we further generate a "key terms" list using **ChatGPT** and store them as metadata along with the Section embeddings document.

### Step 2. Query by user ("question")

- We create embeddings for the 'question' (query by the user) using the Embeddings API.
- Using the question's embeddings, we do a search on the Chromadb collection and get a list of matching Sections.
- Usually the db search result is not that great, the expected section may not come out as the top item and we have size constraints with Chat GPT API, so we need to find best matching sections from the list.
- We collect the section numbers, titles and "key terms" from the top 20 matching sections returned and send it to Chat GPT API along with the 'question' (query), to find out which sections in the list will have matching content to answer the question correctly. Based on the response from ChatGPT, we filter the db results list further.

*system\_prompt1 = "You are an Indian income tax expert who will help shortlist the most relevant sections to the given question"*

*system\_prompt2 = "You will be provided with a question on Indian income tax law along with the relevant sections. Answer the question as a tax law expert specializing in Indian Income Tax laws would do."*

*user\_prompt = (*

*"You have been provided a context (followed by CONTEXT:) and a question (followed by QUESTION:)\n"*

*"The context consists of a list of chapters and sections\n"*

*"Each context line contains six fields in the format as id|chapter\_id|chapter\_title|section\_id|section\_title|keywords\n"*

*"Analyse each section separately and find out which sections are most related to the given question\n"*

*"consider section and subsections as separate entities\n"*

*"Give more weight to section\_id, section\_title and technical words\n"*

*"Just output only the id of the matched rows comma separated (no explanation required).\n"*

*f"CONTEXT:\n {context}\n"*

*f"QUESTION: {question}"*

**Step 3. Finally we combine the document contents of the sections in our filtered list use it as 'context' for the 'question'. Using this 'context' we ask ChatGPT again to answer the question.**

*{"role": "system", "content": "You are an Indian income tax expert who answer a query. You will be provided with the query as well as the relevant sections pertaining to the query."},*

*{"role": "user", "content": "Answer the following income tax query:"*

*+ question*

*+ "by using the following text only:"*

*+ context},*

Possible optimization is to send the Chat-GPT API the question itself initially with some context of section and chapter ids and titles and have it write out the chromadb query itself.

#### **Whatsapp Bot Demo:**

- **Add +1 (415) 523-8886 to your contacts**
- **Type “join activity-flow”**

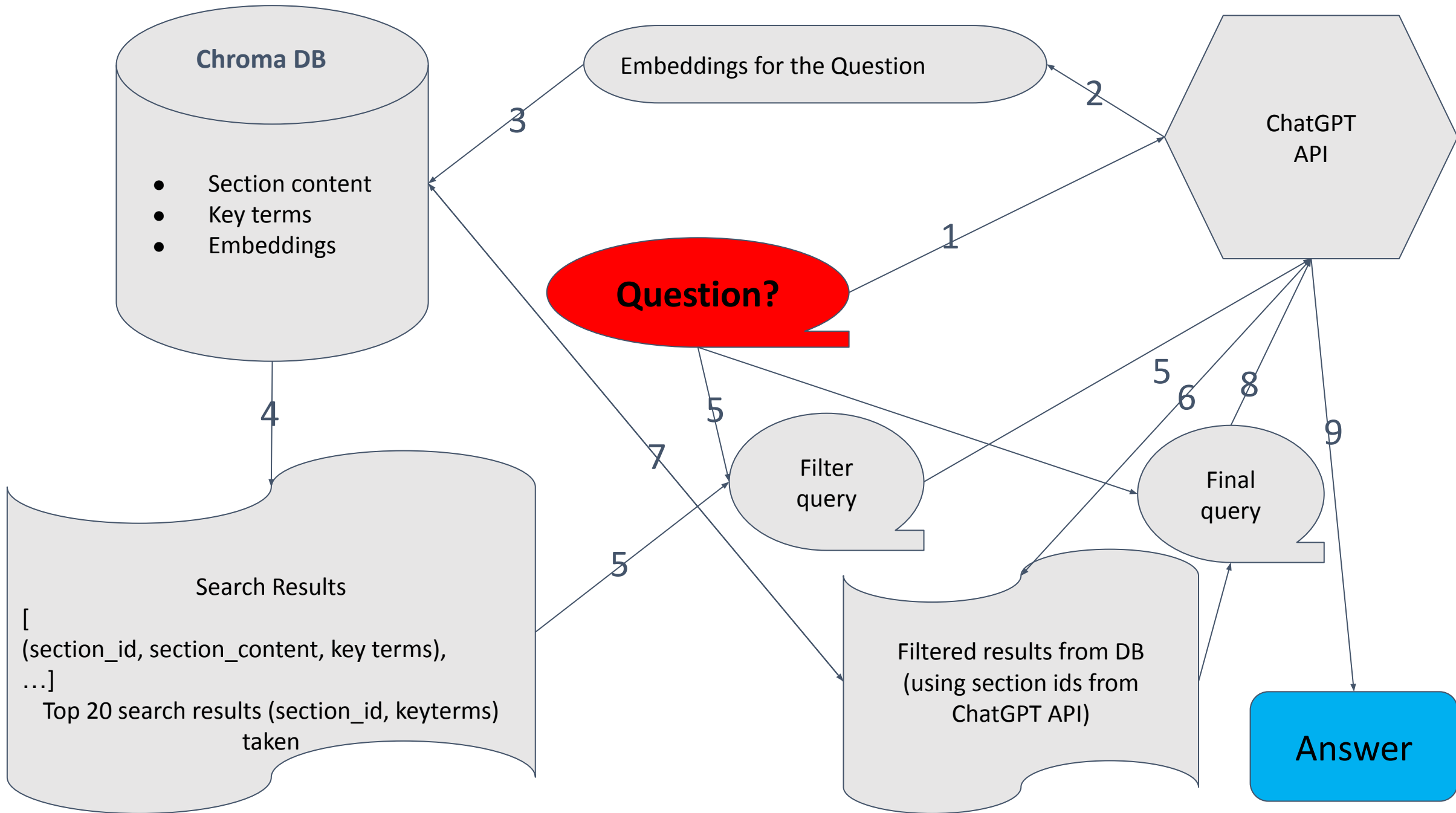
(Type hi or any message to get the menu...

Type back or menu to go back to the menu)

#### **Bottomline:**

Pros: Easy to use API, impressive results.

Cons: Expensive, Size-constraints are negatives.





## Using Chat-GPT internal knowledge

Cost for your query (\$0.0137 (~₹1.14) (tokens: 483))

Under Indian Income Tax laws, any payment made to a non-resident for professional services may attract provisions of Section 195 of the Income Tax Act, 1961. This section mandates the deduction of tax at source (TDS) on any sum chargeable under the provisions of the Act, which is payable to a non-resident, not being a company, or to a foreign company.

When you make a payment to a UK-based lawyer for legal advice, it is considered as a fee for professional or technical services. As such, it is subject to TDS under Section 195. The rate of TDS is determined by the Double Taxation Avoidance Agreement (DTAA) between India and the UK, if applicable. The DTAA aims to provide relief from double taxation on the same income.

11:37

Before deducting TDS, you must verify if the UK lawyer has a Permanent Establishment (PE) in India. If the lawyer has a PE, the income would be taxed at the corporate tax rate applicable in India after allowing for deductions on expenses. If the lawyer does not have a PE in India, the TDS rate prescribed under the DTAA shall apply, which is generally lower than the domestic tax rate.

If the DTAA does not provide specific relief or if no DTAA exists, you will need to deduct TDS at the rate specified in the Income Tax Act or the rate in force, which is generally higher.

Remember that before making the TDS deduction, you should also consider whether the lawyer provides a Tax Residency Certificate (TRC) and other necessary documents that help claim the DTAA benefits.

11:37

In any event, it is important to ensure compliance with the TDS provisions and file necessary forms, such as Form 15CA (required to be filed electronically by the person responsible for making the payment to a non-resident) and Form 15CB (a certificate from a chartered accountant certifying the details of the payment, the rate of TDS, DTAA benefits, etc.).

Since tax laws are subject to frequent changes and legal interpretations, it is advised to consult with a tax professional or chartered accountant to ensure full compliance with the applicable tax provisions before making such payments.

11:37

## Using my DB with Chat-GPT API

Cost for your query (\$0.0703 (~₹5.83) (tokens: 6377))

Based on the information provided in the text regarding the DTAA between India and the UK (specifically Article 15 on Independent Personal Services), here is the scenario relevant to your question about whether tax should be deducted on payments to a UK lawyer for legal advice:

According to the DTAA's Article 15, income derived by an individual resident of one contracting state (in this case, the UK) from the performance of professional services (like that of a lawyer) may be taxed in that state. It could also be taxed in the other contracting state (India) only if:

1. The individual is present in that other state (India in this case) for a period or periods aggregating to 90 days in the relevant fiscal year.
2. He has a fixed base regularly available to him in that other contracting state (India) for the purpose of performing his activities.

11:39

If neither of these conditions is met (the UK lawyer hasn't been in India for 90 days or more in the fiscal year and does not have a fixed base in India), the income of the lawyer for services rendered should only be taxable in the UK according to the DTAA.

Therefore, as long as the UK lawyer does not meet these conditions relevant to their presence or having a fixed base in India, you would not be required to deduct tax in India on payment for their legal advice. However, this is a general interpretation and specific cases can have complexities that might require a more detailed examination. For such situations, it is always recommended to consult a tax professional or the regulatory tax authority for clarification and compliance.

11:39



# Llama2 7B/70B

Llama 2 7B Chat - a Hugging Face project

huggingface.co/spaces/huggingface-projects/llama-2-7b-chat

Spaces huggingface-projects/llama-2-7b-chat like 417

Running on ZERO 2 %

Chatbot

What is the difference between depreciation and additional depreciation in the indian income tax act

In the Indian Income Tax Act, depreciation and additional depreciation are two separate concepts with distinct meanings and provisions. Here's a comparison of the two:

**Depreciation:**

- **Definitions:** Depreciation is defined under Section 2(13) of the ITA as the diminution in value of any asset owing to obsolescence, wear and tear, or any other reason.
- **Meaning:** Depreciation is the decrease in the value of an asset over its useful life due to various factors such as aging, deterioration, technological advancements, etc.
- **Allowable amount:** The allowable amount of depreciation is calculated using the prescribed formula, which takes into account the cost of the asset, its residual value, and the period of its usage.
- **Deduction:** Depreciation is allowed as a deduction from gross total income under Section 32 of the ITA.
- **Types:** There are two types of depreciation - (a) Straight line method, and (b) Written Down Value (WDV) method.

**Additional Depreciation:**

- **Definition:** Additional depreciation is defined under Section 32A of the ITA as an extra depreciation allowance provided to certain assesseees for certain assets.
- **Meaning:** Additional depreciation is granted to encourage investments in specific sectors

## Additional Depreciation:

- **Definition:** Additional depreciation is defined under Section 32A of the ITA as an extra depreciation allowance provided to certain assesseees for certain assets.
- **Meaning:** Additional depreciation is granted to encourage investments in specific sectors such as infrastructure, renewable energy, and affordable housing.
- **Allowable amount:** The allowable amount of additional depreciation is 10% or 15% of the cost of acquisition of the asset, whichever is lower, subject to certain conditions.
- **Deduction:** Additional depreciation is allowed as a deduction from gross total income under Section 32A of the ITA.
- **Applicability:** Additional depreciation is available only to those assesseees who are eligible for depreciation under Section 32 of the ITA and meet the conditions specified in Section 32A.

## Key differences between Depreciation and Additional Depreciation:

1. **Definition:** While depreciation is defined as the diminution in value of an asset, additional depreciation is specifically meant to provide an extra depreciation allowance for certain assets.
2. **Sectors:** Depreciation is generally allowed for all types of assets, while additional depreciation is restricted to specific sectors such as infrastructure, renewable energy, and affordable housing.
3. **Rate of depreciation:** The rate of depreciation for additional depreciation is either 10% or 15% of the cost of acquisition, whichever is lower, while the rate of depreciation for straight line method and WDV method varies.
4. **Period of deduction:** Depreciation is deductible over the useful life of the asset, while additional depreciation is deductible over a period of five consecutive assessment years.
5. **Eligibility:** Only those assesseees who are eligible for depreciation under Section 32 of the ITA are entitled to additional depreciation under Section 32A.

In conclusion, while depreciation is a general concept allowing deductions for the decreased value of assets, additional depreciation is a specific provision aimed at encouraging investments in select sectors and providing an extra depreciation allowance to eligible assesseees.

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