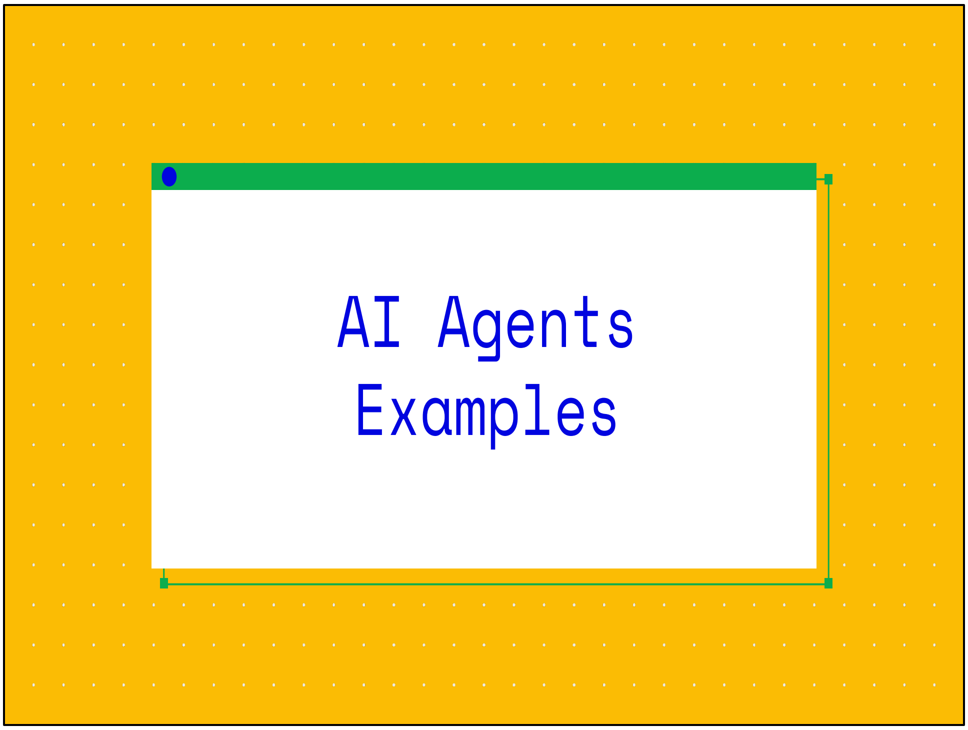
Intelligent Agents

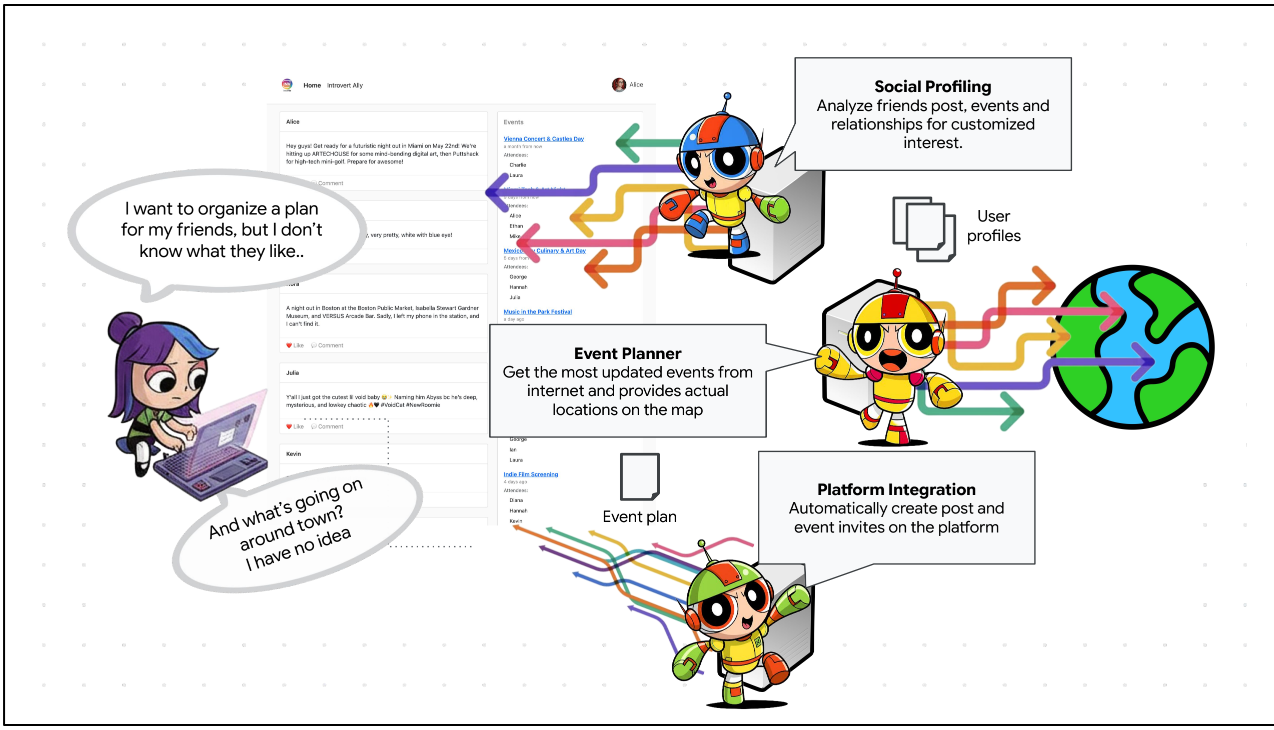
Agenda:

1. AI Agents Example
2. AI
3. ML
4. NN
5. DL
6. GenAI
7. Questions

Here is a quick overview of what we'll cover today. We'll start with some examples of AI agents, then work our way through the concepts of Artificial Intelligence (AI), Machine Learning (ML), Neural Networks (NN), and Deep Learning (DL), before touching on Generative AI (GenAI). We'll conclude with a Q&A session.



We're now moving into the first part of our agenda. We'll look at some real-world examples to understand what an AI agent is and what it can do.



In this example, we have a social network web app that aims to simplify its members' creation of new events using Intelligent Agents.

1. **Orchestrator Agent** (not shown in the diagram)
2. **Social Profiling Agent**
3. **Event Planning Agent**
4. **Platform Integration**

Orchestrator Agent:

- This agent acts as the central coordinator.
- It receives the initial user request from the web app, understands the overall goal (e.g., "plan an event for me and my friends"), and then delegates specific tasks to the appropriate specialized sub-agents in a logical sequence.
- It manages the flow of information between sub-agents and ensures the final result is delivered back to the user.

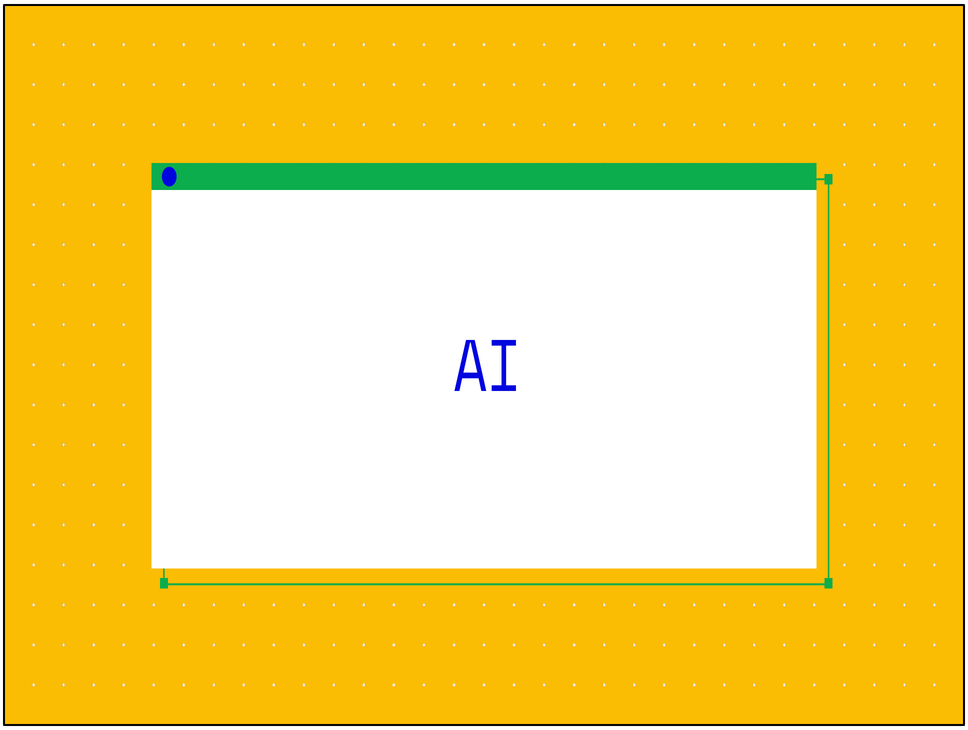
Social Profiling Agent:

- This agent employs social listening techniques to analyze

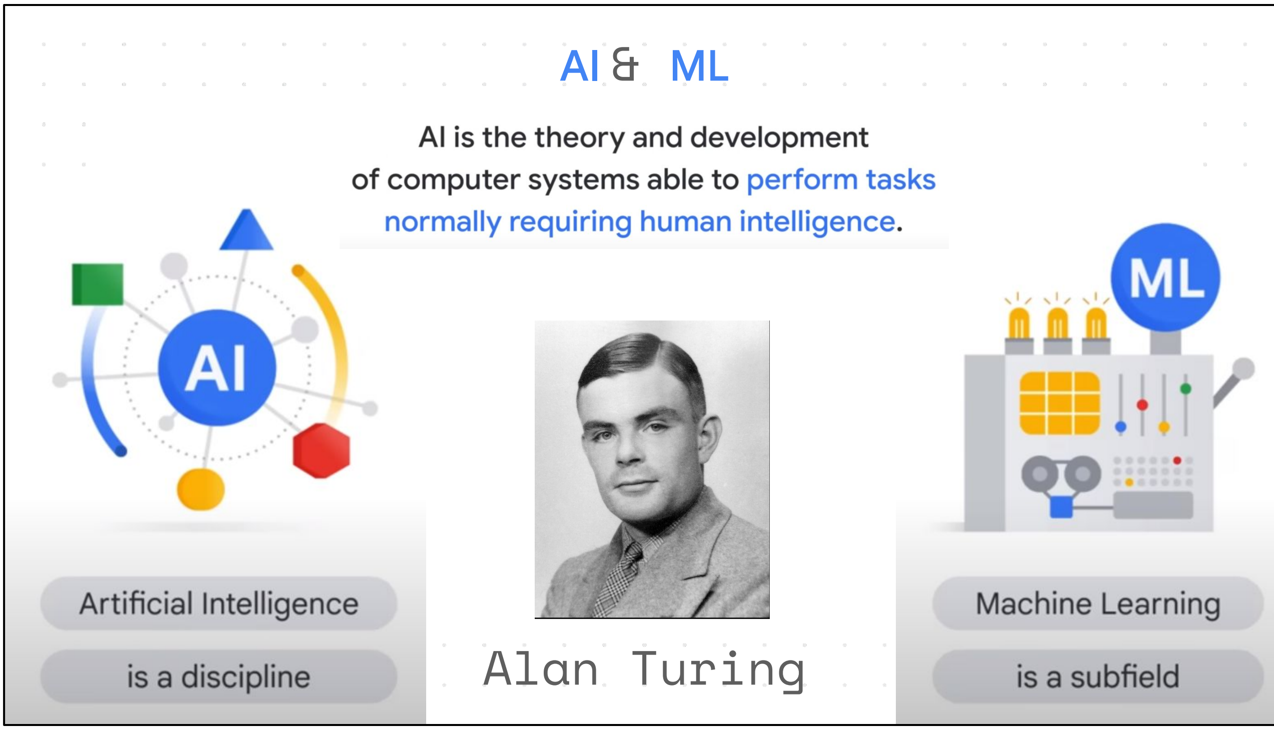
    - user connections,
    - interactions, and
    - potentially broader public trends related to the user's preferences.
- Its purpose is to identify shared interests and suitable activity characteristics (e.g., preferences for quieter gatherings, specific hobbies).

Event Planning Agent:
- Using the insights from the Social Profiling Agent, this sub-agent searches online resources for specific events, venues, or ideas that align with the identified criteria (such as location, interests).

Platform Integration Agent:
- This agent takes the finalized plan from the Event Planning Agent.
- Its key function is to interact directly with the web app.
- So this sub-agent has the specific capability to draft an event suggestion and create a post outlining the plan.



We are now moving into a fundamental topic: Artificial Intelligence (AI).



More about Alan Turing: https://www.britannica.com/biography/Alan-Turing

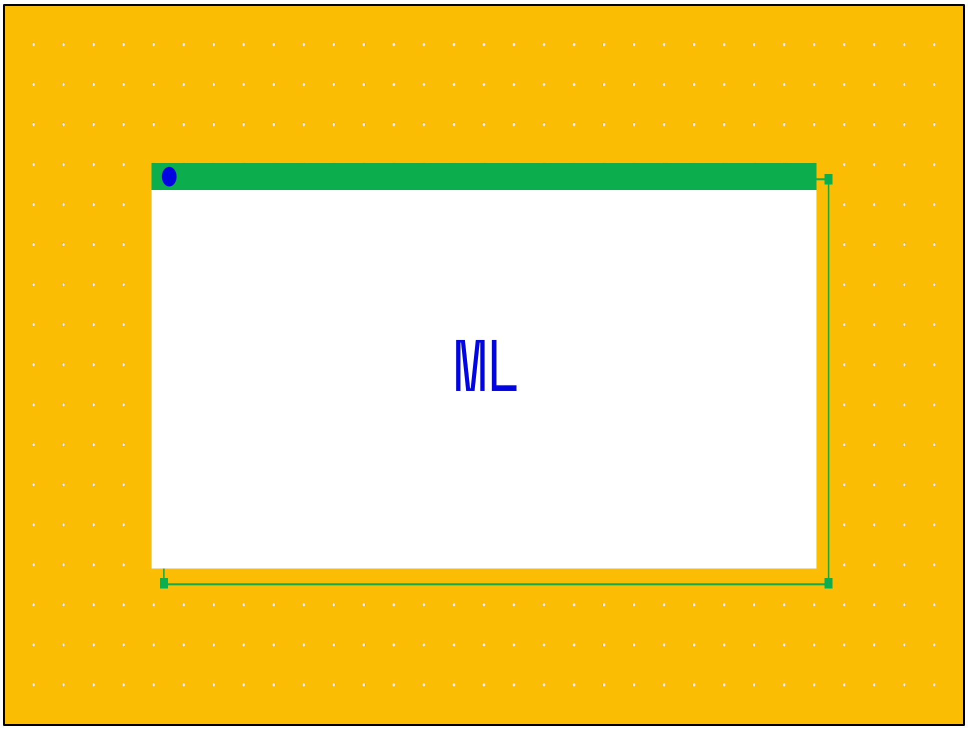
AI

- AI is the theory and development of computer systems able to perform tasks normally requiring **human intelligence**.
- A discipline, like physics for example.
- A branch of computer science that deals with the creation of **intelligence agents**, which are systems that can reason, and learn, and act autonomously.
- AI has to do with the theory and methods to build machines that think and act like humans.
- Old subfields: Expert Systems, Symbolic Reasoning, Neural Networks

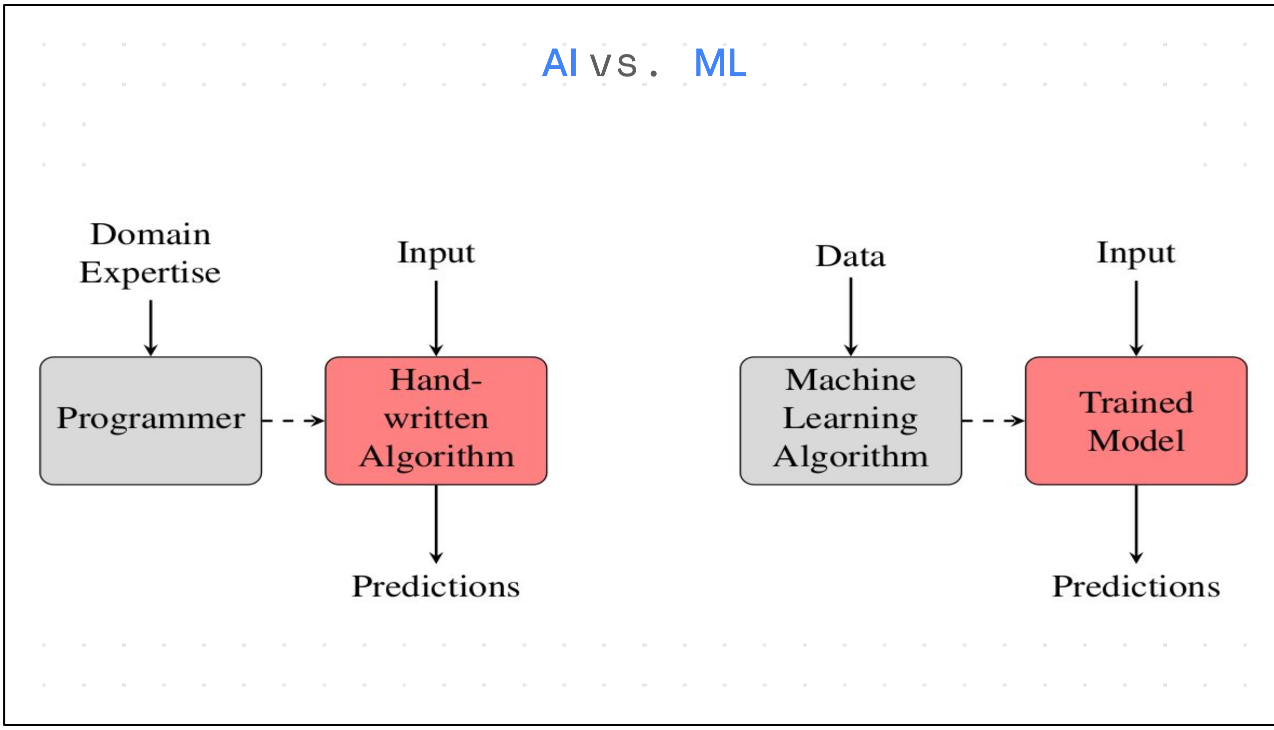
ML

- A program or system that trains a model from input data.
    - That trained model can make useful predictions from new or never before seen data drawn from the same one used to train the model.

- A subfield of AI.
- **ML** gives computers the ability to learn from data without being explicitly programmed.
- The core idea is to train a model on a large dataset so that it can identify patterns and make predictions or decisions on new data.



We are now going to focus on Machine Learning (ML).



We break AI down into two main types:

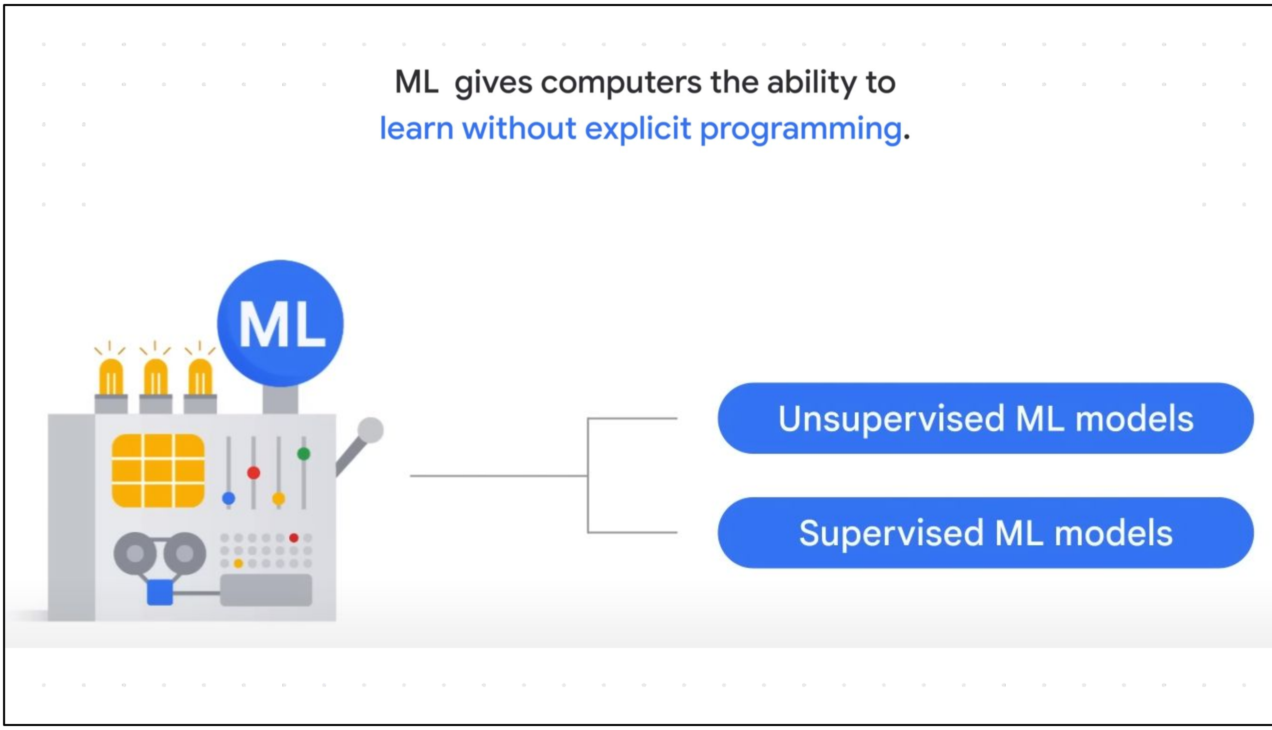
1. **Traditional AI**: This includes rule-based systems, expert systems, etc.
2. **Machine Learning (ML)**: This is the modern approach where the model learns from data without being explicitly programmed.

AI & ML

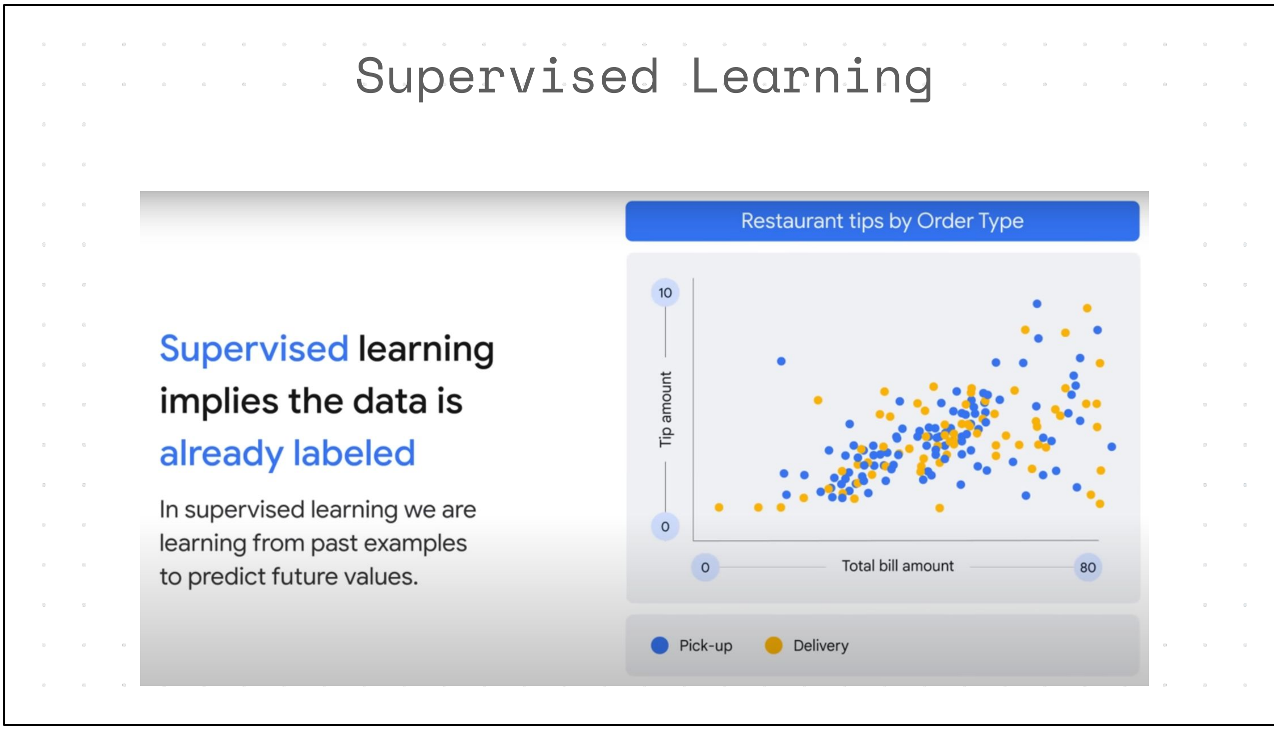
We, as humans, have only managed to reach AI through ML

AI & ML

Now, ML is the dominant subfield of AI

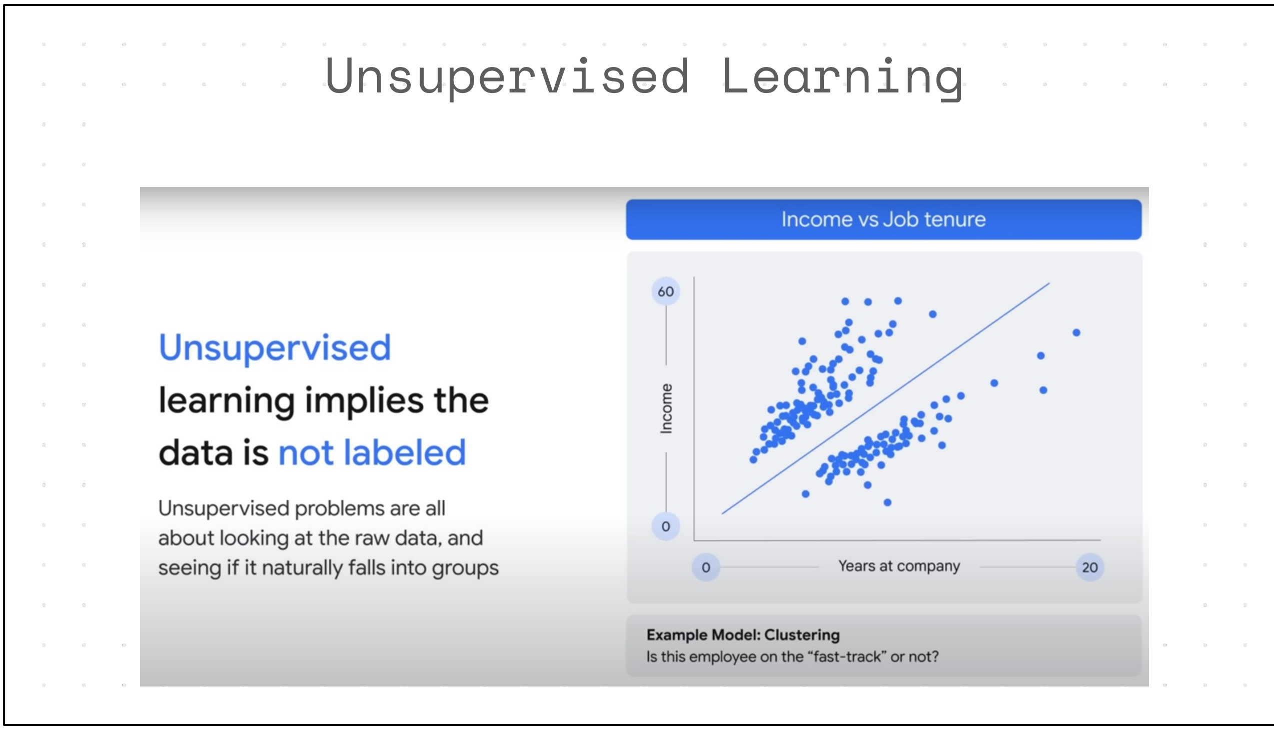


- ML gives the computer the ability to learn without explicit programming.
- Two of the most common classes of machine learning models are unsupervised and supervised ML models.



Supervised ML

- We have labels.
  - Labeled data is data that comes with a tag like a name, a type, or a number.
- The model tries to reduce this error until the predicted and actual values are closer together.
  - This is a classic optimization problem.



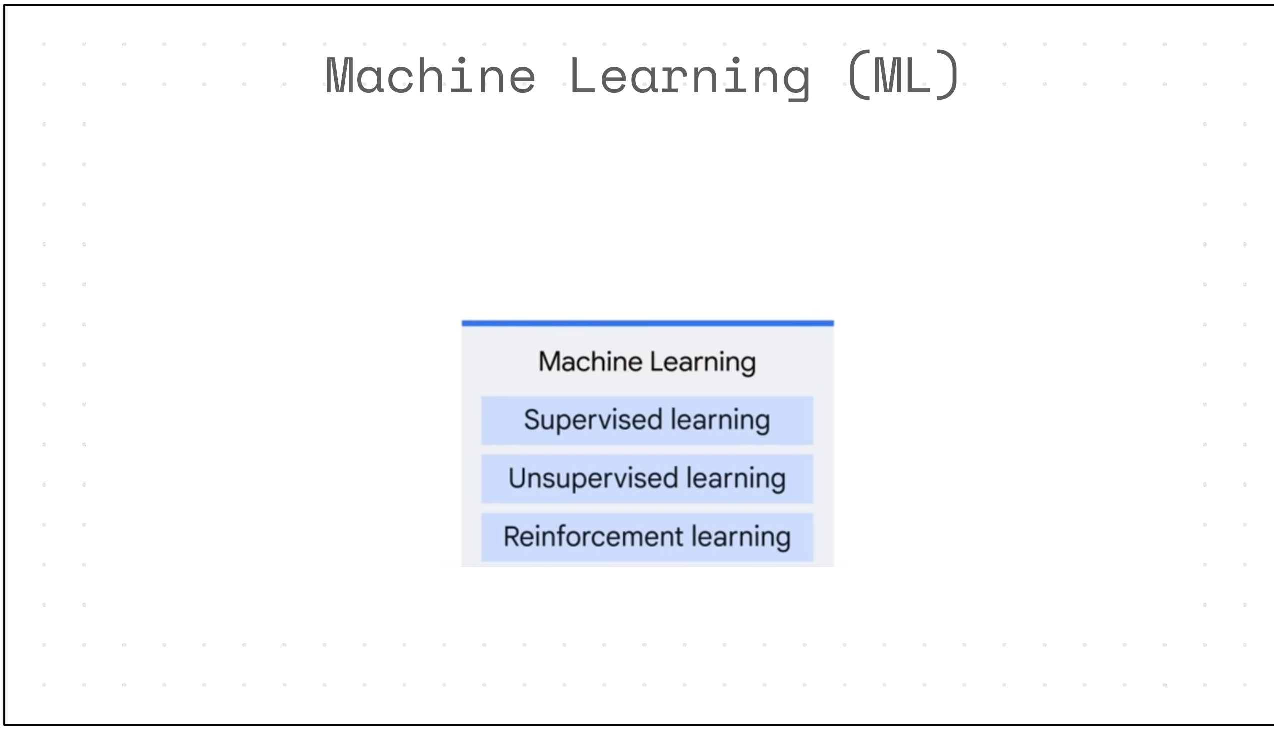
Unlabeled data is data that comes with no tag.

- In a **machine learning clustering problem**, the algorithm's goal is to group similar data points together based on their features, without any pre-existing labels.
- In the above example, the data points are employees, and the features are their years of service and income.
- The algorithm will analyze employee data and find natural groupings, or clusters, within it.
- For example, it might identify:
  - A group of new employees with low salaries.
  - A group of long-serving employees with high salaries.
  - And, most importantly, a group of employees who have a relatively low number of years of service but a very high income.
    - This last cluster is what the model would classify as "fast track."

- The output isn't a simple yes/no classification; it's a model that, given a new employee's years of service and income, can tell which cluster they belong to.
- When a new employee's data is fed into the model, the algorithm places them in the most similar group.
- If their data aligns with the "low years of service, high income" cluster, the model "classifies" them as on the fast track.

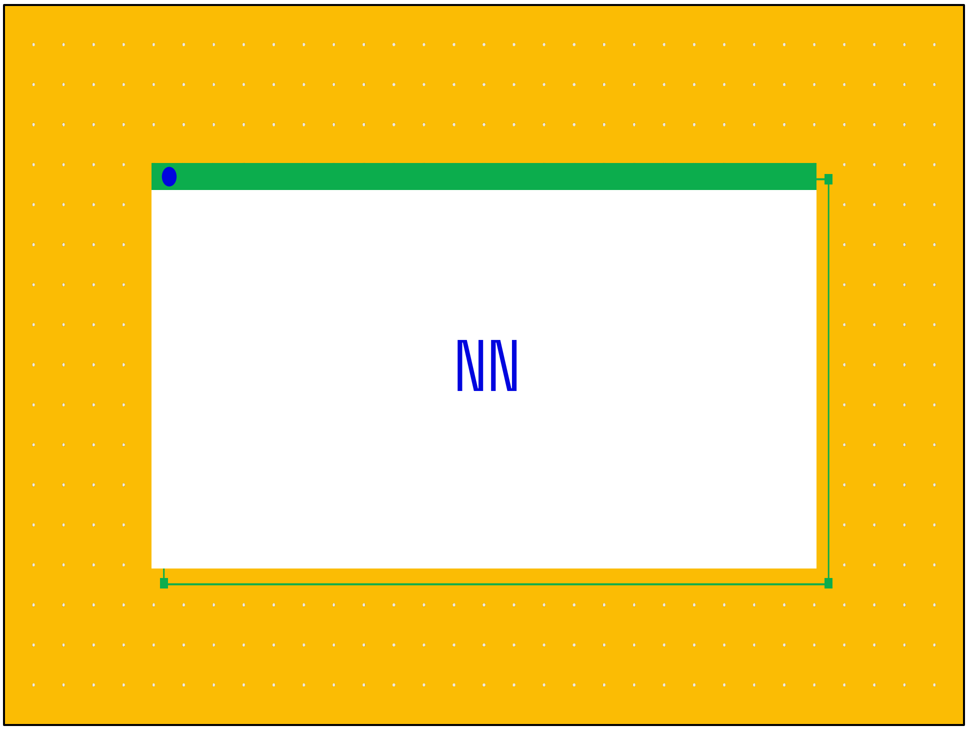
- In the context of clustering problem, "fast track" is a label that we, as a human, would assign to the specific cluster that the ML algorithm has identified.
- The model doesn't know what "fast track" means; it only sees patterns in the data.
- We are the one who interprets the pattern and labels it as "fast track."

- So, in this ML problem:
    - The model's job is to identify the clusters.
    - Our job is to interpret those clusters and give them a meaningful label, like "fast track."

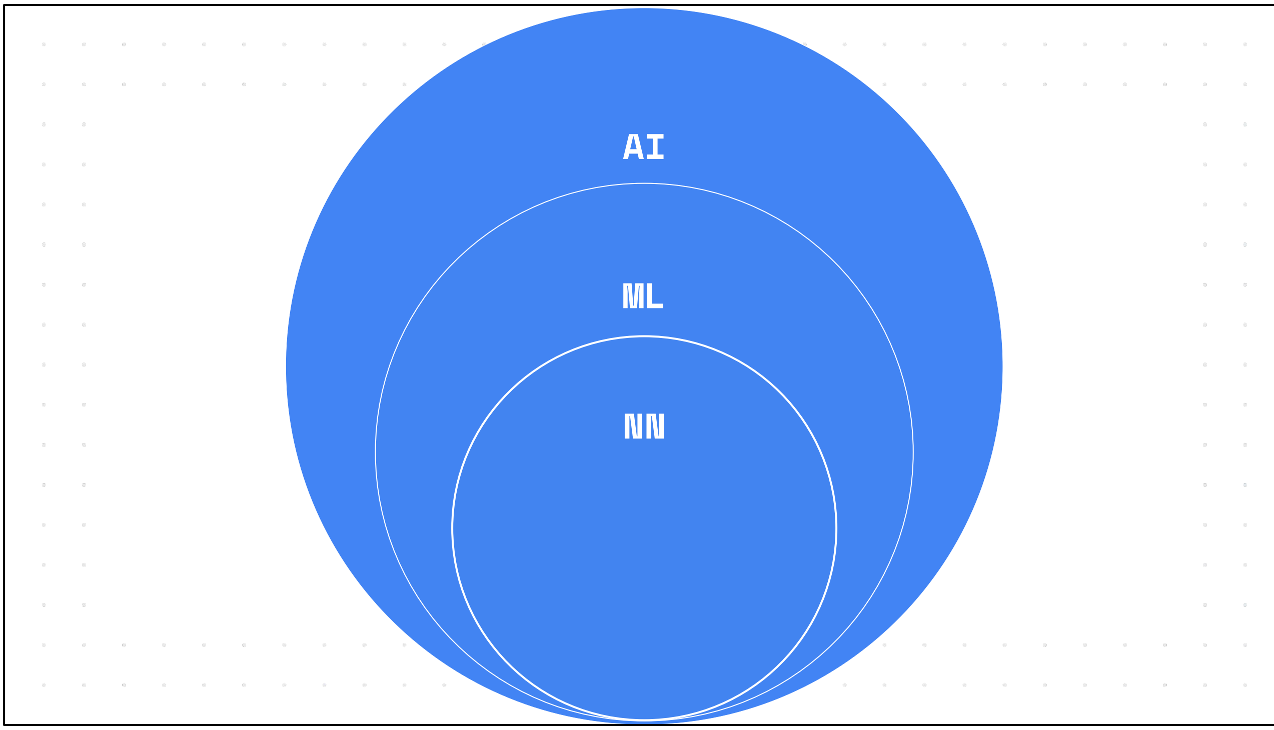


The main types of ML:

1. **Supervised Learning**: The model learns from labeled data to make predictions. This is used for classification and regression tasks.
2. **Unsupervised Learning**: The model learns from unlabeled data to find hidden patterns and structures. This is used for clustering.
3. **Reinforcement Learning**: The model learns by perceiving and interacting with an environment, taking actions, and learn through trial and error.
   - It receives rewards for good actions and penalties for bad ones.
   - A training method based on rewarding desired behaviors and/or punishing undesired ones.



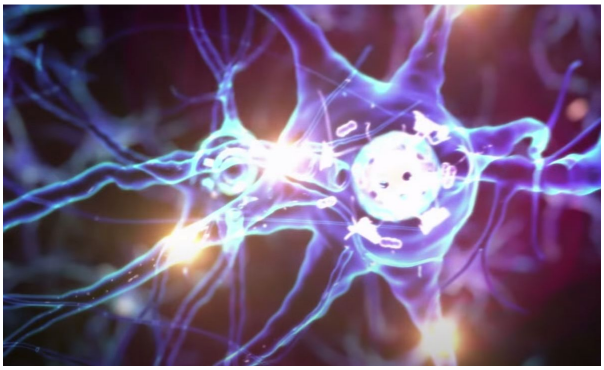
We're now moving into the topic of Artificial Neural Networks (ANNs), which are the backbone of deep learning.



Artificial Neural Networks are a type of machine learning model inspired by the human brain.

- They consist of layers of interconnected "neurons" that process data and pass it to the next layer.
- Each connection has a weight, and each neuron has a bias and an activation function.

(Biological) Neural Networks



Some studies: About 100 billion (10^11) neurons in the human brain

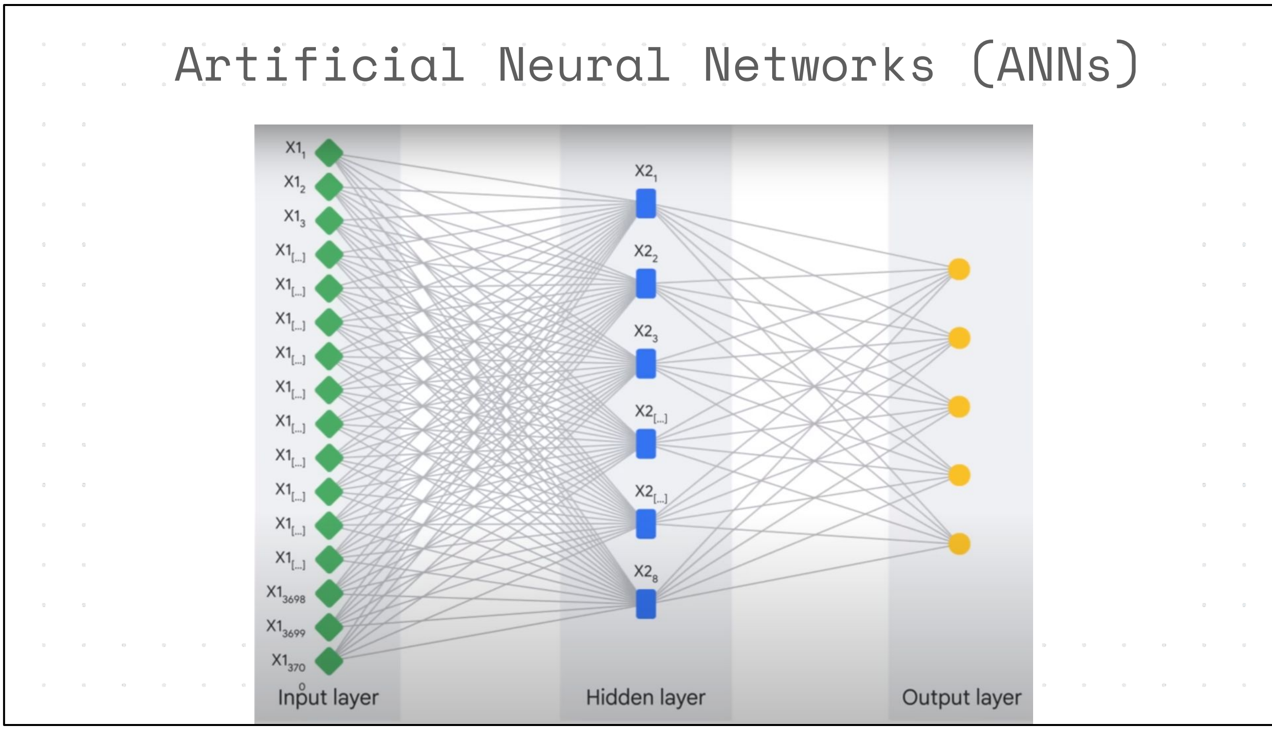
Some studies: About 100 Trillion (10^14) neuron connections in the human brain

https://hms.harvard.edu/news/new-field-neuroscience-aims-map-connections-brain#:~:text=In%20the%20human%20brain%2C%20some,the%20human%20brain%20to%20fathom

In the human brain, approximately 86 billion neurons form 100 trillion connections with one another.

https://www.nature.com/scitable/blog/brain-metrics/are_there_really_as_many/

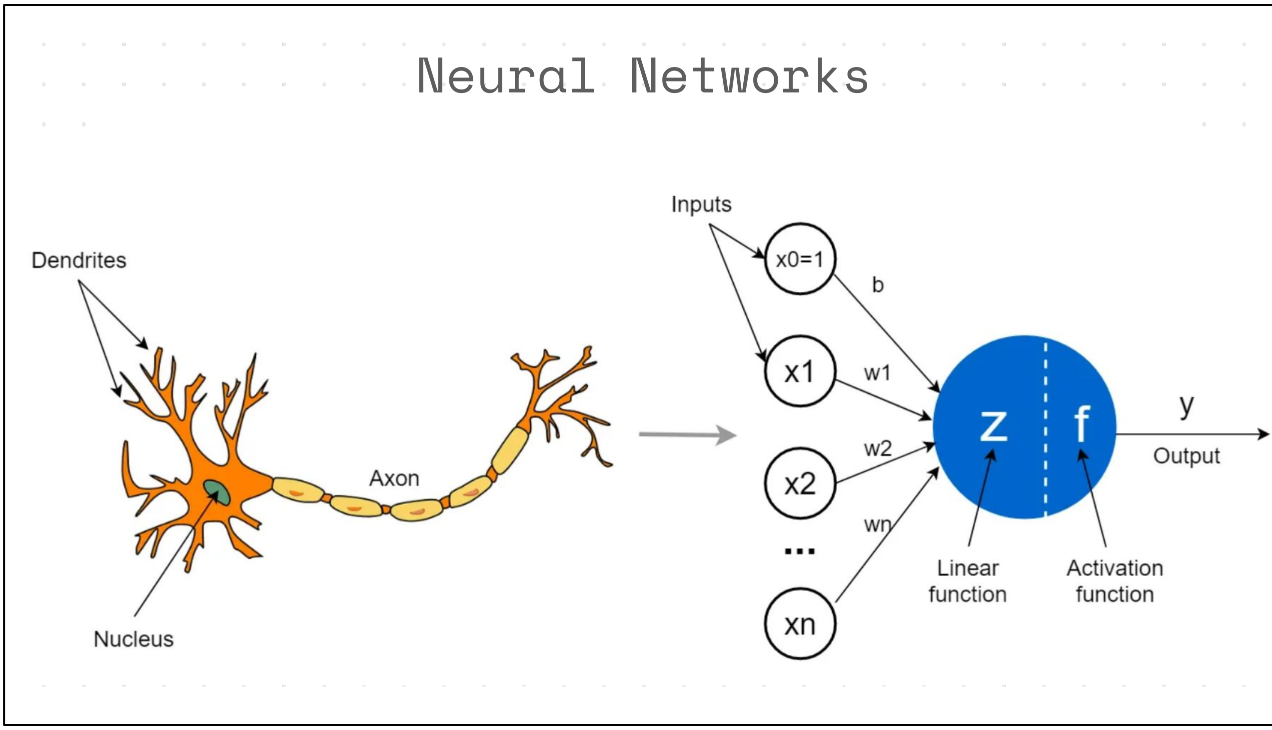
- Approximately 86 billion neurons in the human brain.
- The latest estimates for the number of stars in the Milky Way is somewhere between 200 and 400 billion.



This diagram shows a simple, fully connected neural network. It has an input layer, a hidden layer, and an output layer. We can see how the neurons are interconnected and how data would flow through the network.

Neural Networks can use both labeled and unlabeled data.

- This is called **semi-supervised learning**.
- In **semi-supervised learning**, a neural network is trained on a small amount of labeled data and a large amount of unlabeled data.
- The labeled data helps the neural network to learn the basic concepts of the task while the unlabeled data helps the neural network to generalize to new examples.



biological neuron

- receives its input signals from other neurons through dendrites (small fibers)
    - Likewise, a **perceptron** receives its data from other **perceptrons**.
- The connection points between dendrites and biological neurons are called **synapses**.
    - Likewise, the connections between inputs and perceptrons are called **weights**.
    - They measure the importance level of each input.
- In a **biological neuron**, the **nucleus** produces an output signal based on the signals provided by **dendrites**.
    - Likewise, the nucleus (colored in blue) in a perceptron performs some calculations based on the input values and produces an output.
- In a **biological neuron**, the output signal is carried away by the **axon**.
    - Likewise, the axon in a perceptron is the output value which will be the input for the next perceptrons.

A single artificial neuron (perceptron) in neural networks

- takes a weighted sum of its inputs, adds a bias, and then applies an activation function to produce an output.
- The activation function is crucial for introducing non-linearity into the network.

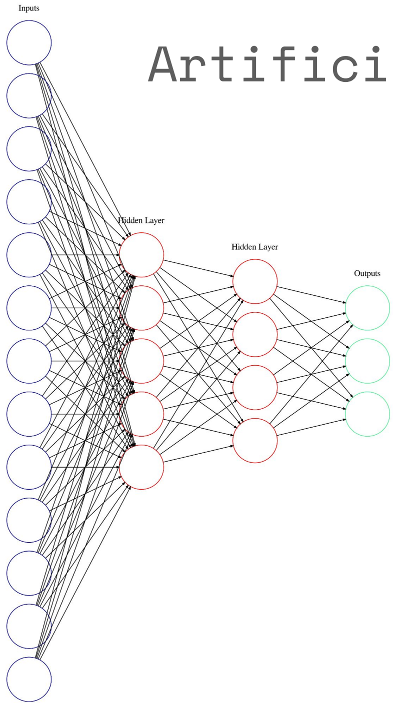
Without **activation functions**, a **neural network** is just a series of linear operations.

- This means that no matter how many layers you add, the final output would still be a linear function of the input.
- A linear model is simple and can only solve simple problems.

Activation functions, such as ReLU, Sigmoid, or Tanh, introduce non-linearity into the network.

- This is the most crucial reason for their use.
- By applying a non-linear transformation to the output of each neuron, the network gains the ability to learn and model complex, non-linear relationships in the data.
- This is what allows deep learning models to solve sophisticated problems like image recognition and Natural Language Processing (NLP).

Artificial Neural Networks (ANNs)



Number of internal **parameters** = 109

- Number of weights = 97
  - 13*5 = 65
  - 5 *4 = 20
  - 4 *3 = 12
- Number of biases = 12
  - 5
  - 4
  - 3

How to calculate the number of internal parameters (weights and biases) in a neural network.

- It's the sum of all the weights and all the biases, which are determined by the number of neurons in each layer.

https://towardsdatascience.com/parameters-and-hyperparameters-aa609601a9ac

Parameters in ANN

- are the values your learning algorithm can change independently as it learns and these values are affected by the choice of **hyperparameters** you provide.

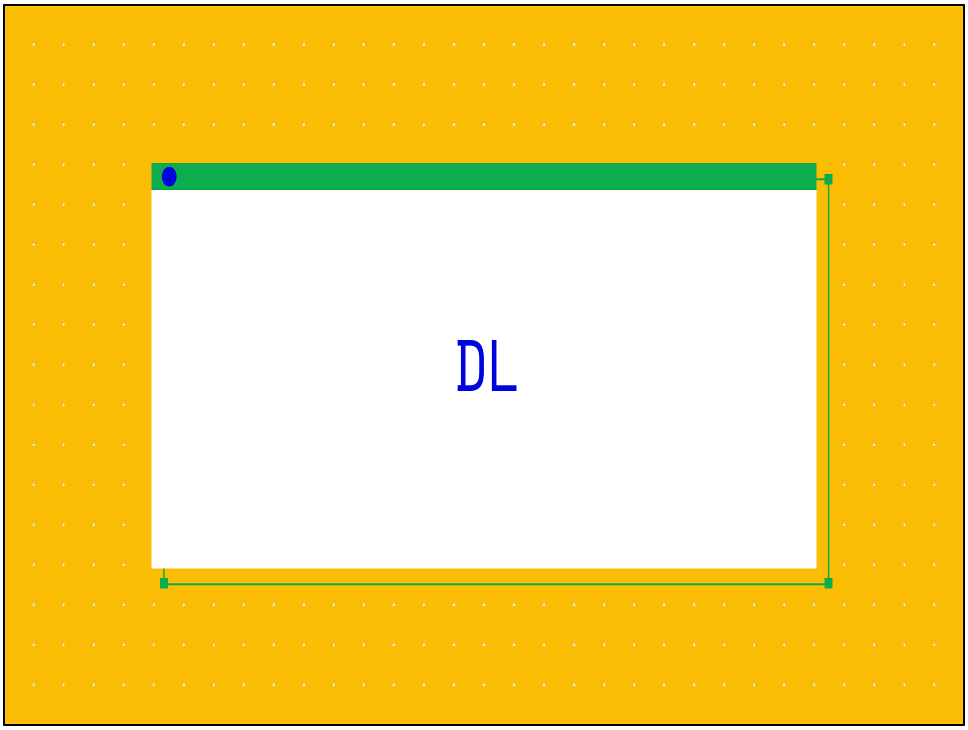
https://learn.flucoma.org/learn/mlp-parameters/

The number of **internal parameters** in a neural network is the total number of weights + the total number of biases.

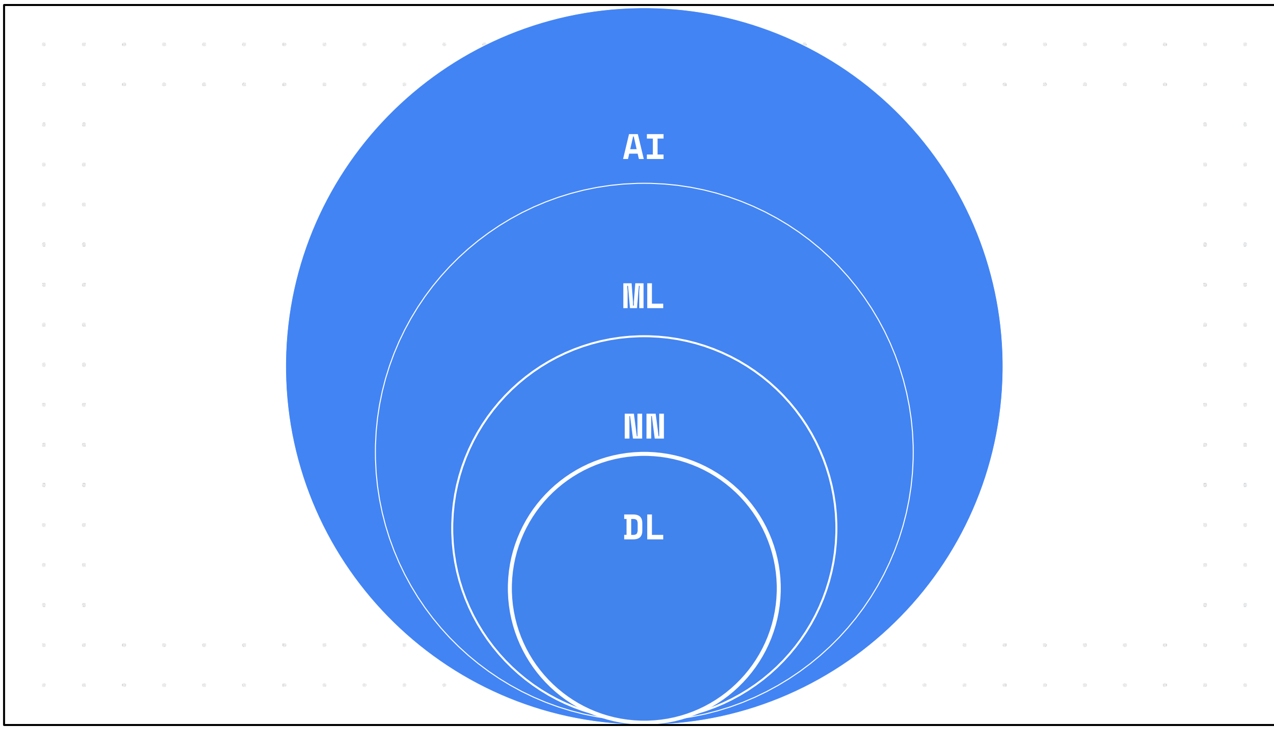
1. The total number of **weights** equals the sum of the products of each pair of adjacent layers.
2. The total number of **biases** is equal to the number of hidden neurons + the number of output neurons.

Number of neurons = 25 → 109 parameters

The **bias** allows a neuron to shift the **activation function**'s output to the left or right, which is essential for giving the model flexibility. Without a bias, the neuron's output is always zero when the inputs are zero, which severely restricts the network's ability to learn certain patterns.



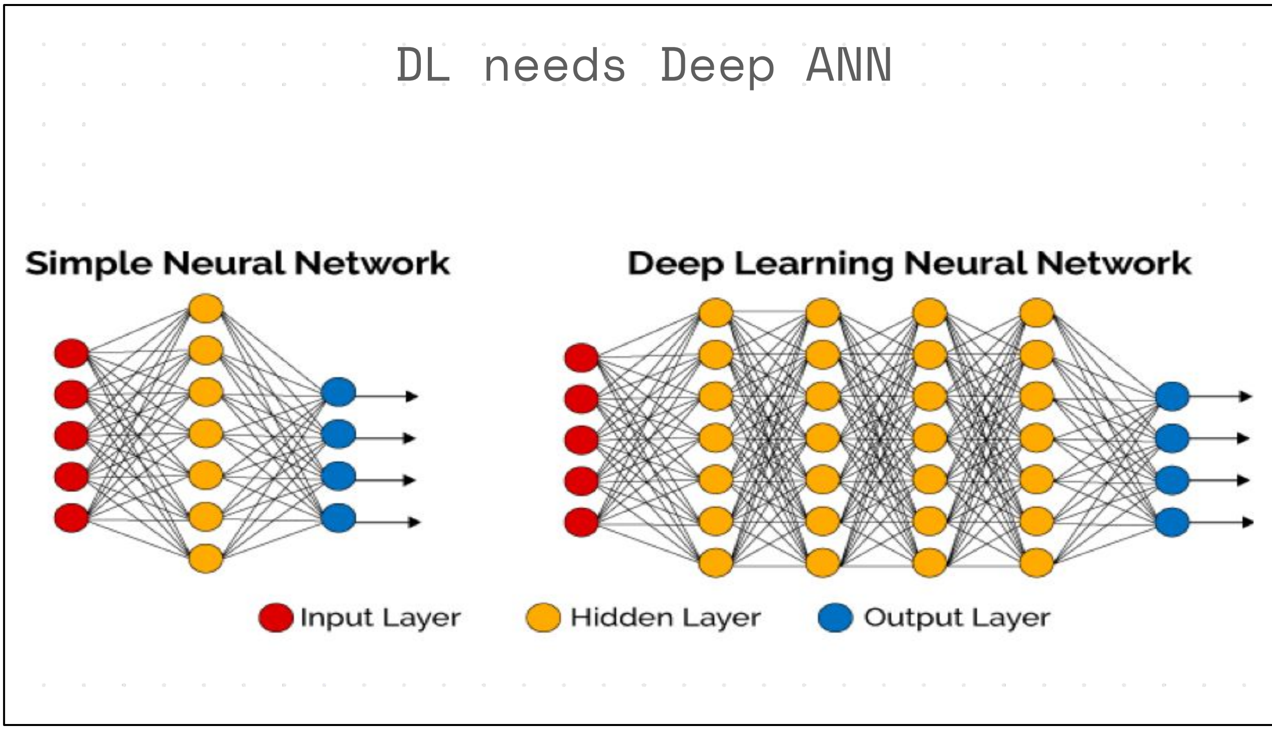
Now we'll discuss Deep Learning (DL).



This diagram clarifies the relationship between all the concepts we've covered. Deep Learning is a subfield of ML that uses a specific type of Neural Network—one with multiple hidden layers.

- While ML is a broad field that encompasses many different techniques,
    - **DL** uses **Artificial Neural Networks (ANNs)**, allowing them to process more complex patterns than traditional ML.
- **Neural Networks** (AKA **Artificial Neural networks (ANNs)** or **Simulated Neural Networks (SNNs)**, are a subset of **ML** and are the backbone of **DL** algorithms.
    - They are called "**neural**" because they mimic how neurons in the brain signal one another.

- **DL** models typically have many layers of neurons, which allows them to learn more complex patterns than traditional ML models.



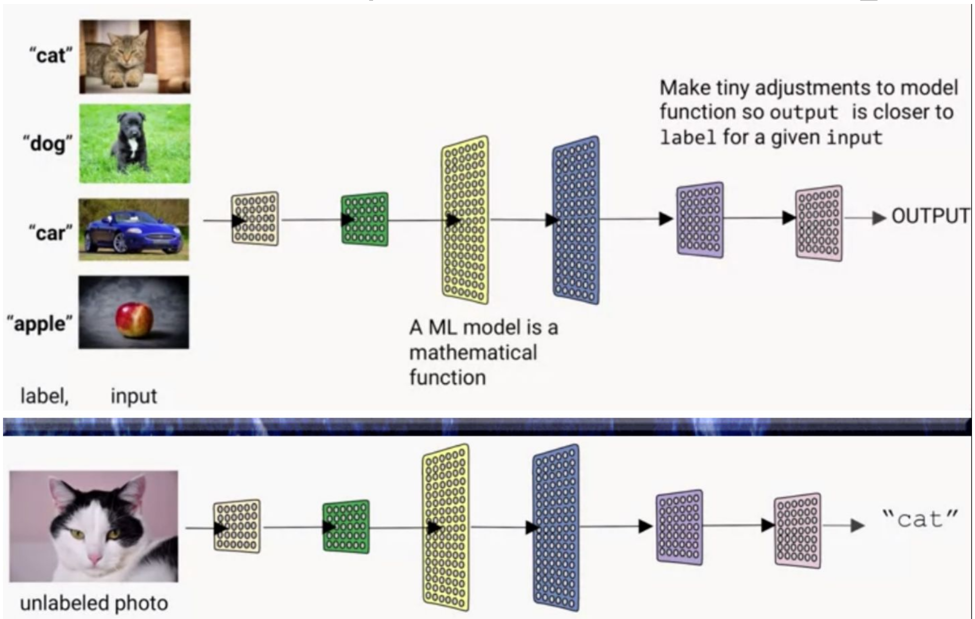
DL: a modern state-of-the-art approach to ML. The key idea here is that DL is defined by its use of "deep" neural networks, which simply means having more than one hidden layer. This depth allows the network to learn more complex representations of data.

A basic neural network consists of three types of layers:

1. **Input Layer**: This is where the data is fed into the network.
    - It has a number of neurons equal to the number of features in your dataset.
2. **Hidden Layer(s)**: These layers are where the actual computation and feature extraction happen.
    - The neurons in these layers process the data from the previous layer and pass the result to the next.
3. **Output Layer**: This layer produces the final result, such as a classification or a numerical value.

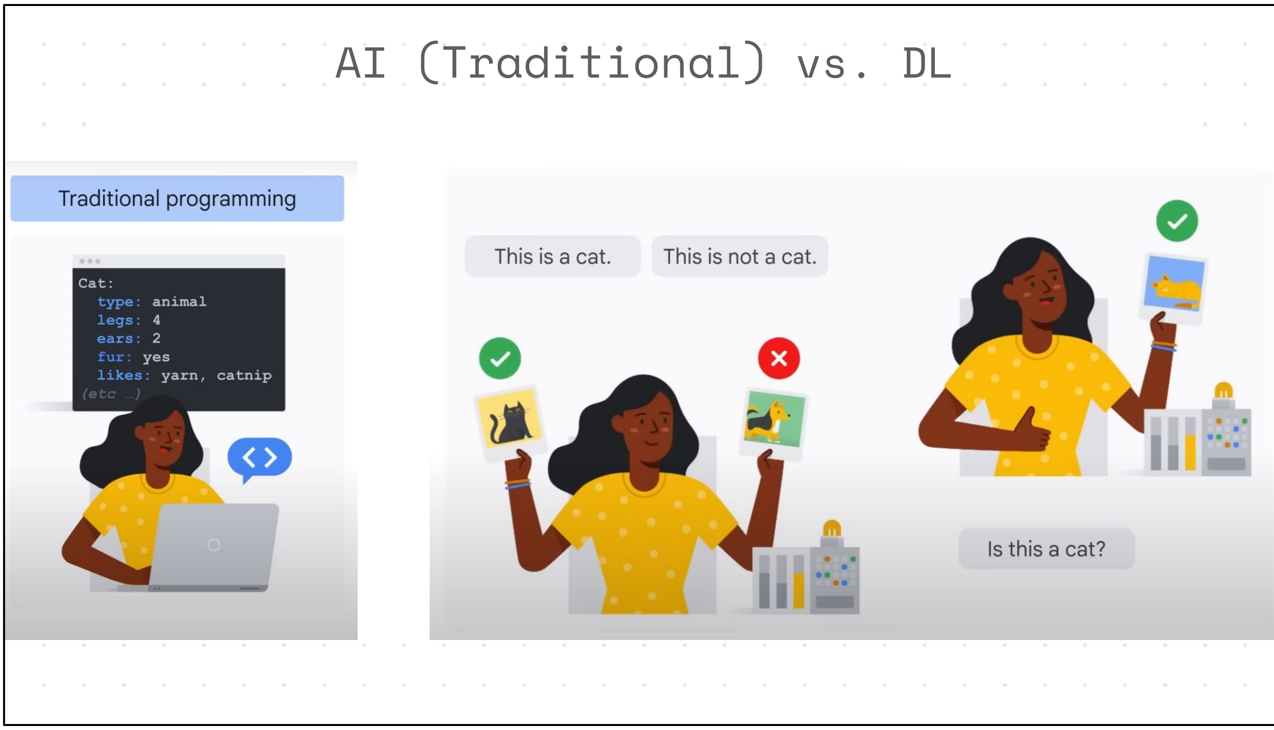
- A **neural network** of more than three layers, including the inputs and the output, can be considered a deep-learning algorithm.
- A model is considered **deep learning** when it has more than one hidden layer.

ANNs & Supervised Learning



Here, we have an ANN with supervised learning.

- The network is trained with labeled data, and it learns to map inputs to correct outputs.
- This forms the foundation for many powerful applications, such as image classification.



Traditional AI vs. Deep Learning

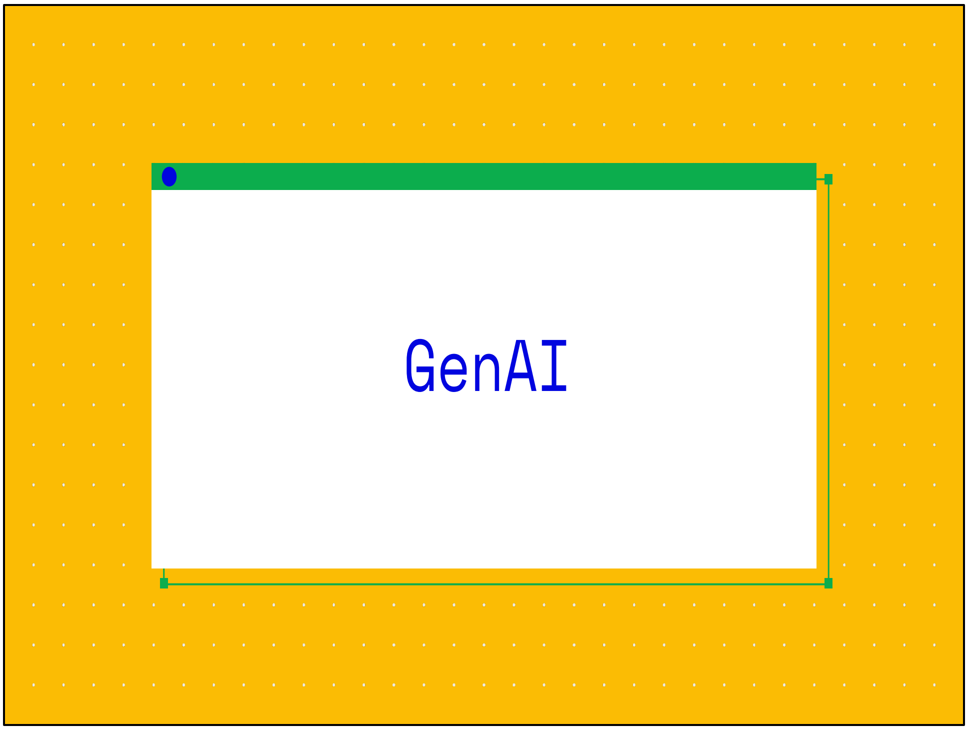
- Traditional AI relies on features that are hand-crafted by humans, while deep learning models learn the features automatically from the data.
- This is a key reason for deep learning success in recent years.

In traditional programming

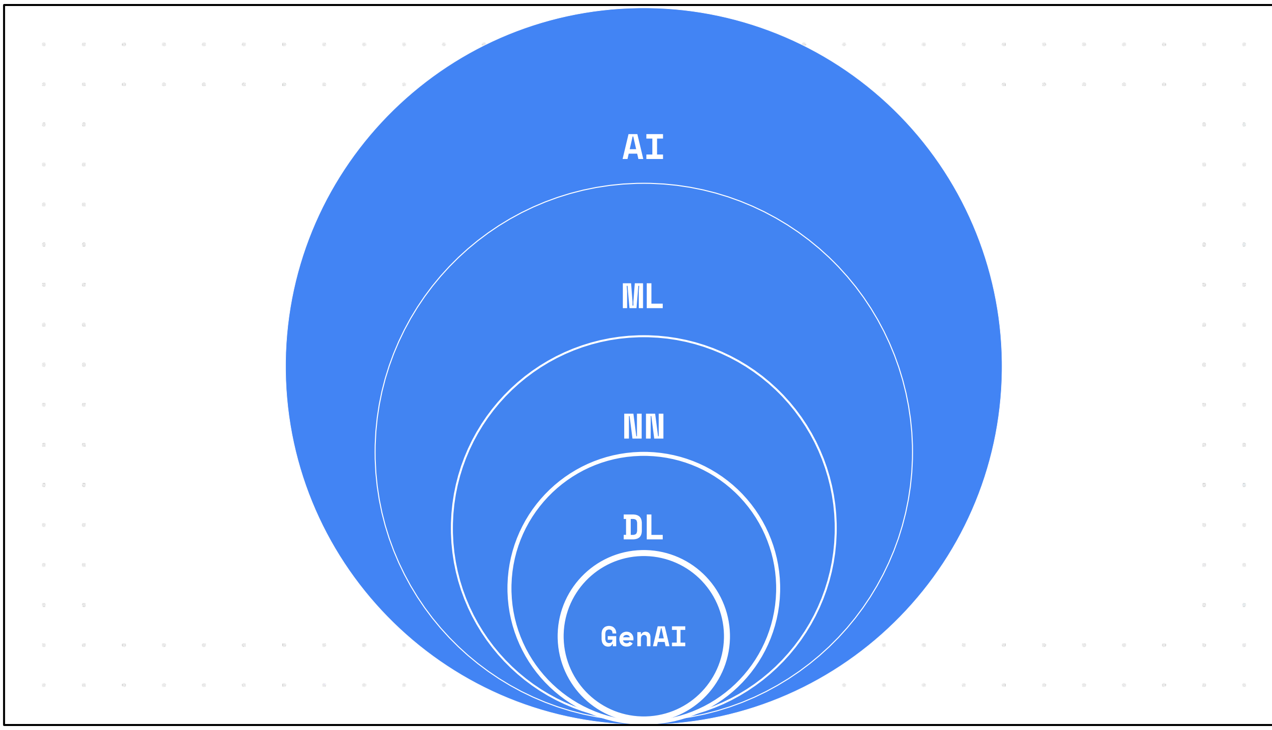
- We used to have to hard code the rules for distinguishing a cat.

In Neural Networks

- we could give the **network** pictures of cats and dogs and ask, is this a cat?
- And it would predict a cat.

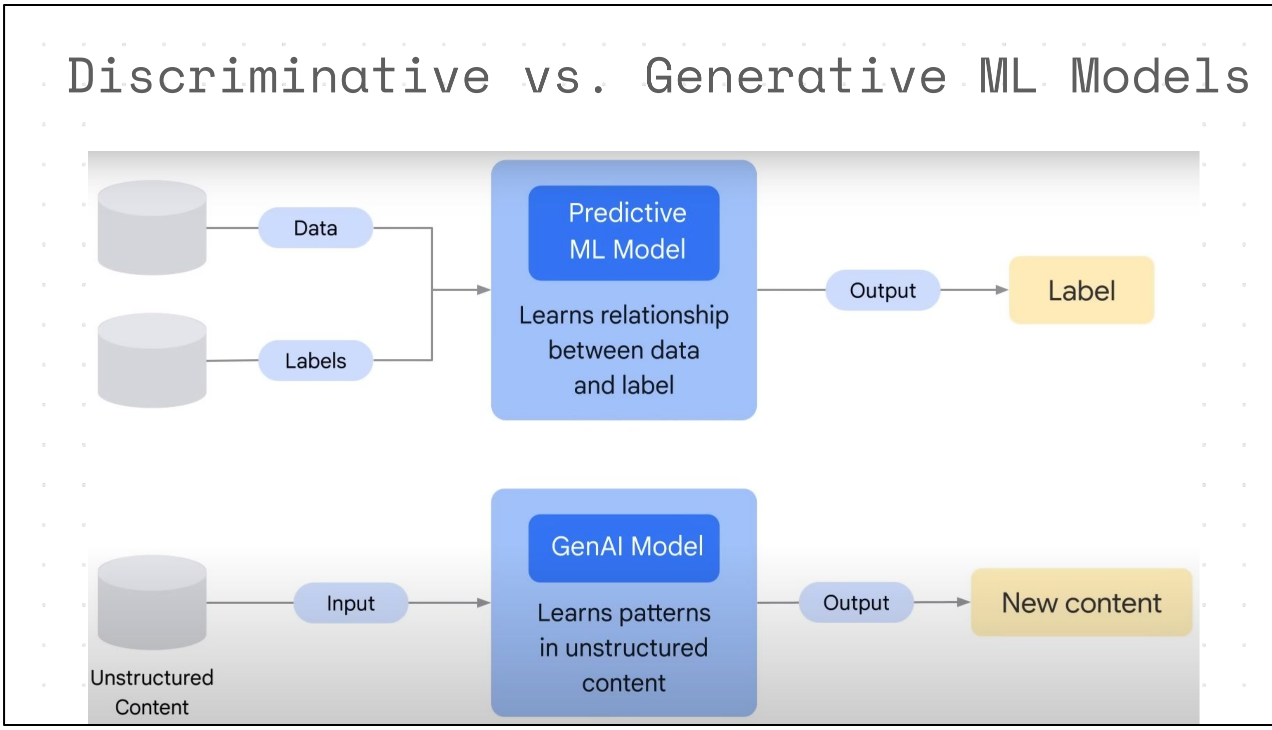


We're now moving to the latest and most exciting topic: Generative AI (GenAI).



This diagram places GenAI within the broader context of the other fields.

- GenAI is a subset of Deep Learning (deep neural networks).
- Gen AI is a type of AI that can produce new content, including text, images, audio, and synthetic data.

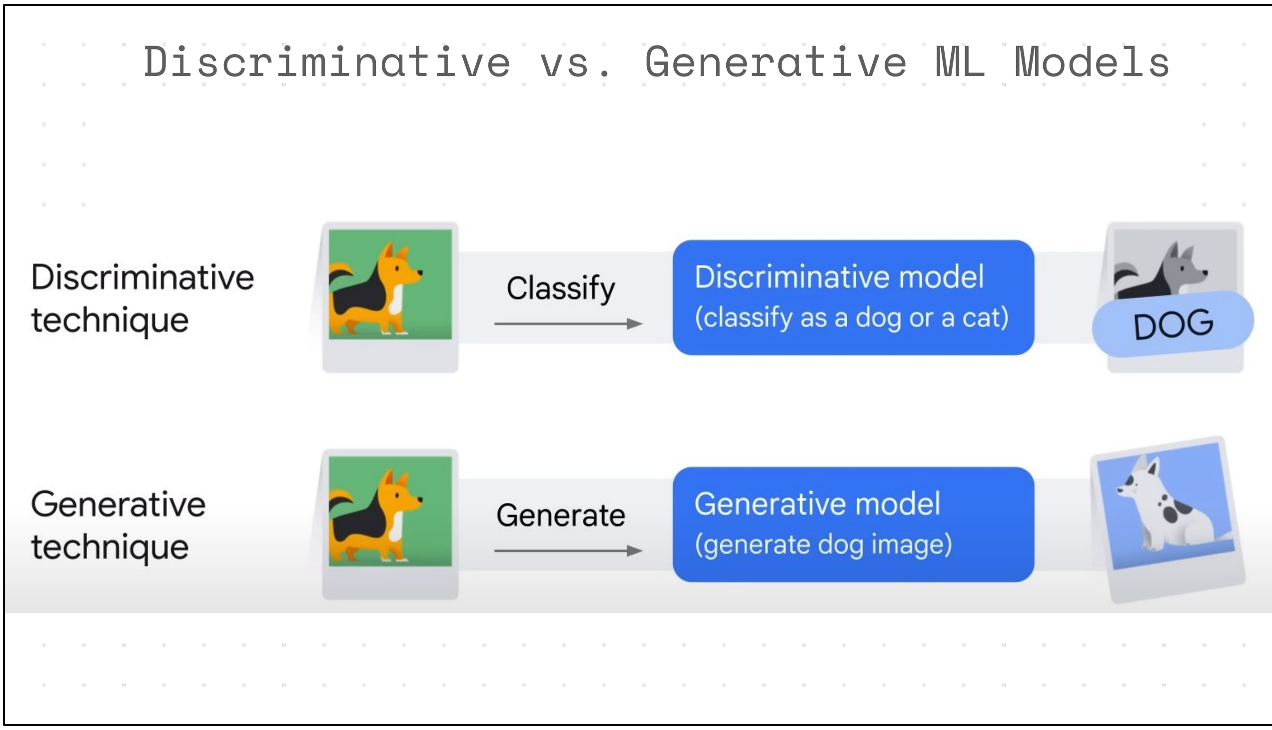


DL models, or **ML models** in general, can be divided into:

1. **Discriminative Model** is a type of model that is used to classify or predict labels for data points.
    - Typically trained on a data set of labeled data points.
    - They learn the relationship between the features of the data points and the labels.
    - Once is trained, it can be used to predict the label for new data points.
2. **Generative Model** generates new data instances based on a learned probability distribution of existing data.
    - Thus generates new content.

We can classify ML models into **discriminative** and **generative** types.

- While "**predictive**" is often used, it's more of a description of a model's purpose rather than its underlying method.



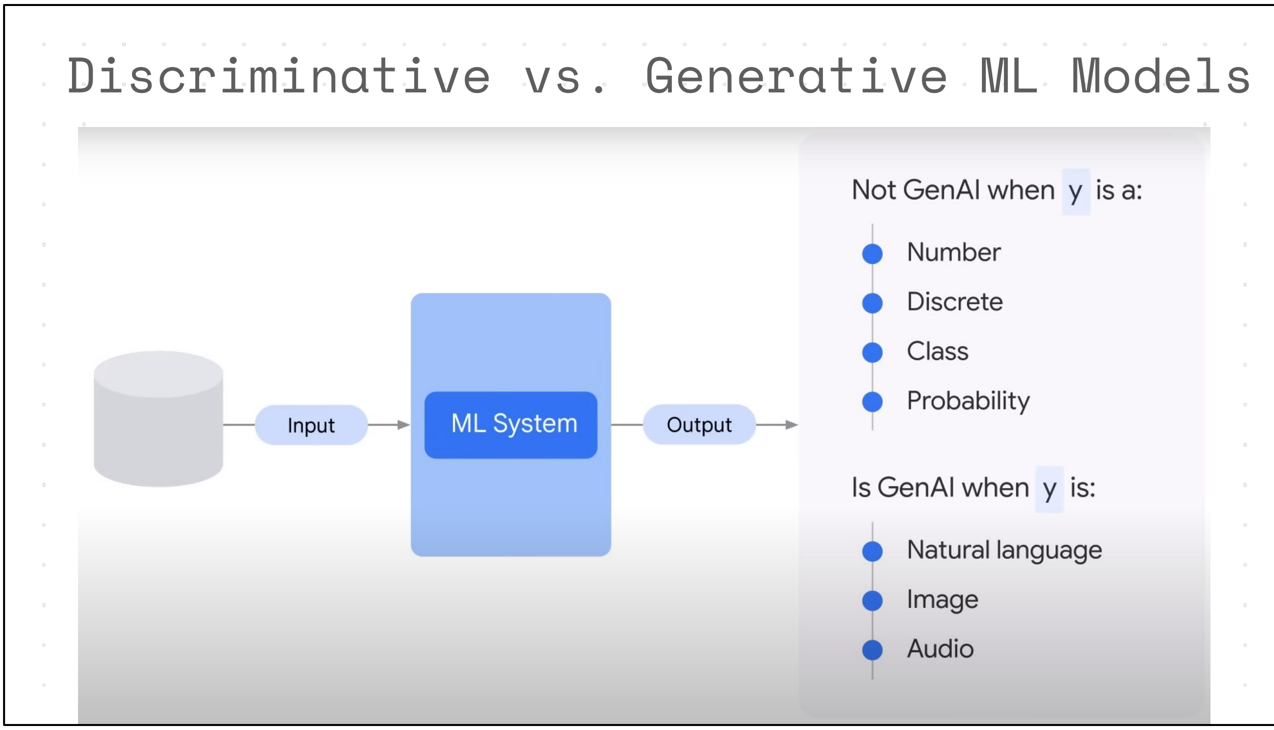
There is a fundamental distinction in ML models.

- **Discriminative models** are designed to classify or differentiate between data points, while
- **Generative models** are designed to create new, synthetic data.

This diagram visually explains the difference.

- A **discriminative model** learns the boundary between two classes, while
- a **generative model** learns the underlying distribution of each class, allowing it to generate new data for that class.

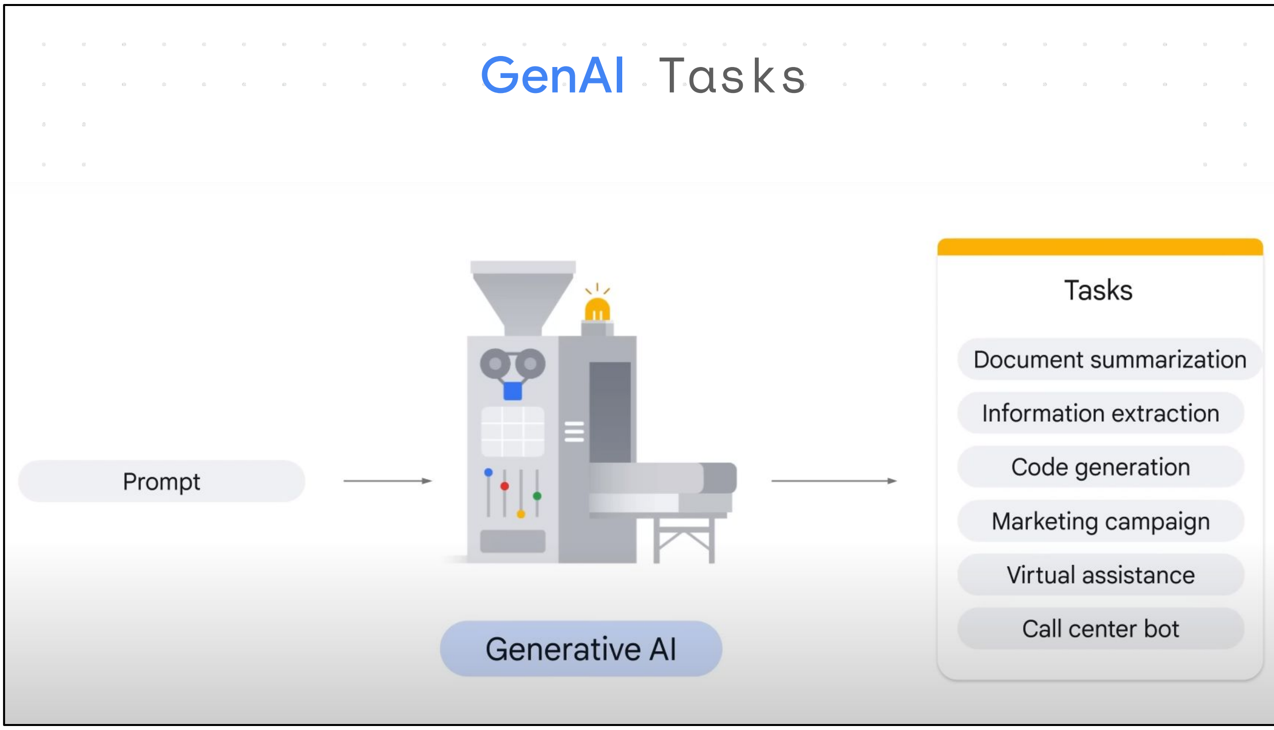
A **discriminative model** asks, "What is the boundary between cats and dogs?" while a **generative model** asks, "What is a cat?" or "What is a dog?"



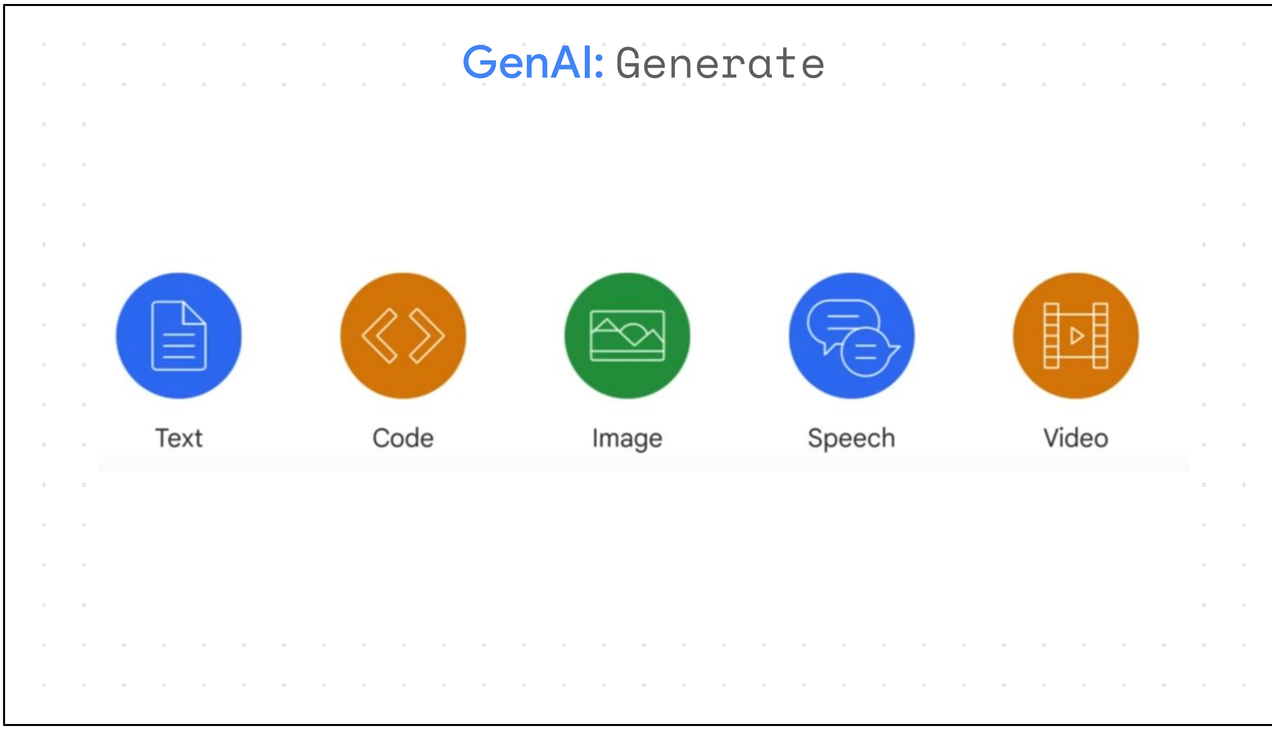
Please Note

https://www.g2.com/articles/discrete-vs-continuous-data

- There is structured and unstructured data.
- There are qualitative (or categorical) data and quantitative (or numerical) data.
- Quantitative variables can be either discrete or continuous.



- **Discriminative models** are used for classification and regression tasks.
- **Generative models** are used for tasks like image generation, text summarization, and music creation.

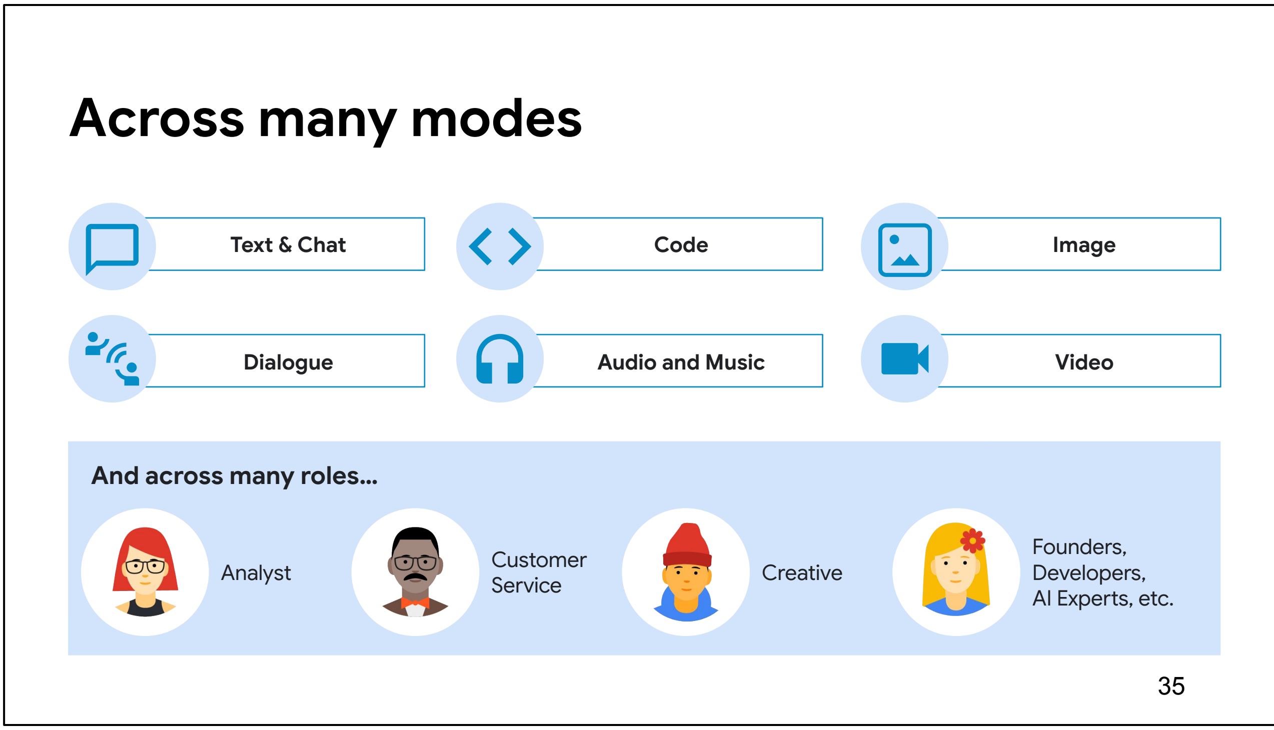


Gen AI is a subset of **DL**, which means it

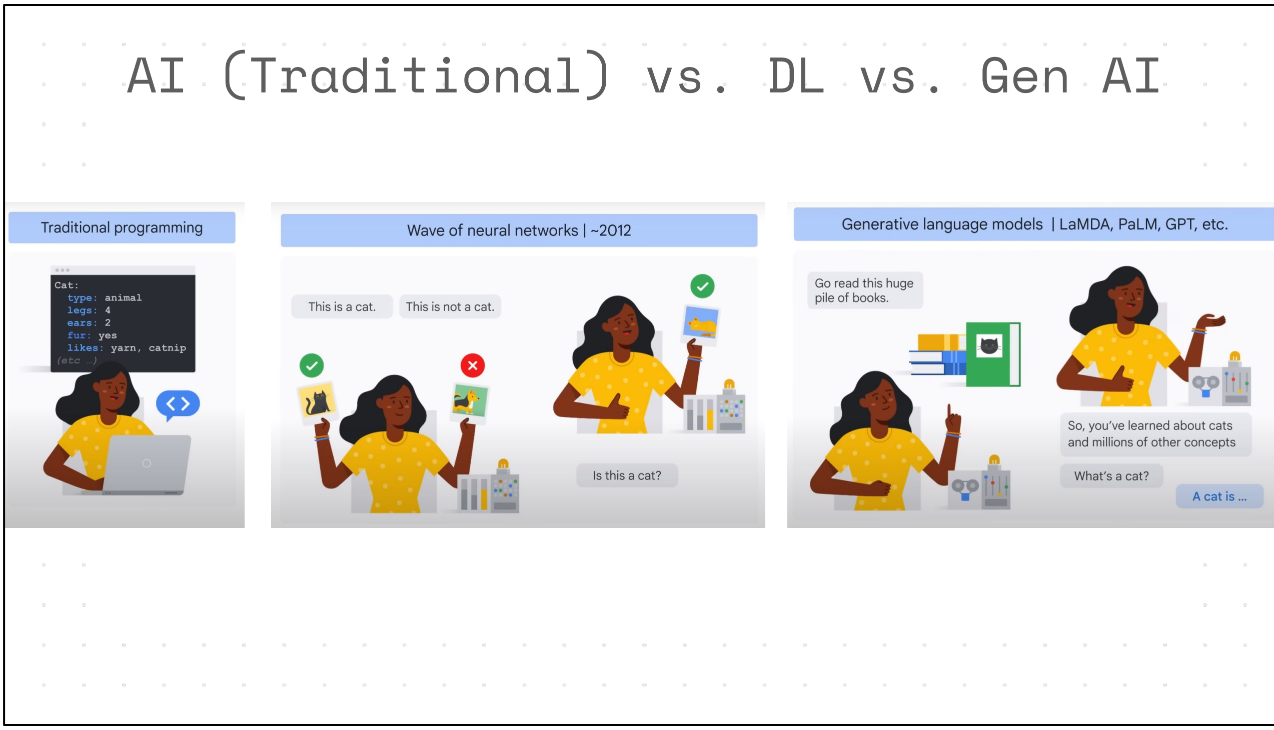
- uses **ANNs**
- can process both labeled and unlabeled data using supervised, unsupervised, and semi-supervised methods
- A type of AI that can produce new content, including text, images, audio, and synthetic data.

What is GenAI?

- A type of AI that creates new content based on what it has learned from existing content.
- The process of learning from existing content is called training.
- Essentially, it learns the underlying structure of the data and can then generate new samples that are similar to the data it was trained on.



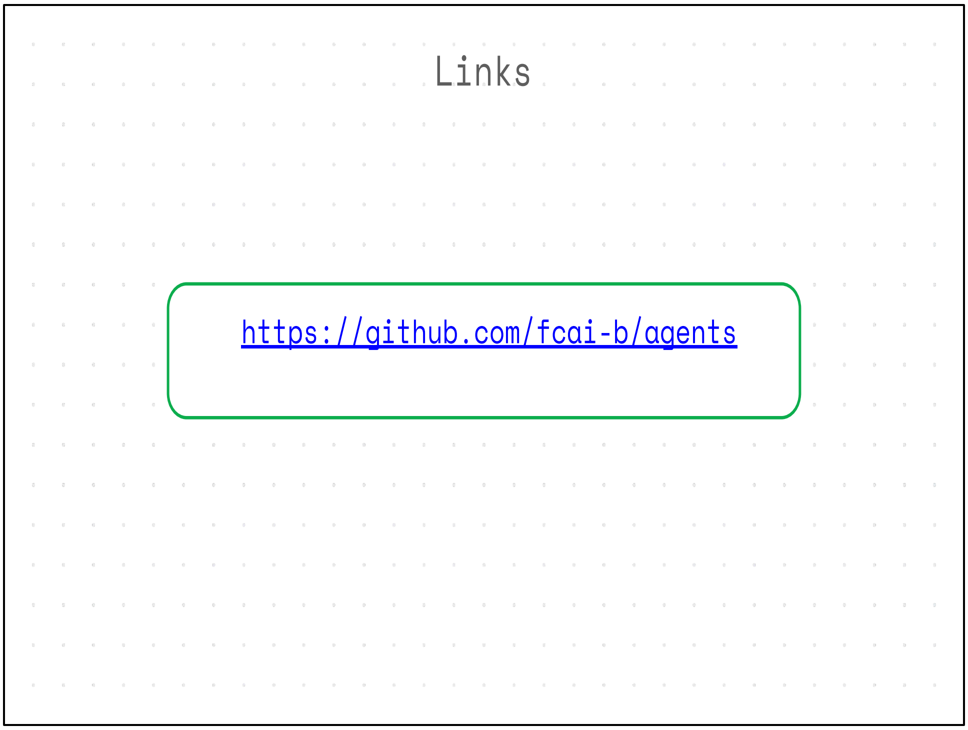
You can check some of the roles that can benefit from the GenAI in the above diagram.



In Gen AI

- We as users can generate our own content, whether it be text, images, audio, video, or others.
- For example, models like **Pathways Language Model (PaLM)**, or **Language Model for Dialogue Applications (LaMDA)**,
    - ingest very, very large data from multiple sources across the internet and
    - build **Foundation Language Models** we can use simply by asking a question (typing it into a prompt or verbally talking into the prompt).
- So when you ask it what's a cat, it can give you everything it has learned about a cat.

Questions



This slide provides link to the GitHub repository related to this course, where you can find more resources and information. Please keep checking the repo link weekly, especially before the next lecture, to have the latest update.