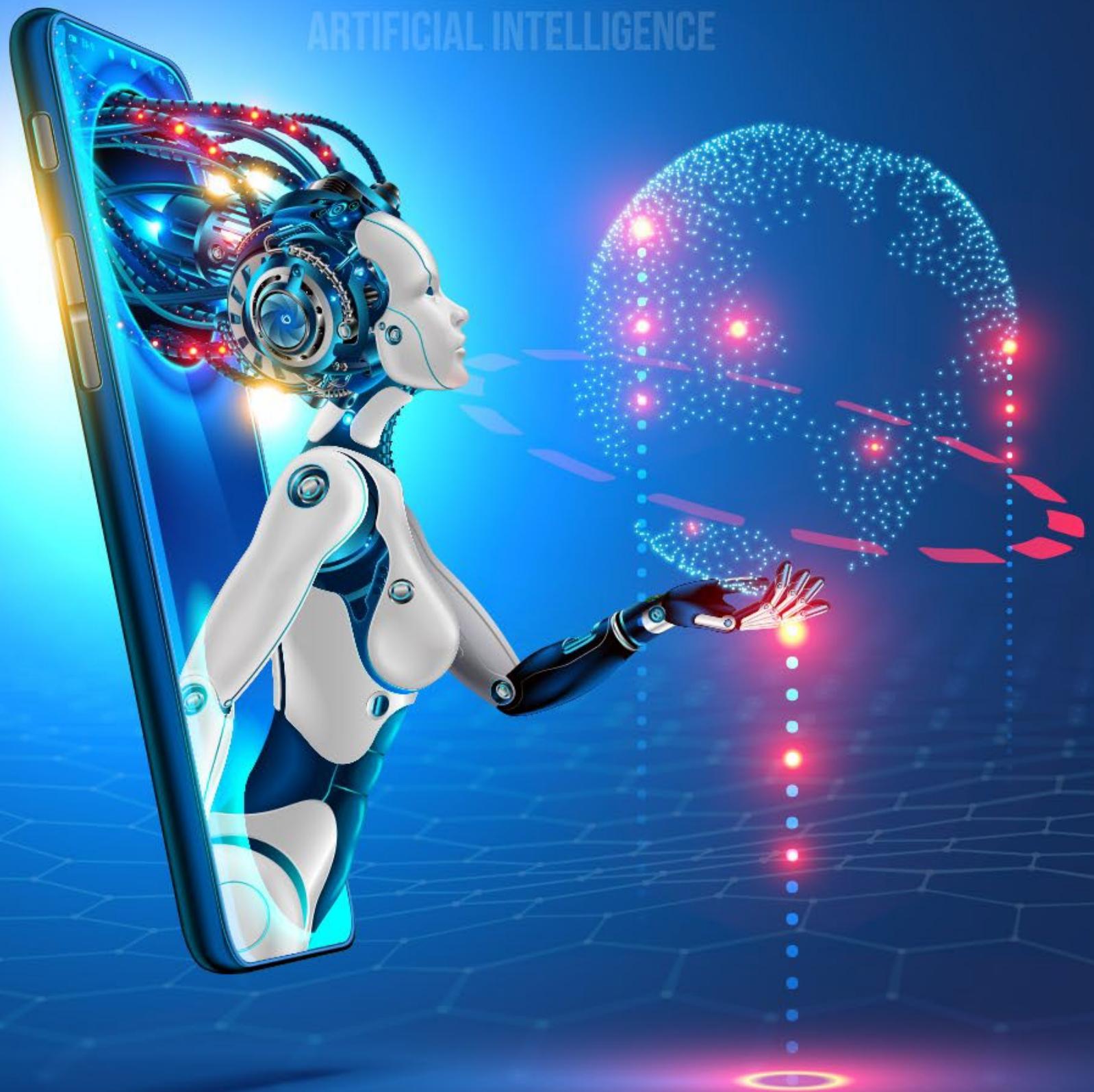


DATA AND
ARTIFICIAL INTELLIGENCE



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Deep Learning with Keras with
TensorFlow

DATA AND ARTIFICIAL INTELLIGENCE



Introduction to AI and Deep Learning

Learning Objectives

By the end of this lesson, you will be able to:

- Describe artificial intelligence and deep learning
- Outline the history of artificial intelligence
- List successes of deep learning
- Discuss object detection using self -driving cars
- Discuss the applications of deep learning
- Outline the life cycle of a deep learning project



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Artificial Intelligence

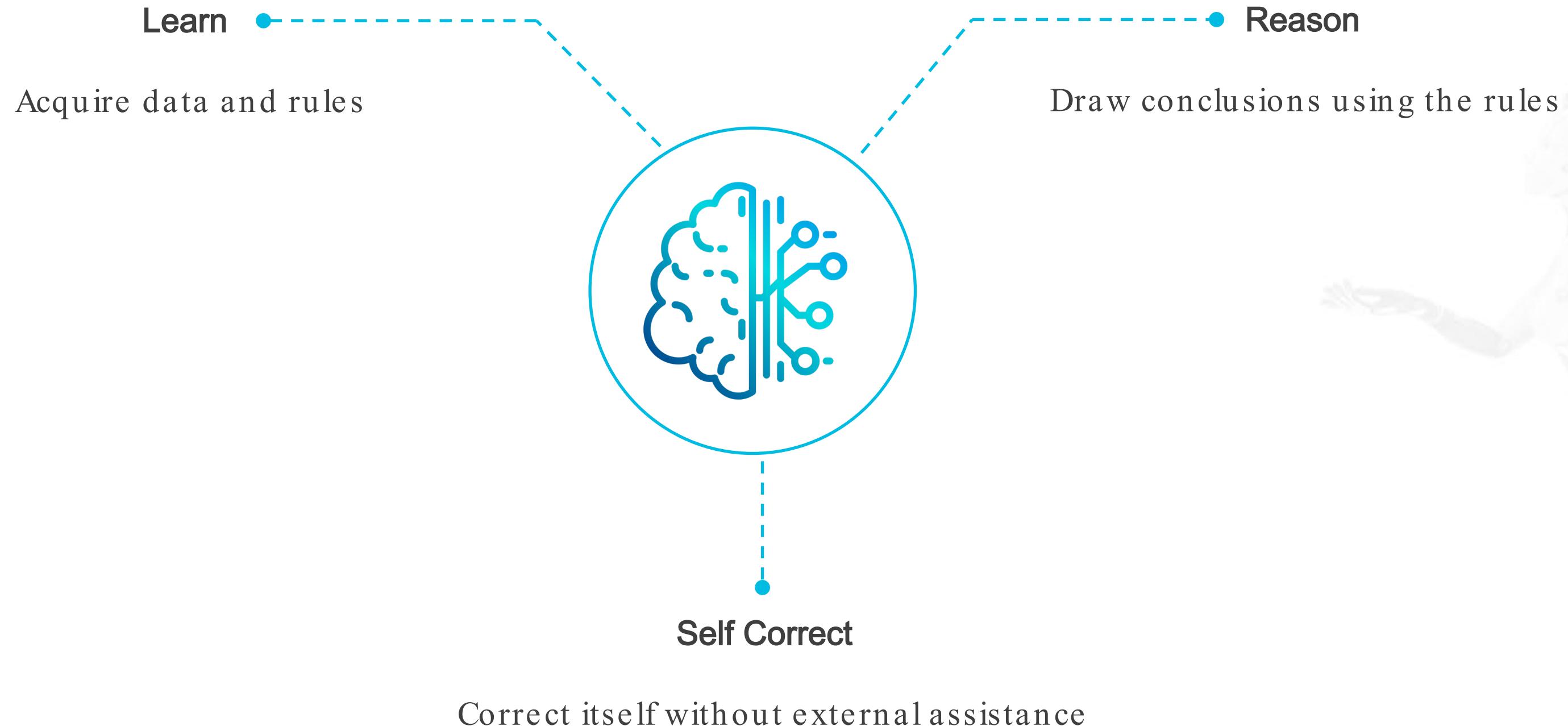
Artificial Intelligence

Artificial intelligence (AI) is a branch of computer science that attempts to simulate human intelligence in machines.



Artificial Intelligence

For a machine to be classified as AI, it must perform the tasks given below:

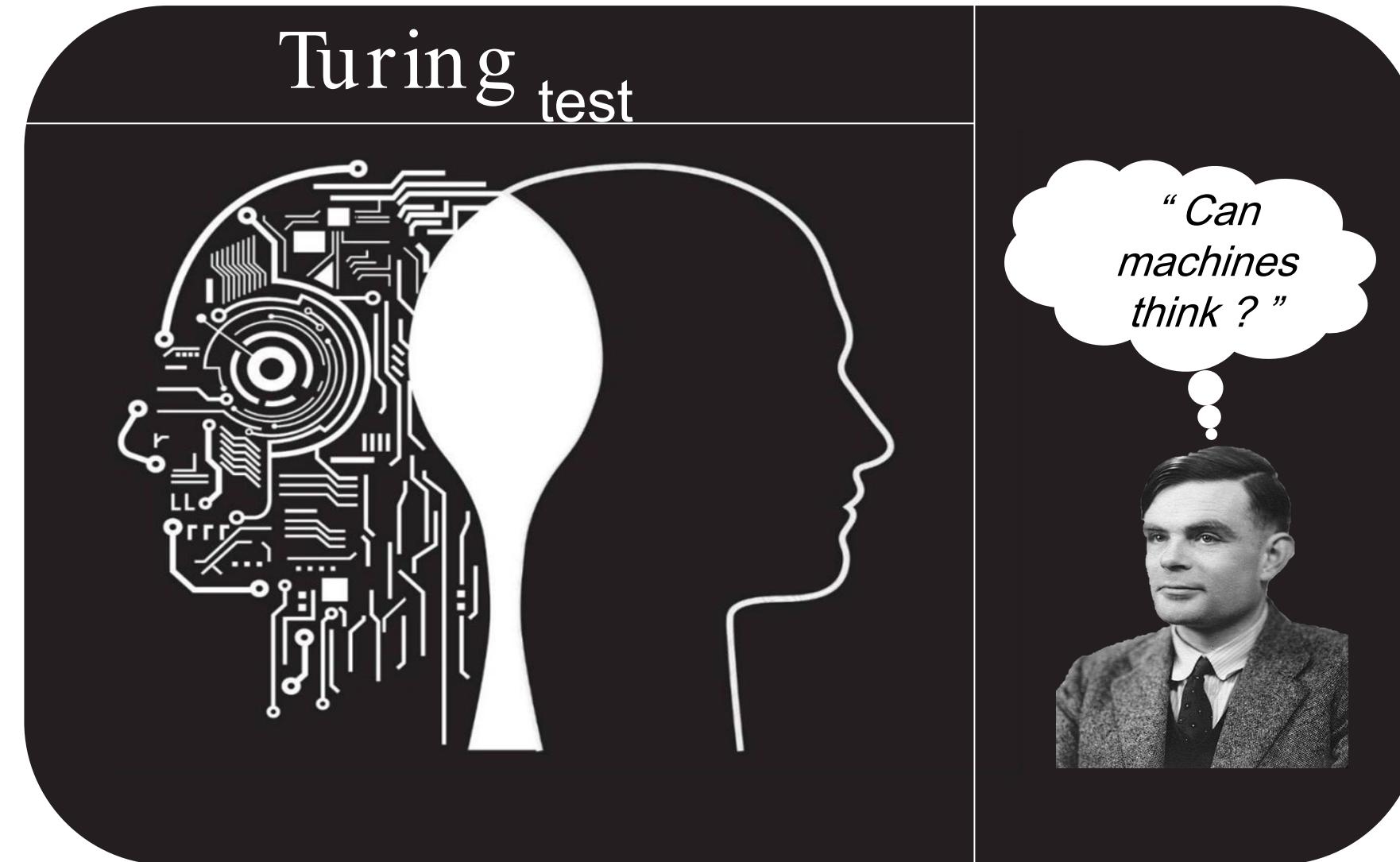


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History of AI

The Turing Test

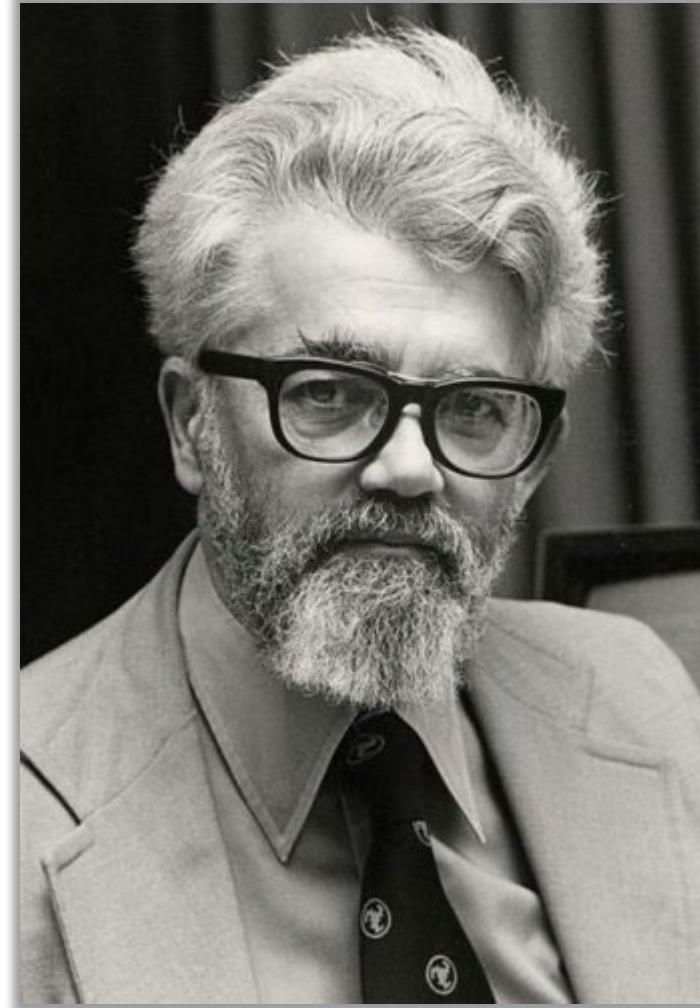
In 1950, Alan Turing wrote a paper proposing a test that looked at whether a computer can think like a human being.



The paper focused on answering the question, "Can machines think?"

Father of AI

In 1955, John McCarthy coined the term “ Artificial Intelligence ” in a conference at Dartmouth.



He was very influential in the early development of AI and also helped develop the Lisp programming language.

Rise of AI: 1956–1974

The years after the conference in Dartmouth were the most crucial period in AI development and discovery.



DARPA developed computers solved algebra word problems, proved theorems, and learned to talk English.

1986

Rise of Machine Learning

- Neural networks return to popularity
- Major advances in ML algorithms and applications

1995

AI as Science

- Vision, language, and information mining techniques gain popularity

2006

Face Recognition

- Consumer cameras offer face recognition software

Man vs. Machine

Garry Kasparov was defeated by Deep Blue chess computer in 1997.



This was the first time a computer won over a reigning world chess champion.

State of AI

Artificial Intelligence is already proliferating in our lives. For example:



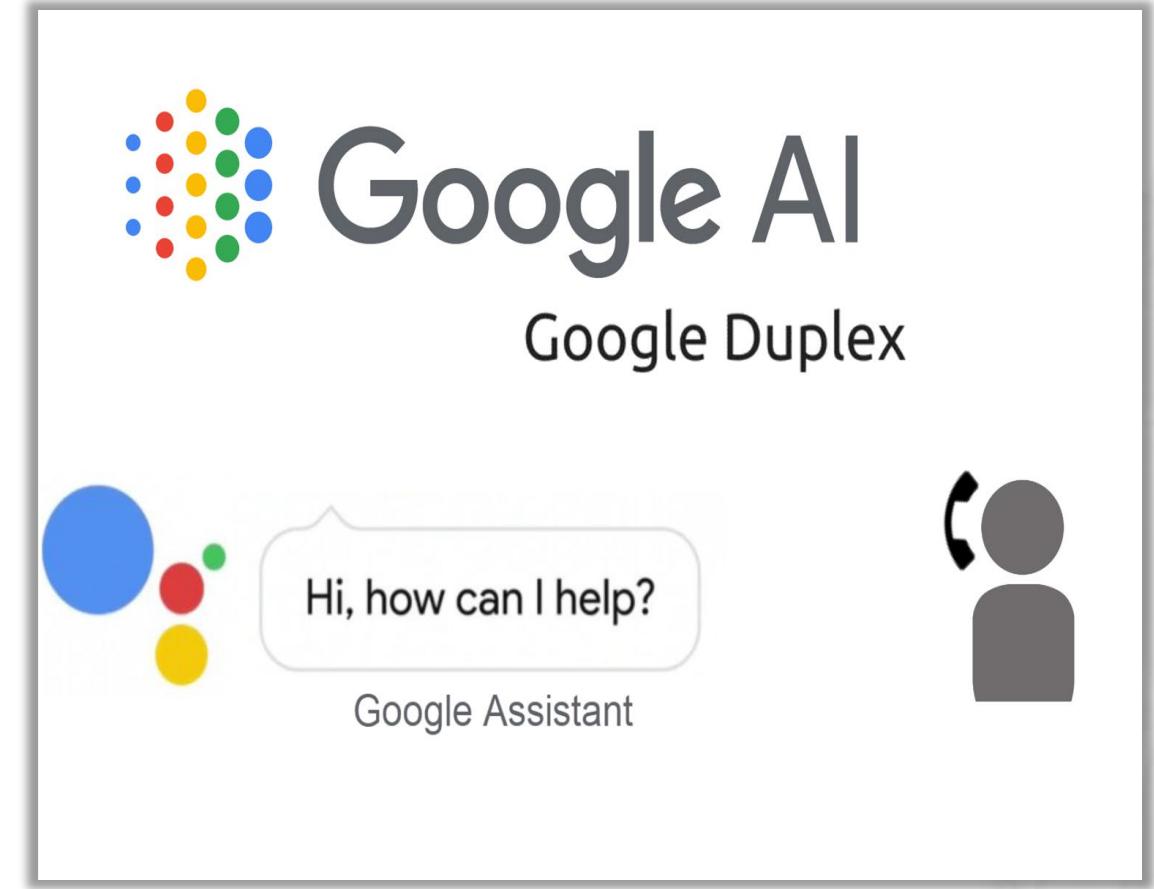
Pepper

Can recognize human faces
and basic emotions



Da Vinci ® Surgical Systems

Can perform
minimally invasive surgeries

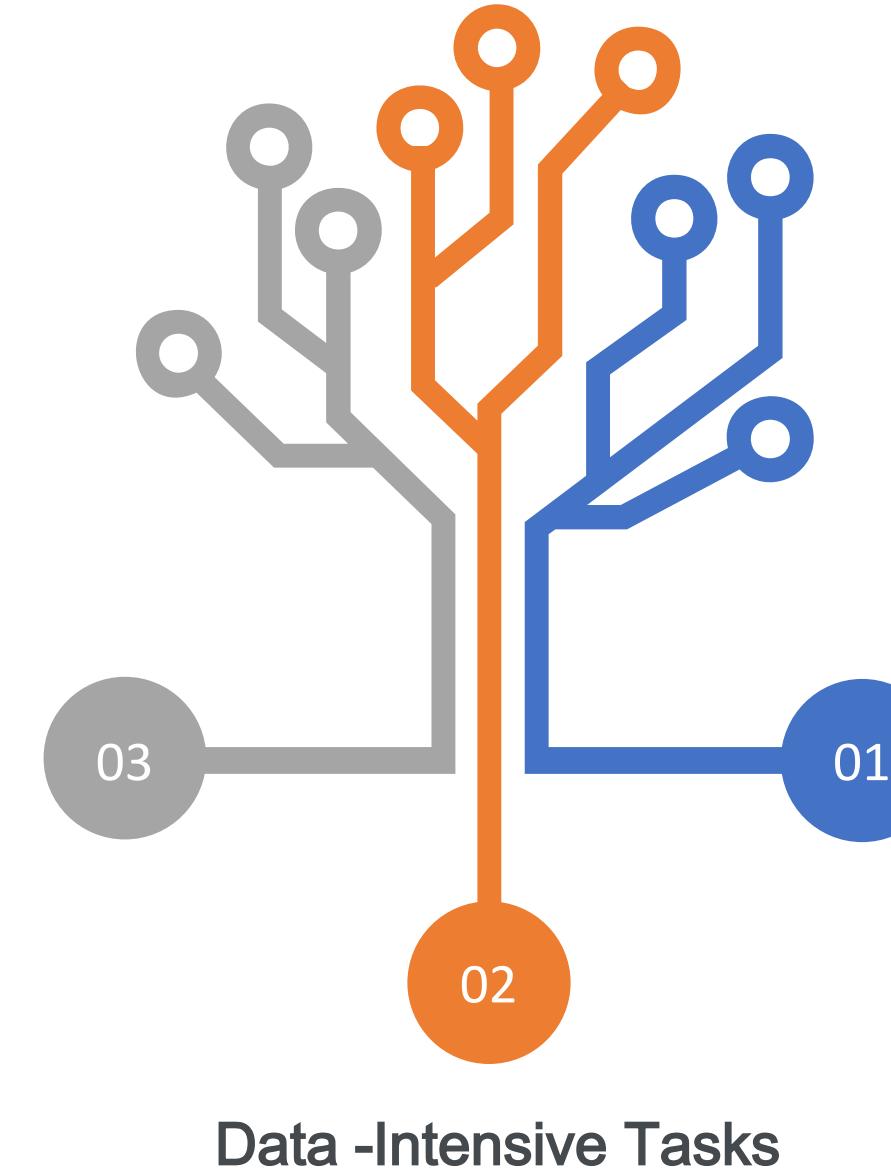


Google Duplex

Can make reservations
or appointments, over the phone

What Can AI Do?

Here are some problems best suited for AI to solve:



Advantages of AI

Error Reduction

With incredible precision, accuracy, and speed, AI has a low error rate compared to humans.

Digital Assistants

AI can assist users in their daily chores and activities.

Difficult Explorations

AI can work in hostile environments that would injure or kill humans to complete dangerous tasks and endure problems.



Medical Applications

AI has a significant application in early detection and monitoring of various diseases.

Repetitive Jobs

Machines think faster than humans and can perform repetitive jobs swiftly.

No Breaks

Machines, unlike humans, don't need to sleep, rest, take breaks, or get entertained.

Limitations of AI

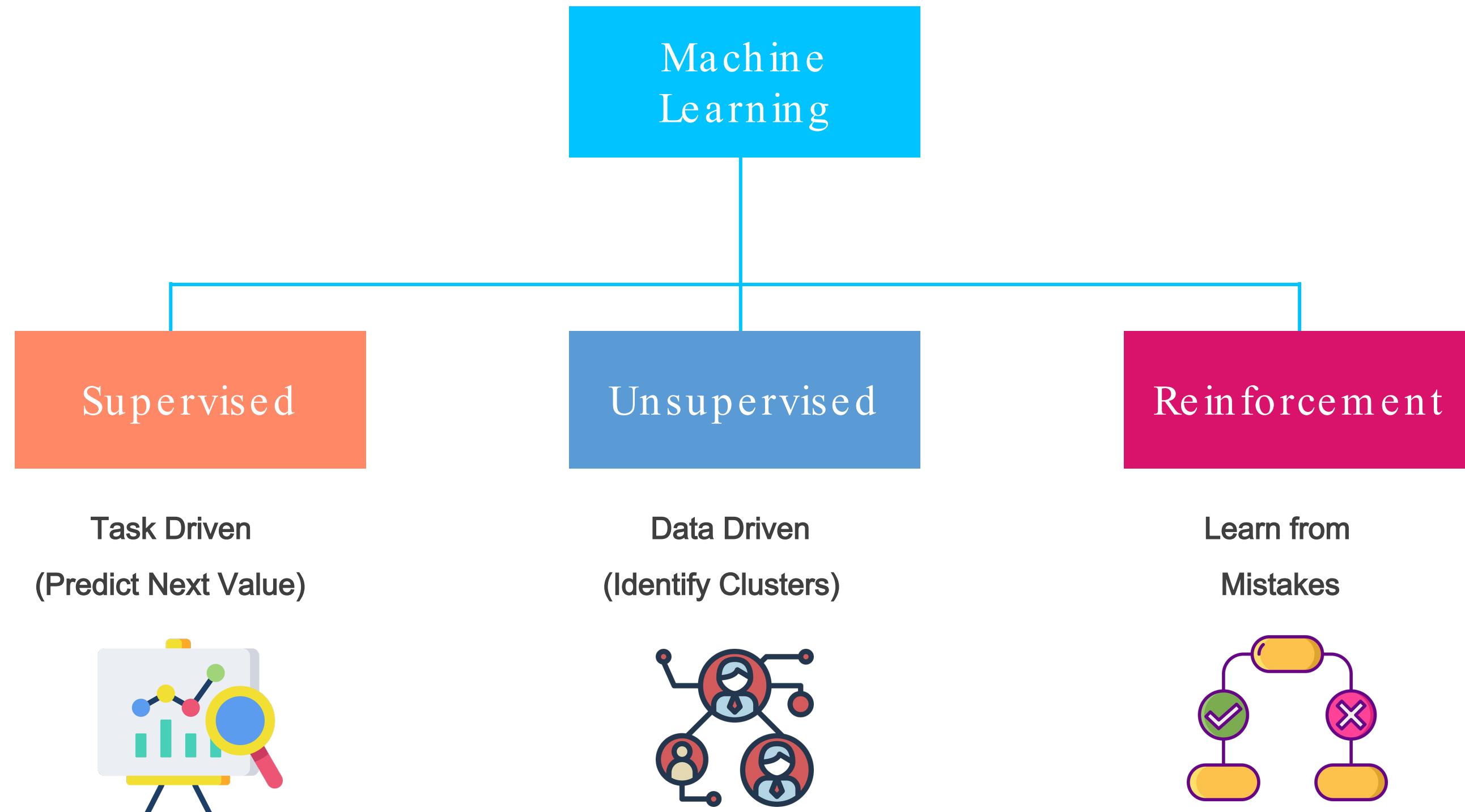
- 1 Very challenging to capture all traits of human intelligence
- 2 Current focus of development lies with lucrative domain specific applications
- 3 Limited ability with respect to the diversity of domain problems
- 4 Unpredictability or failure in emergency situations
- 5 High cost for R&D and production



Recap: Machine Learning

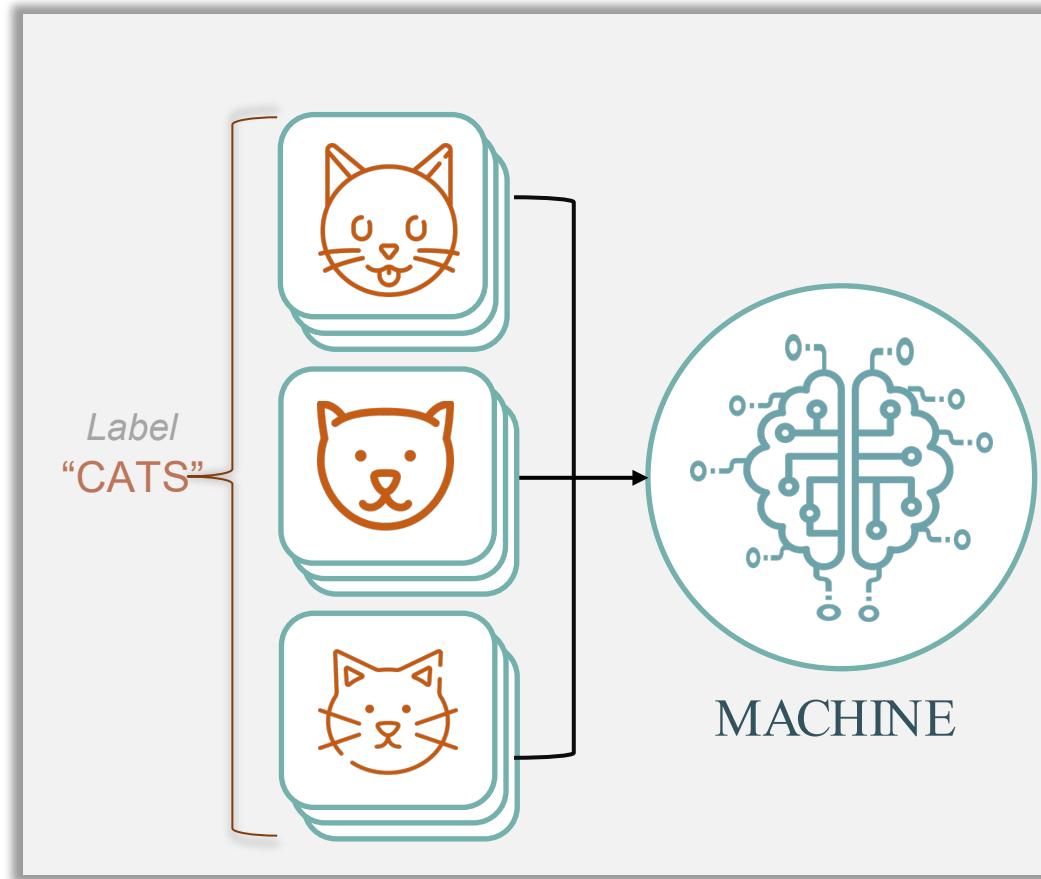
Types of Machine Learning

Machine learning comprises three primary techniques:

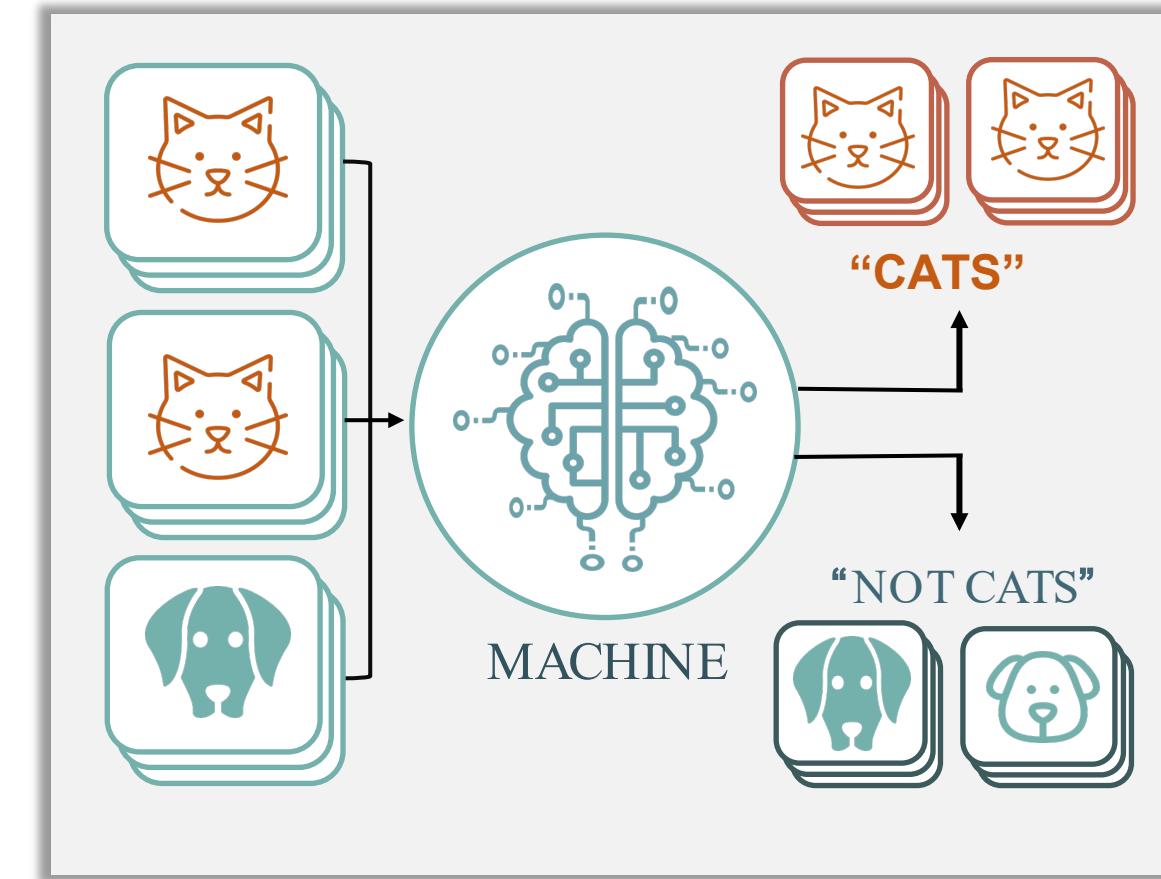


Supervised Learning

The goal of supervised learning is to build a mapping function (f) that takes the input data (x) and predicts the output data (Y).



Step 1: Provide labeled input and output to train

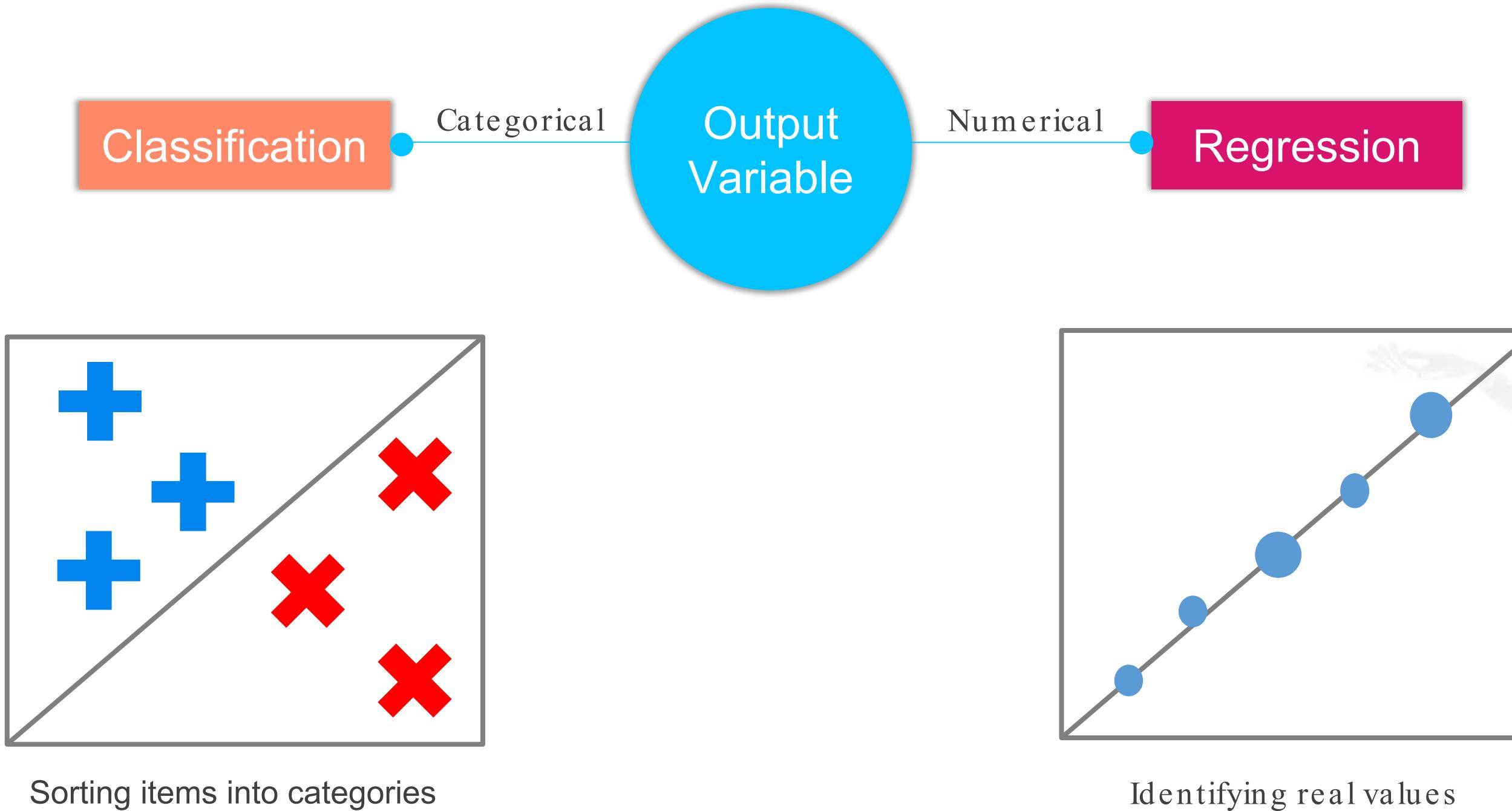


Step 2: Provide new unlabeled data to test

The mapping function (f) has to achieve a certain level of performance to be considered fit for production.

Types of Supervised Learning

There are two types of supervised learning depending on the type of the output variable.



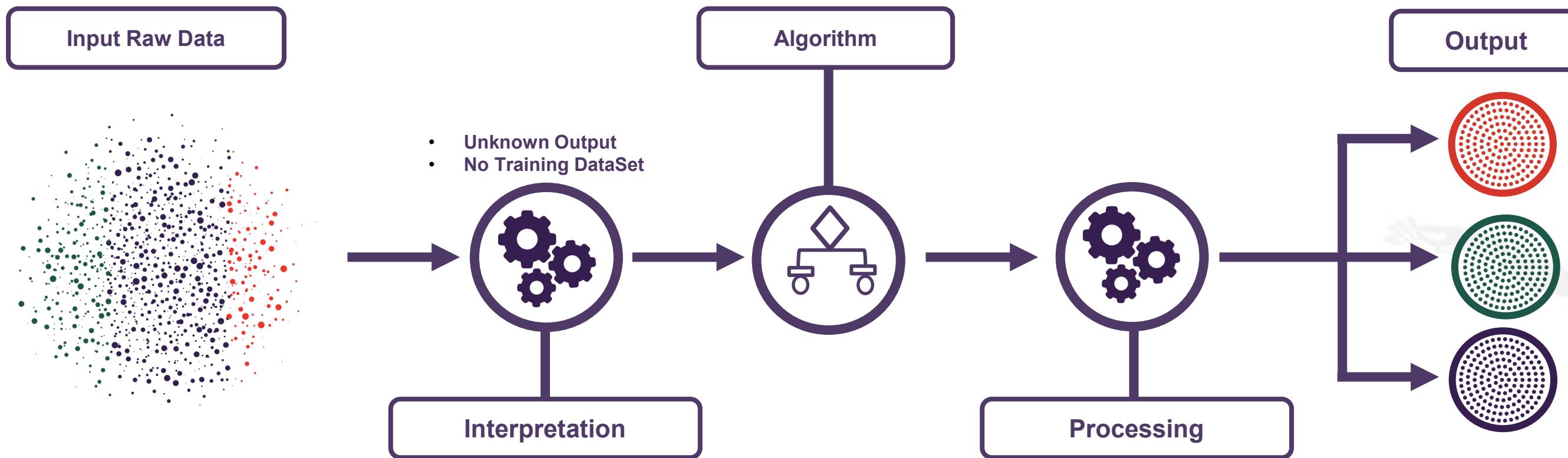
Supervised Learning Algorithms

A list of supervised machine learning algorithms include:

- Linear Regression
- Logistic Regression
- Support Vector Machines
- Naive Bayes
- Decision Trees
- Linear Discriminant Analysis

Unsupervised Learning

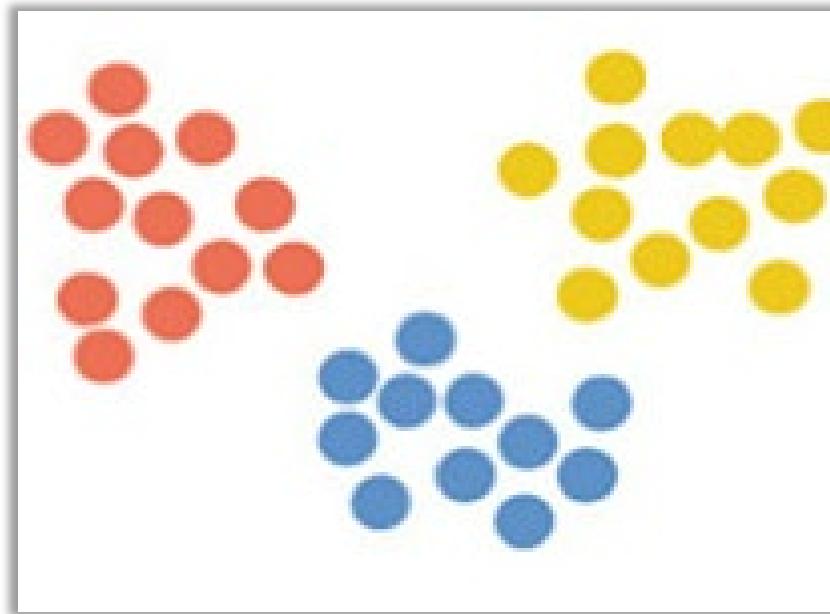
In unsupervised learning, only the inputs are known and the model is trained on the inputs to find the underlying patterns in the data.



Types of Unsupervised Learning

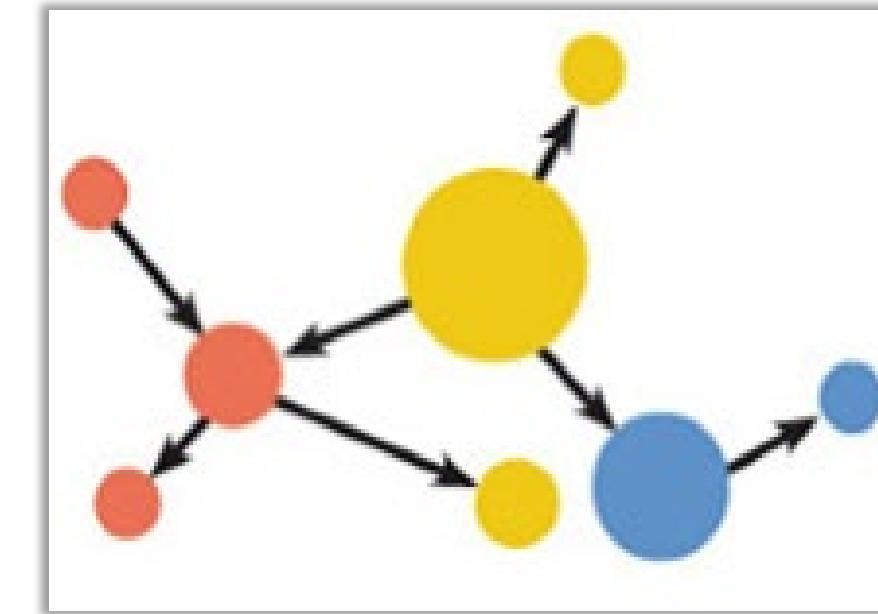
Unsupervised learning is classified into two categories of algorithms:

Clustering



Discover groups inside the input data

Association



Discover rules inside the input data

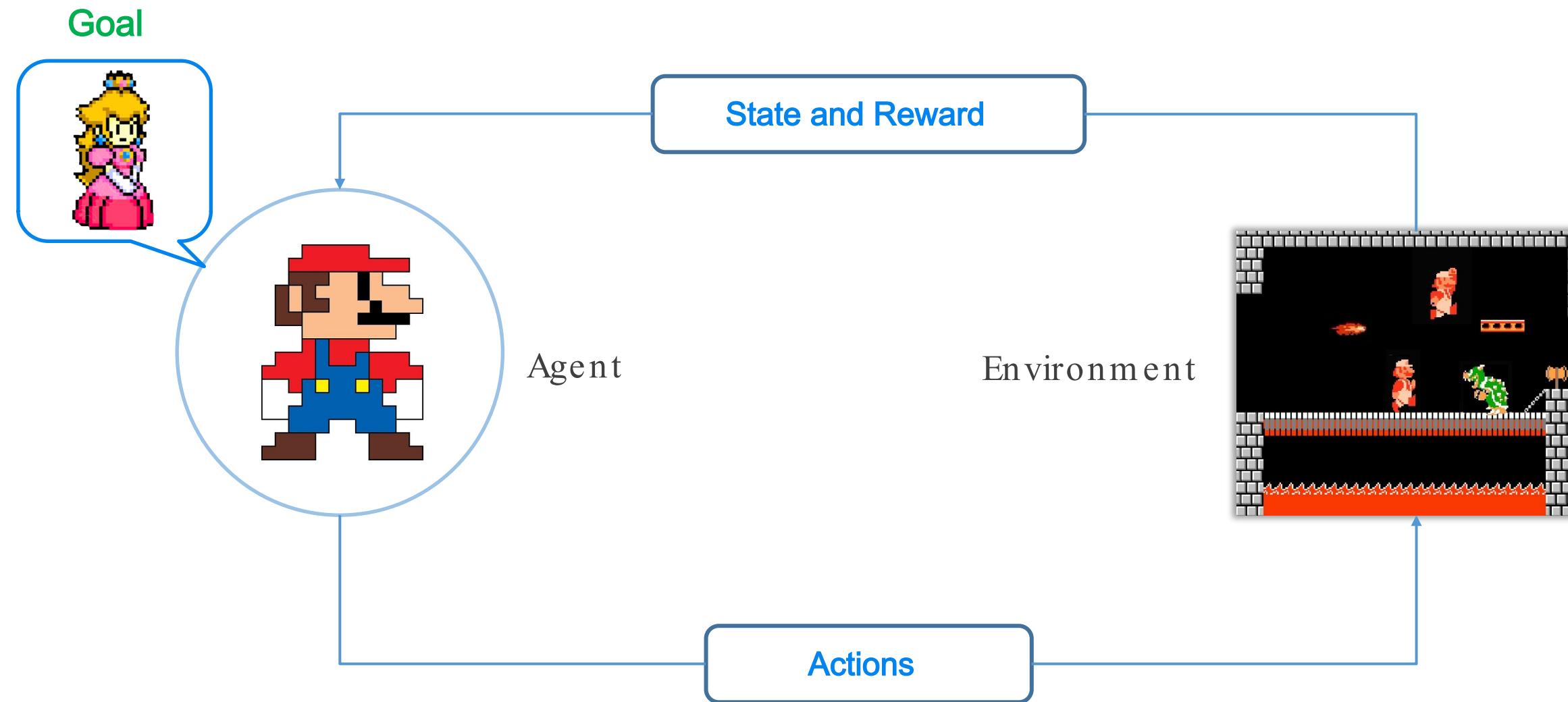
Unsupervised Learning Algorithms

A list of unsupervised machine learning algorithms include:

- K-means Clustering
- Apriori Algorithm
- Hierarchical Clustering
- Principal Component Analysis
- Density-Based Spatial Clustering of Applications with Noise (DBSCAN)
- Non-Negative Matrix Factorization

Reinforcement Learning

Reinforcement learning agents are goal -oriented. They learn by trial and error in an environment that provides rewards or penalties in response to the agents' outputs.



The aim is to find the best path that maximizes the likelihood of winning reward.

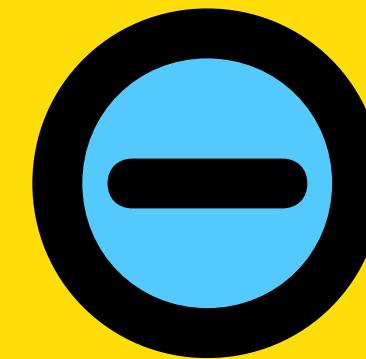
Types of Reinforcement Learning

There are two types of reinforcement learning:



Positive Reinforcement

Desirable stimulus is added to increase the likelihood of a behavior.



Negative Reinforcement

Undesirable stimulus is removed to increase the likelihood of a behavior.

Reinforcement Learning Algorithms

A list of reinforcement machine learning algorithms include:

- Monte Carlo
- Q-Learning
- State–Action–Reward–State–Action (SARSA)
- Deep Q Network
- Q-Lambda
- SARSA-Lambda

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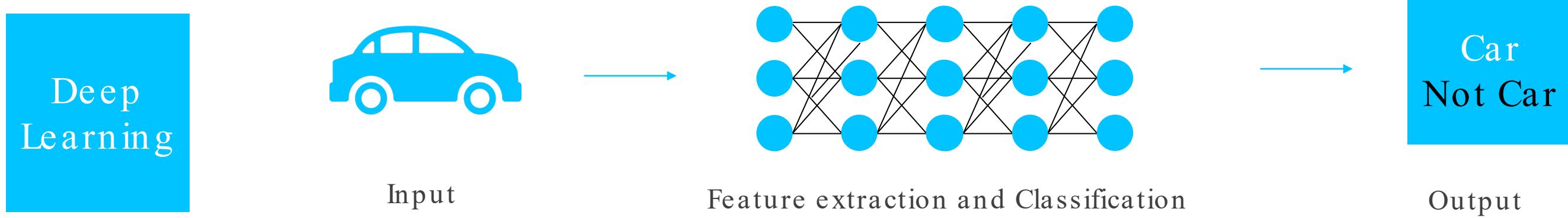
Deep Learning

ML vs. DL

Deep Learning is a subset of Machine Learning and is used to extract useful patterns from data.



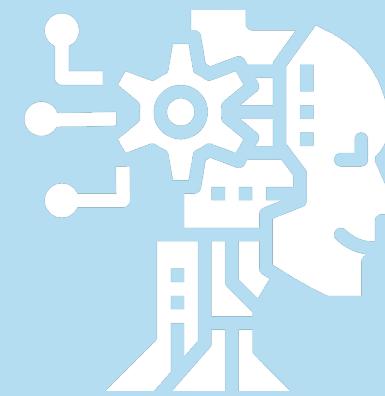
Machine Learning models need human intervention to arrive at the optimal outcome.



Deep Learning models make predictions independent of human intervention.

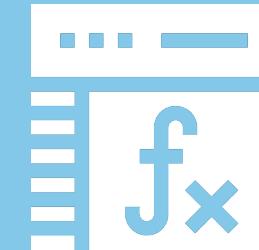
ARTIFICIAL INTELLIGENCE

A technique which enables machines to mimic human behavior



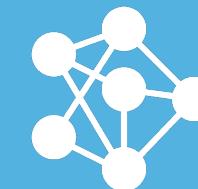
MACHINE LEARNING

Subset of AI technique which use statistical methods to enable machines to improve with experience



DEEP LEARNING

Subset of ML which makes the computation of multi-layer neural network feasible



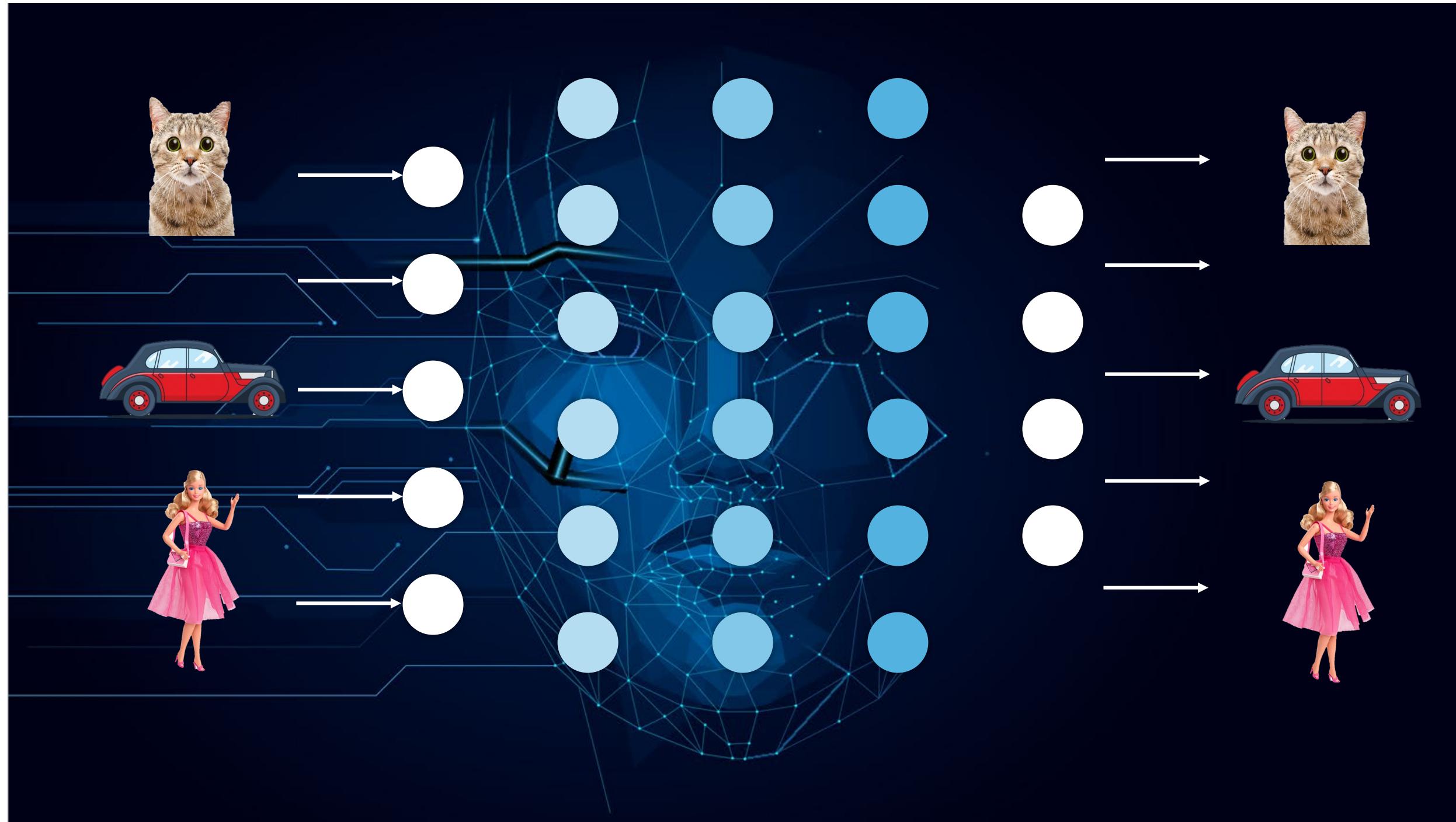
Neural Networks

Deep Learning models utilize artificial neural networks (ANN) that are inspired by the biological neural network of the human brain.



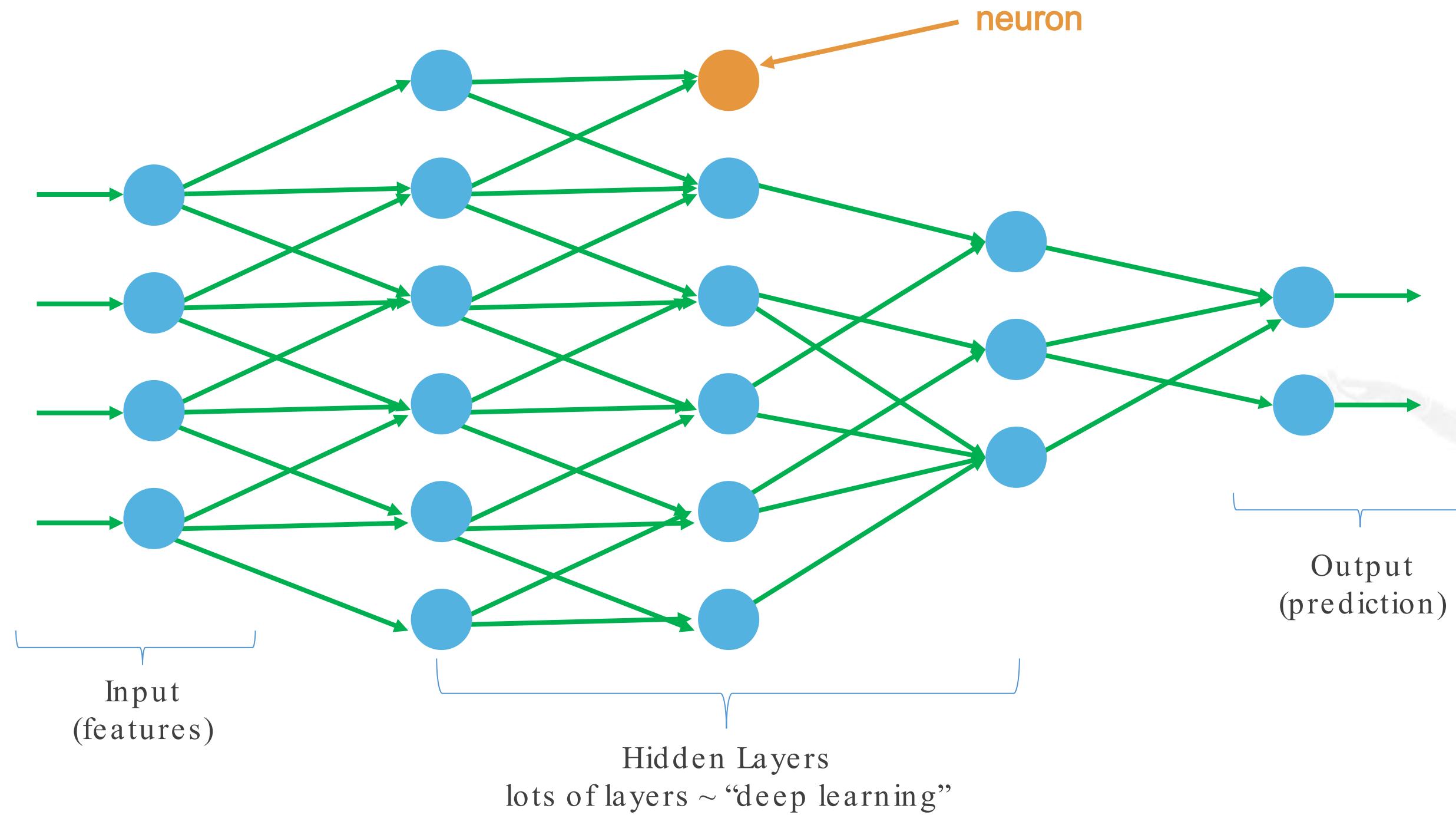
Artificial Neural Network (ANN)

ANNs try to imitate neuronal activity in the brain in order to learn to recognize data patterns.



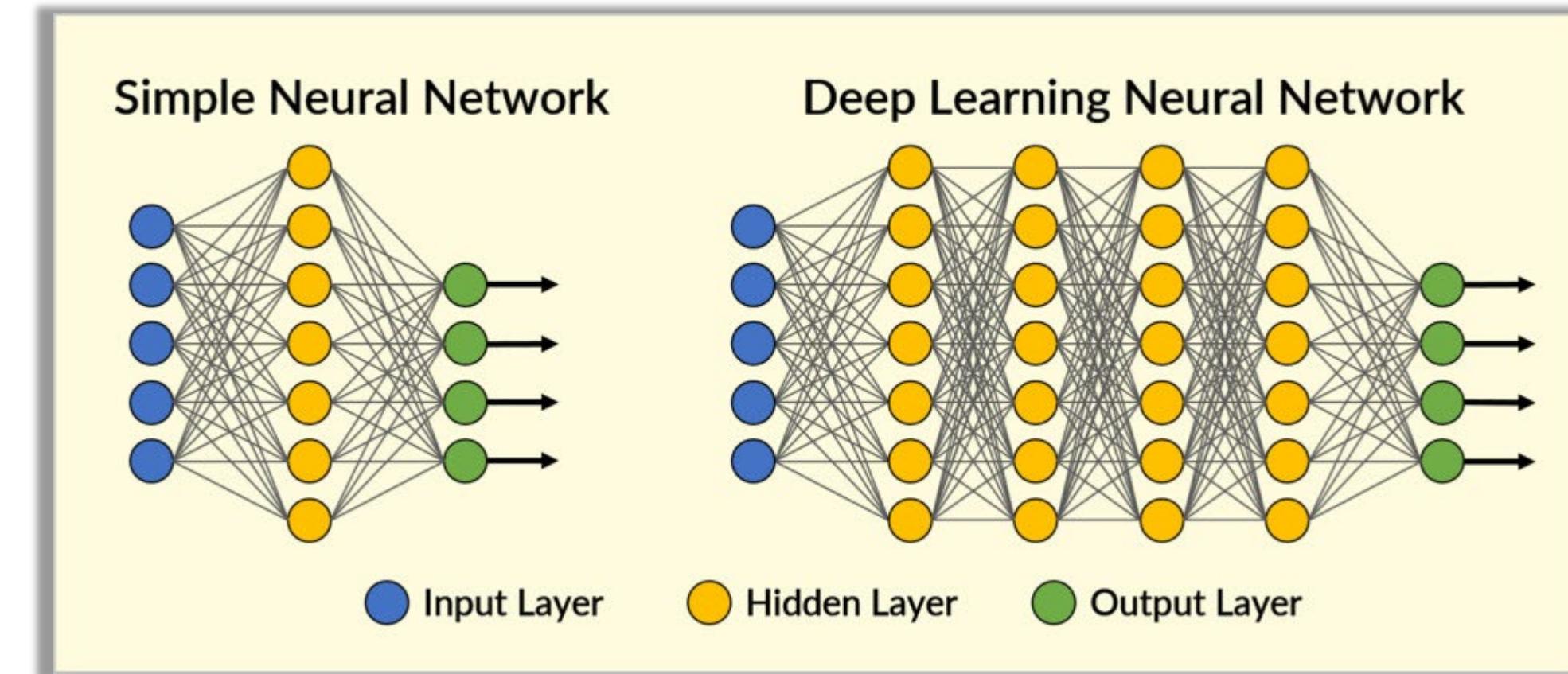
Deep Learning

The deep in Deep Learning refers to the large number of layers of neurons that help to learn various representations of data.



Network Architecture

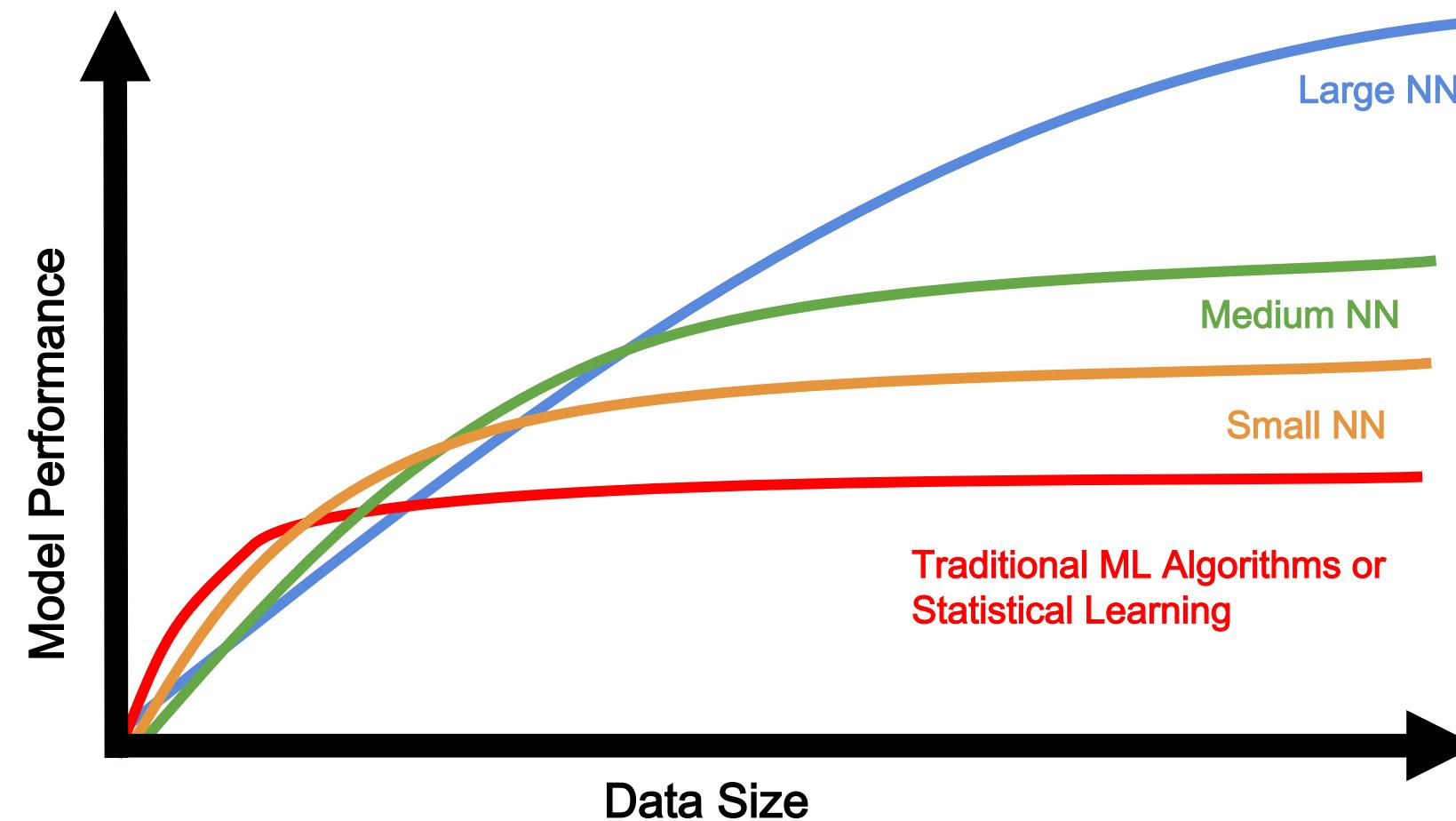
One can programmatically set the number and type of neural layers and the number of neurons comprising each layer.



Shallow neural networks consist of only 1 or 2 hidden layers.

Performance

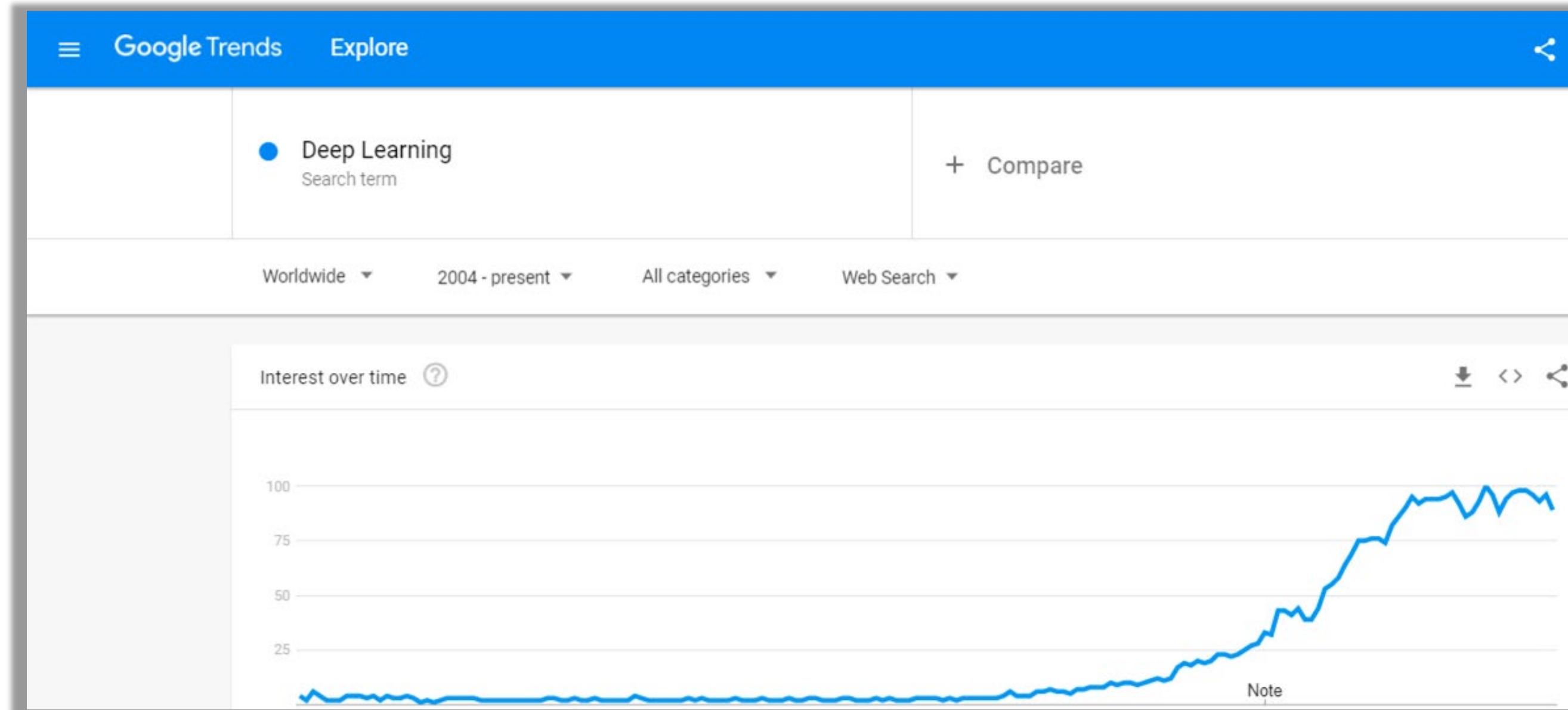
Deep AI models have greater precision than conventional techniques but require more information to train and attain this precision.



Deep Learning: Success Stories from the Last Decade

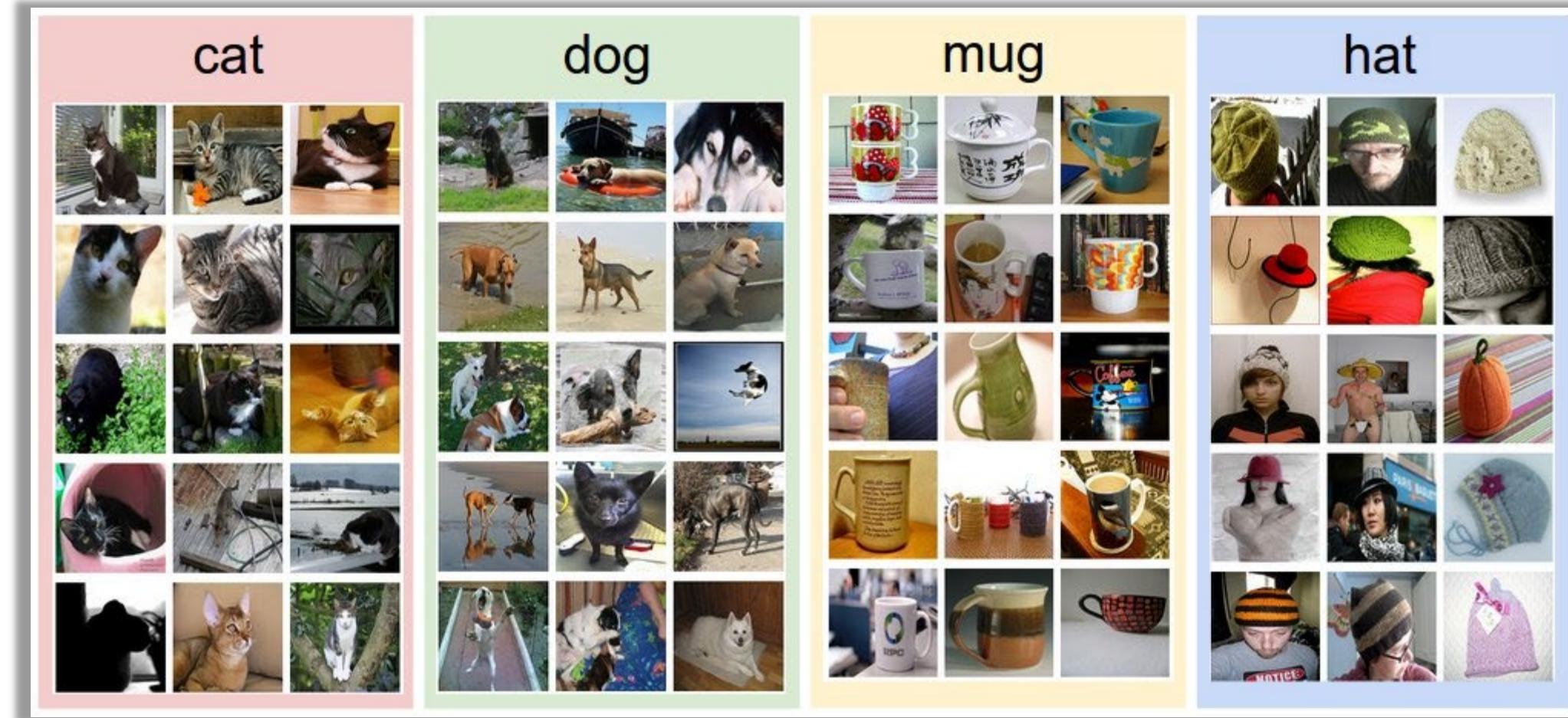
Deep Learning Search Trends

Over the past several years, people are looking for more information on deep learning.



ImageNet

In 2009, a large visual database called ImageNet was created which catapulted deep learning of the 21st century.



The database has more than **14 million labeled images**

which can be used to train neural nets.

The History Began from AlexNet

In 2012, a neural network named AlexNet was trained on more than a million images from the ImageNet database. It won the ImageNet competition by a large margin.

ImageNet Classification with Deep Convolutional Neural Networks

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Geoffrey E. Hinton
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Abstract

We trained a large, deep convolutional neural network to classify the 1.2 million high-resolution images in the ImageNet LSVRC-2010 contest into the 1000 different classes. On the test data, we achieved top-1 and top-5 error rates of 37.5% and 17.0% which is considerably better than the previous state-of-the-art. The neural network, which has 60 million parameters and 650,000 neurons, consists of five convolutional layers, some of which are followed by max-pooling layers, and three fully-connected layers with a final 1000-way softmax. To make training faster, we used non-saturating neurons and a very efficient GPU implementation of the convolution operation. To reduce overfitting in the fully-connected layers we employed a recently-developed regularization method called “dropout” that proved to be very effective. We also entered a variant of this model in the ILSVRC-2012 competition and achieved a winning top-5 test error rate of 15.3%, compared to 26.2% achieved by the second-best entry.

The success of AlexNet spurred more papers and accelerated deep learning renaissance.

Recognizing Cats on YouTube

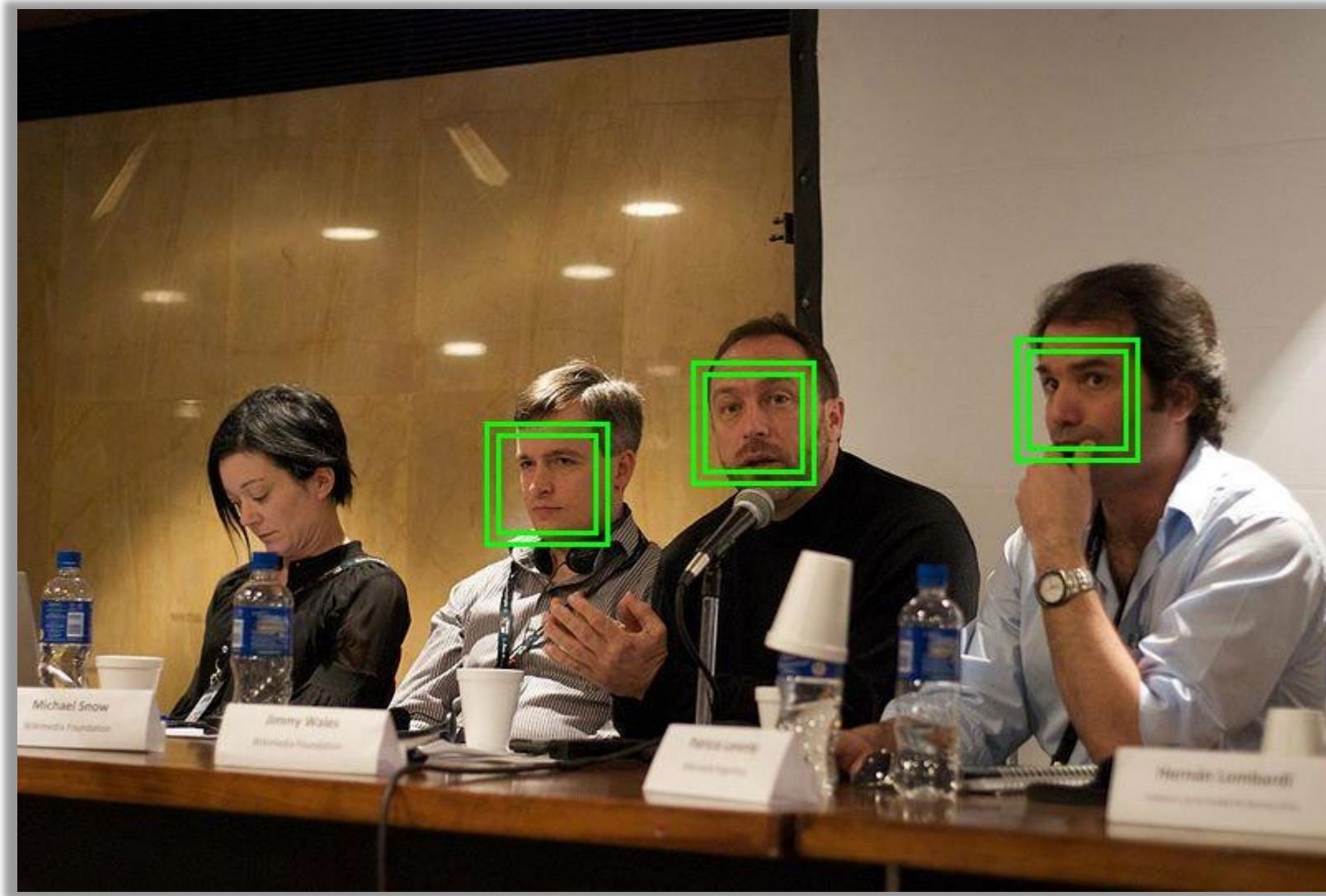
In 2012, Google Brain team trained its neural network to recognize cats by watching unlabeled images taken from frames of YouTube videos.



It was a 70% improvement over any other machine learning technique at the time.

DeepFace

Facebook's DeepFace, released in 2014, used neural networks to identify human faces with 97.35% accuracy.



The facial recognition system was trained on four million images uploaded by Facebook users.

Beating Humans in Go

In 2015, AlphaGo algorithm developed by Google DeepMind becomes the first computer program to defeat a human professional.



The second version, AlphaGo Zero defeated the 18-time world champion Lee Sedol very easily.

Video Games

Video games are used to test and evaluate the performance of artificial intelligence systems.



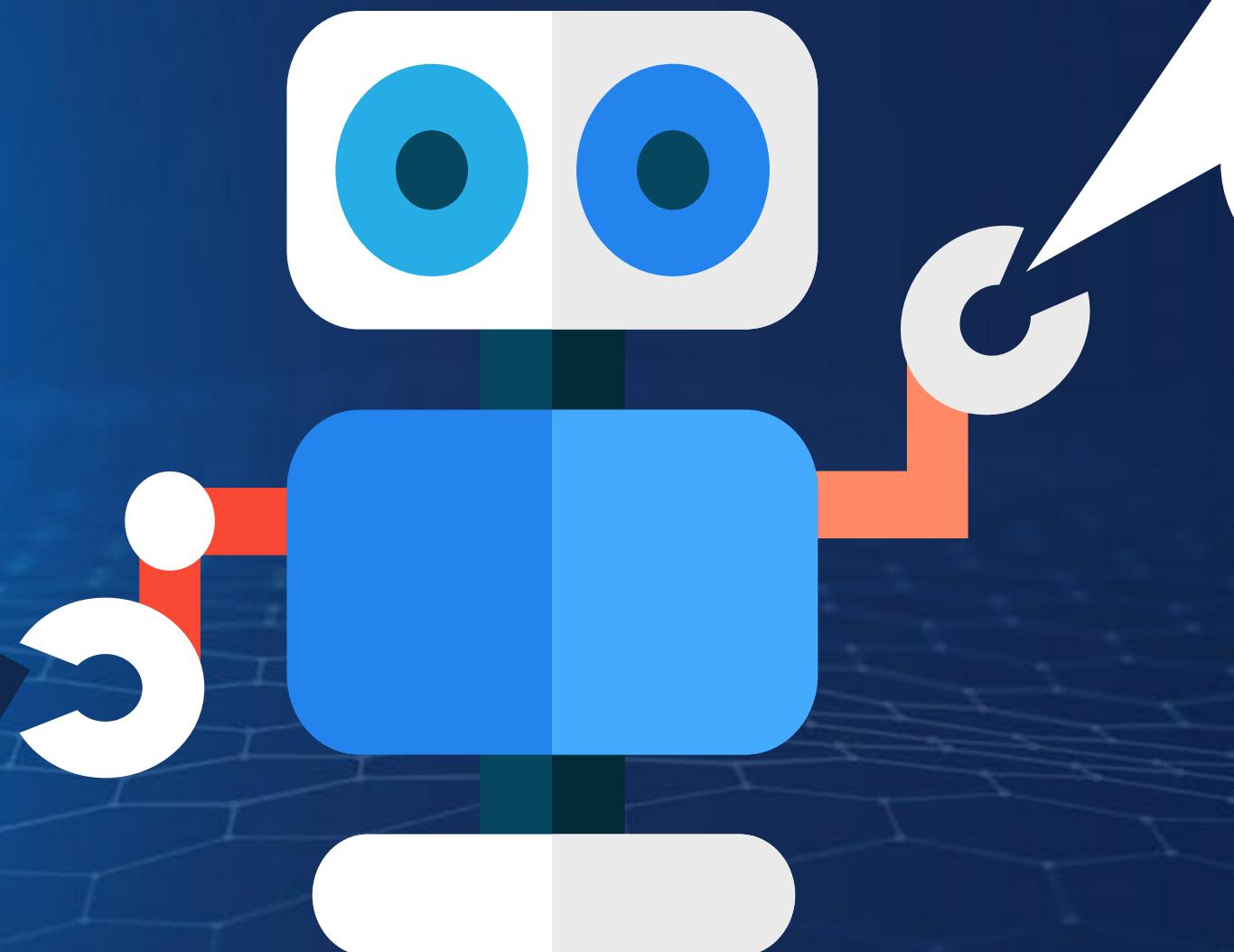
In 2019, the AlphaStar program defeated a top professional player in StarCraft that was considered to be one of the most challenging Real-Time Strategy (RTS) games.

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This prompts you to ask
the question...

*Can machines be used to
automate the
human visual system ?*

Let's find out!



Notice that all previous
efforts and successes of
DL lie in
image classification.

Computers are now enabled
to gain high-level
understanding from digital
images or videos.

DATA AND ARTIFICIAL INTELLIGENCE

Self-Driving Cars

Self-Driving Cars

A self-driving car uses a variety of cameras and sensors to perceive its surroundings and moves safely with little or no human input.



Why the Excitement for Self -Driving?

Self-driving vehicles will be a significant innovation in transportation since they can radically transform how people and goods move around.



Autonomous vehicles will help blind, elderly, and disabled people to move independently, regardless of distance.



Self-driving trucks can drastically reduce delivery times and accidents. Driver and maintenance costs will also reduce.

Advantages of Self -Driving



Less stressful driving

Automated lane changes,
parking, and braking



Energy efficiency

Improved fuel efficiency



Reduced crash rates

Driver error causes 90%
of all crashes



Ease traffic congestion

Better coordinated traffic
leads to less congestion

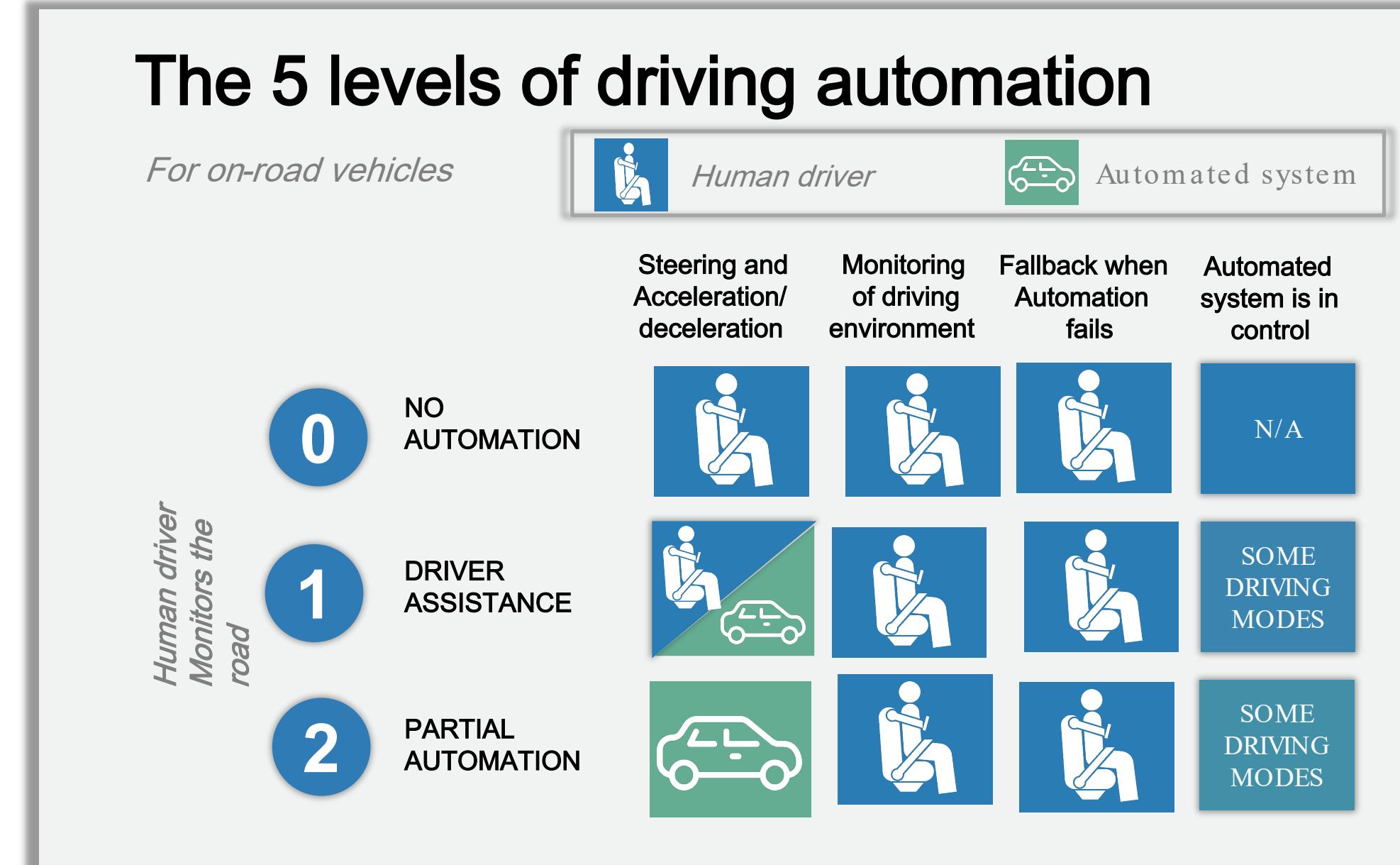


Over the air updates

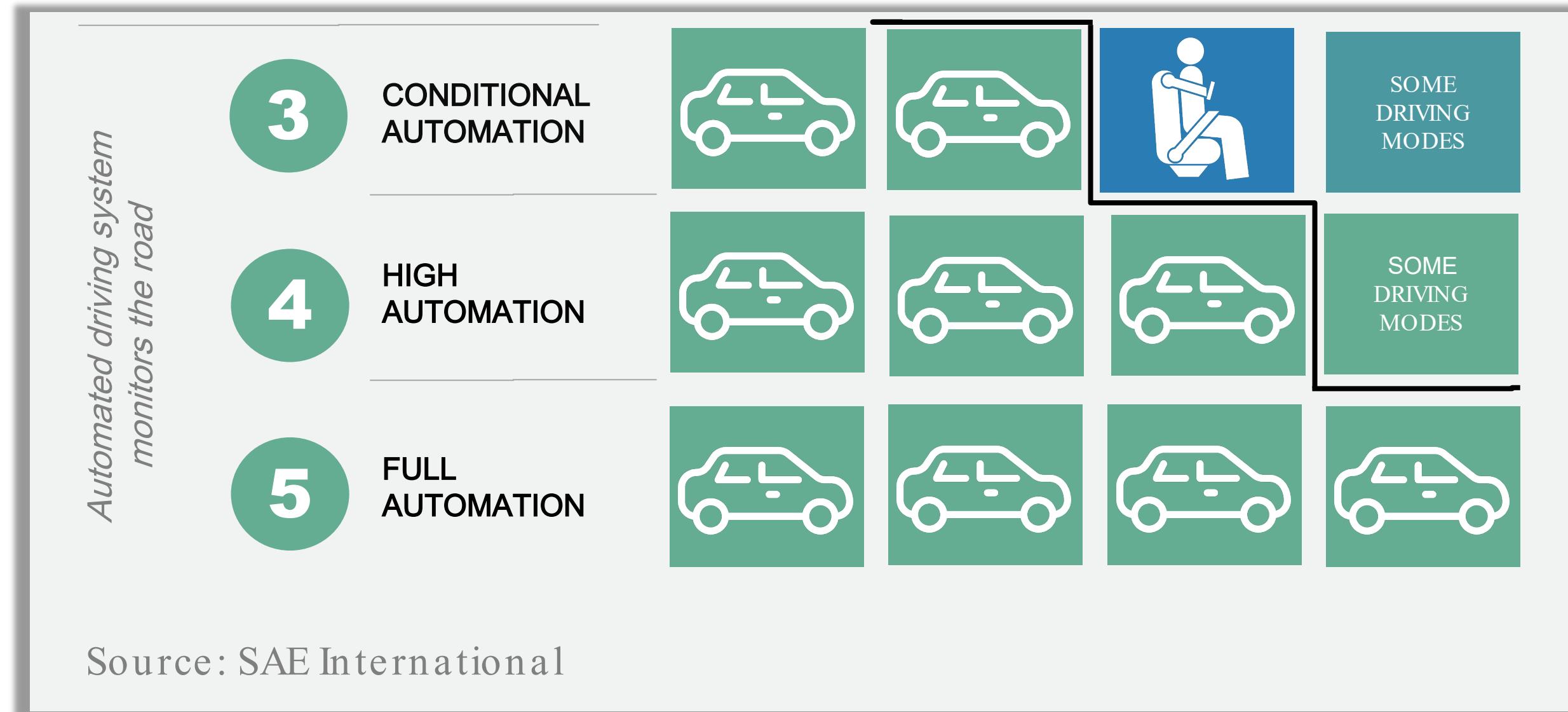
Neural nets get better
with more data

Levels of Driving Automation

The Society of Automotive Engineers (SAE) has defined five levels in the evolution of autonomous driving.

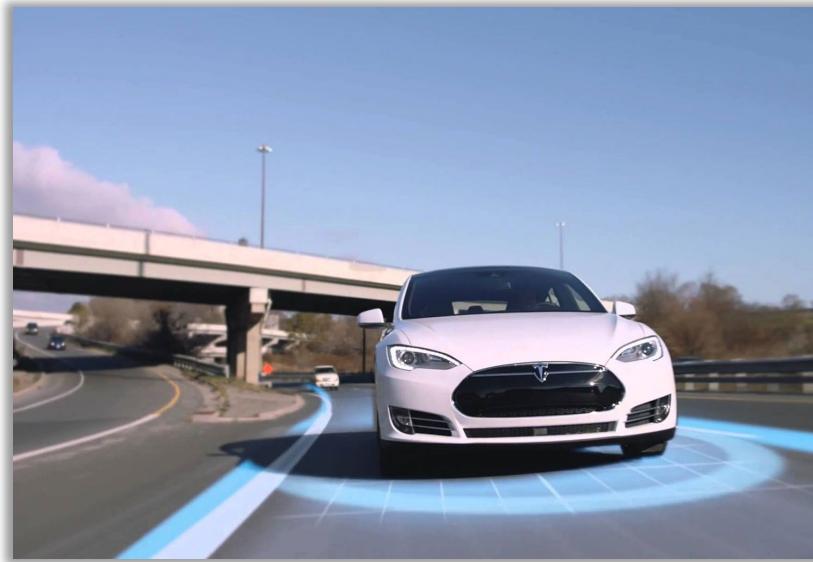


Levels of Driving Automation



Industry Trends

Various self -driving technologies have been developed by leading companies and major automakers.



Tesla



Nissan

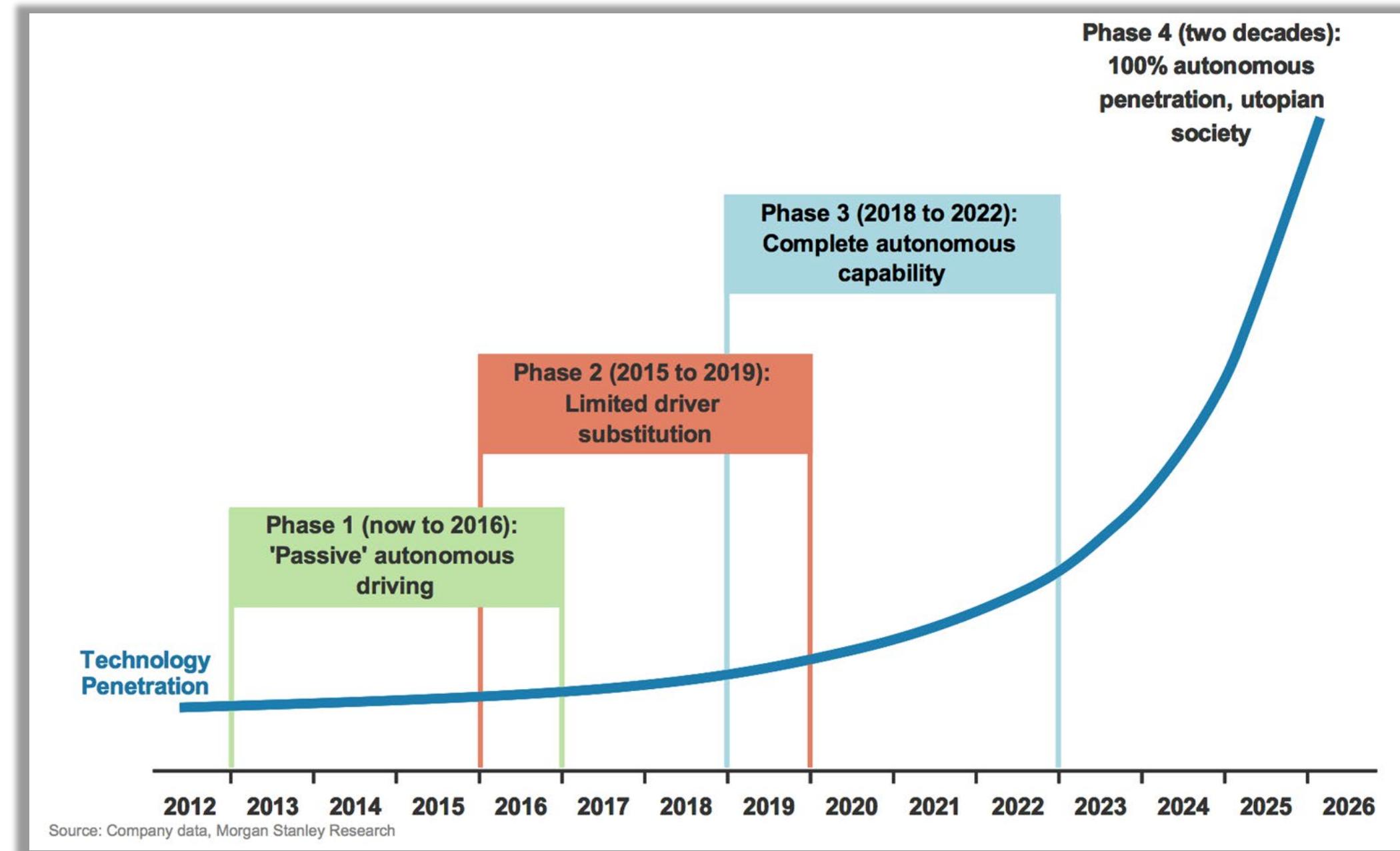


Google Waymo

Presently, self-driving cars are at **Level 3** technology.

Timeline for Adoption

Automobile industry expects a significant rise in cars with some self -driving capacity on the road by the early 2020s.



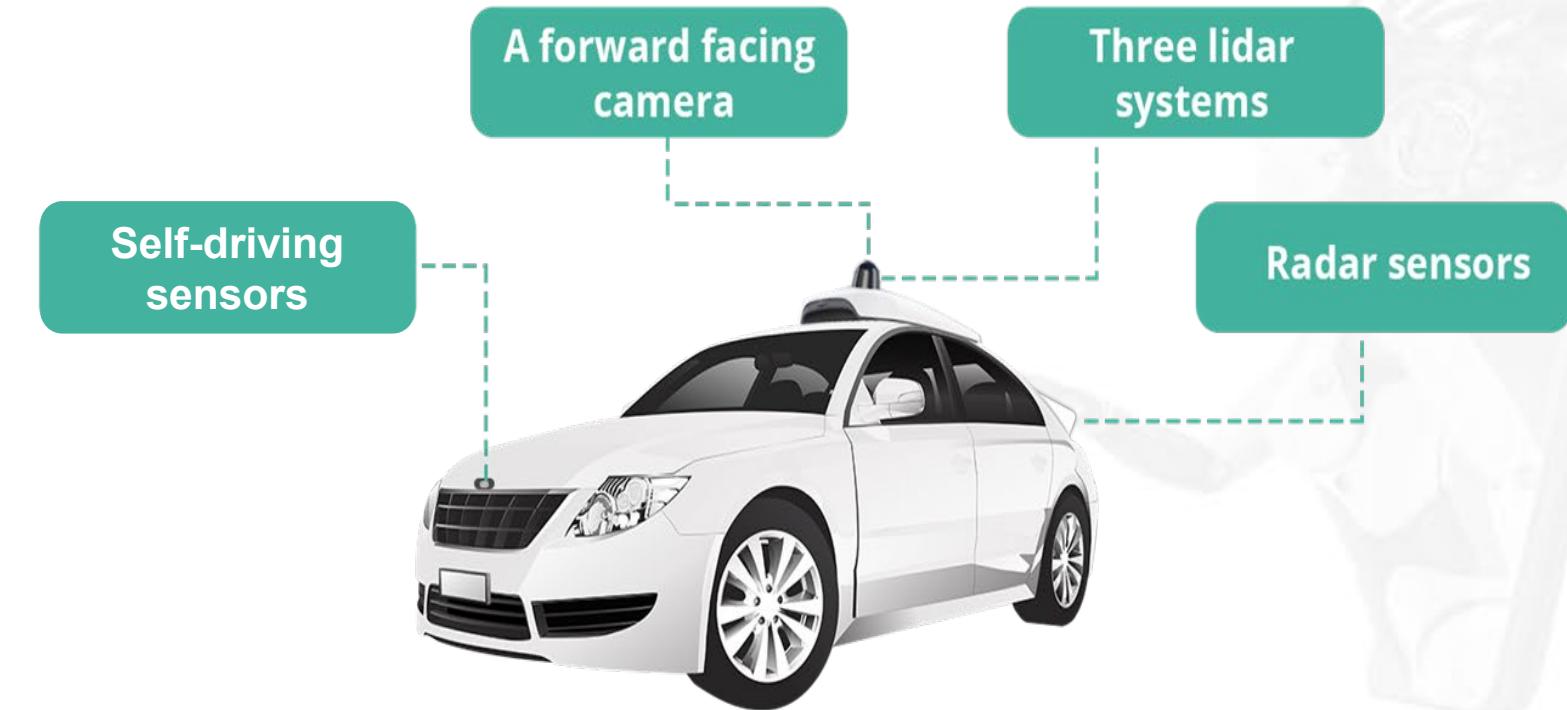
Working of Self-Driving Cars

How Does a Self -Driving Car See?

- 1 Using high -powered sensors and cameras, the vehicle creates and maintains a map of its environment.

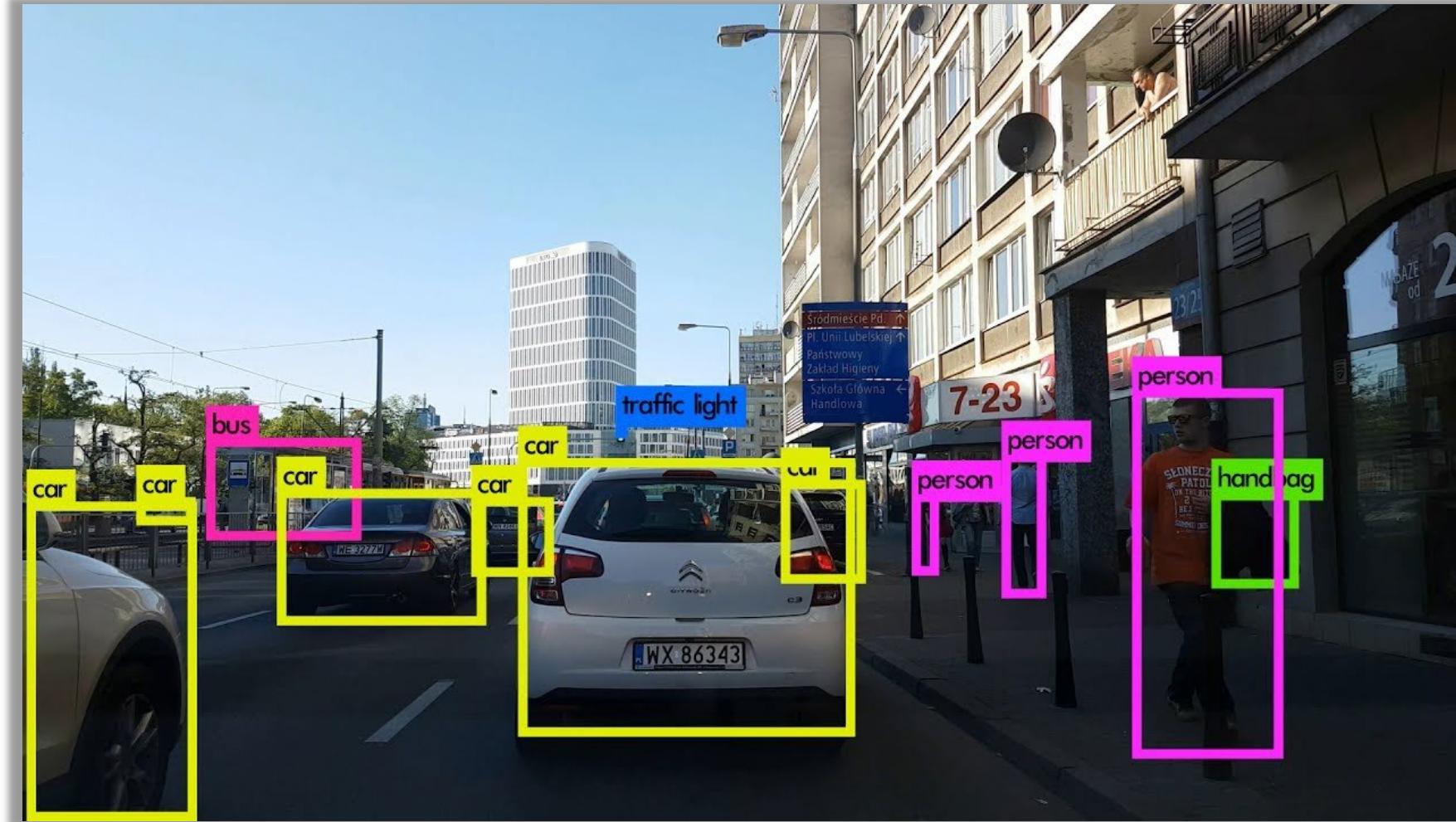
- 2 A powerful onboard computer processes the information in a matter of milliseconds using hard -coded rules and obstacle avoidance algorithms.

- 3 Then, it plots the route and sends instructions regarding vehicle's steering, acceleration, and braking.



How Does a Self -Driving Car See?

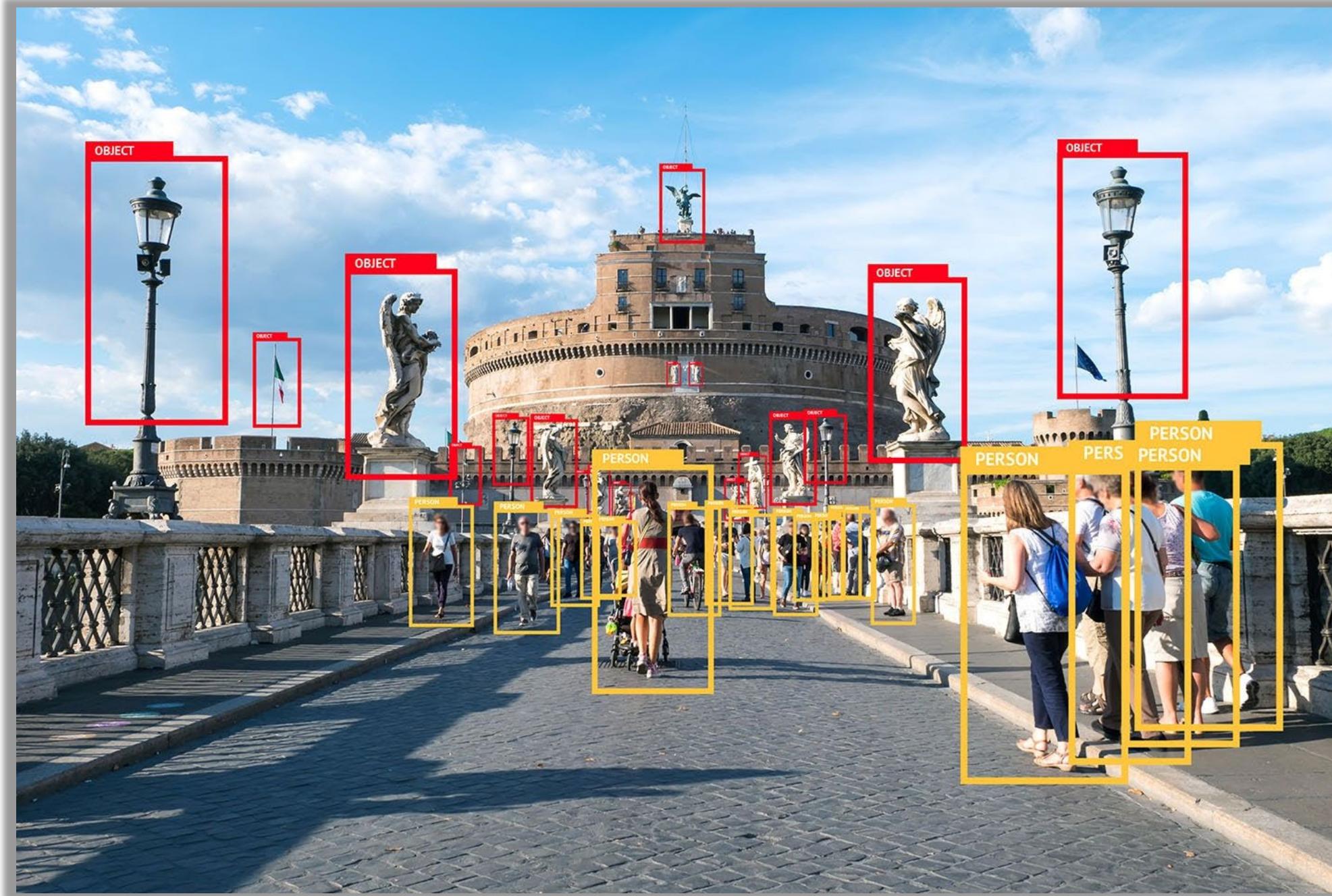
Precise detection of vehicles, pedestrians, and street signs help cars drive as safely as humans.



Detecting moving objects in video streams is a promising and challenging task for modern developers.

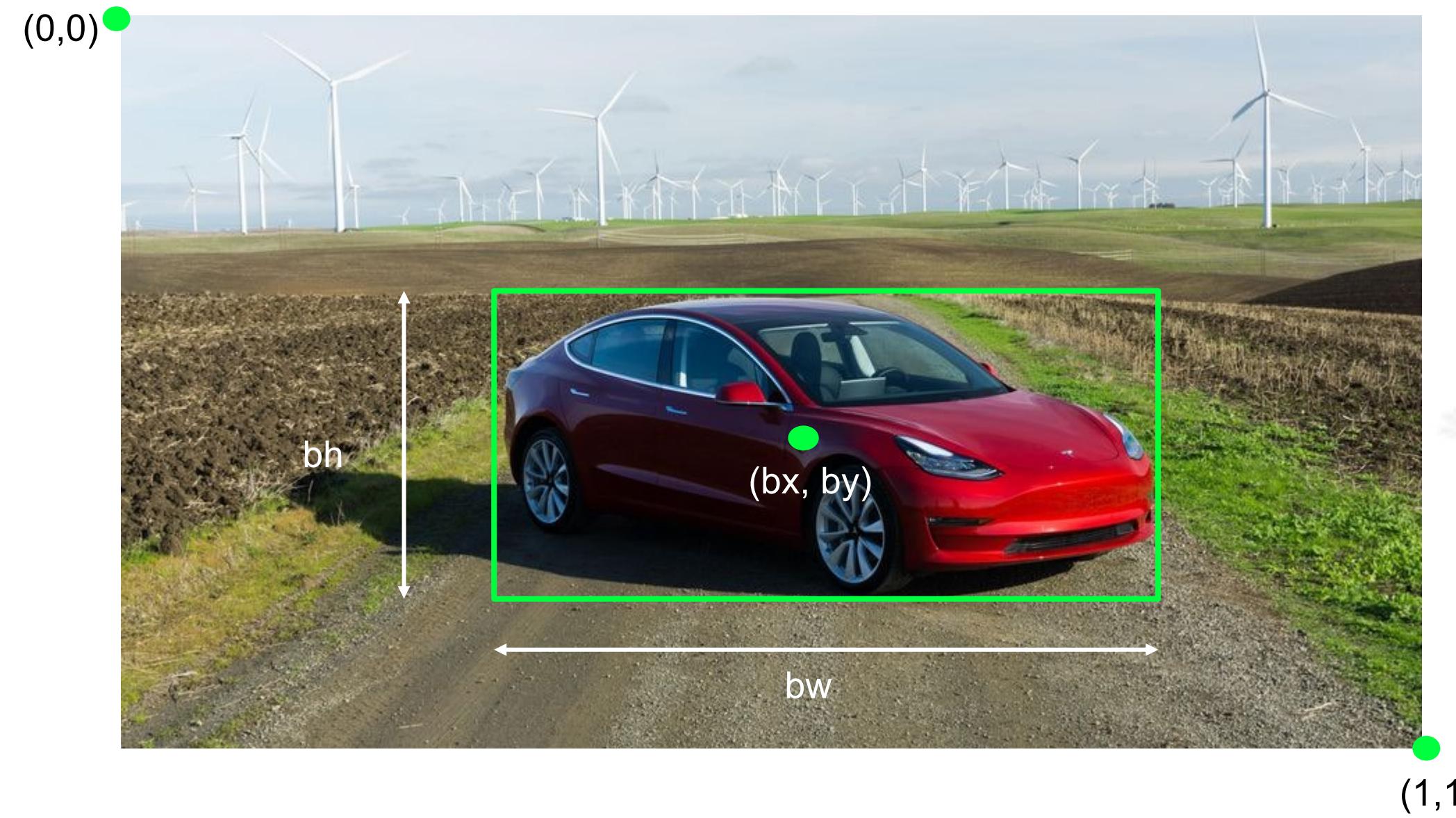
Object Detection

Object detection is used to identify and classify several items with high precision.



Object Localization

Object localization relates to the location of an object in the picture.



Bounding Boxes

The following parameters are used to initialize a bounding box:

◆ **bx, by**

Center coordinates of the bounding box

◆ **bw**

Width of the bounding box

◆ **bh**

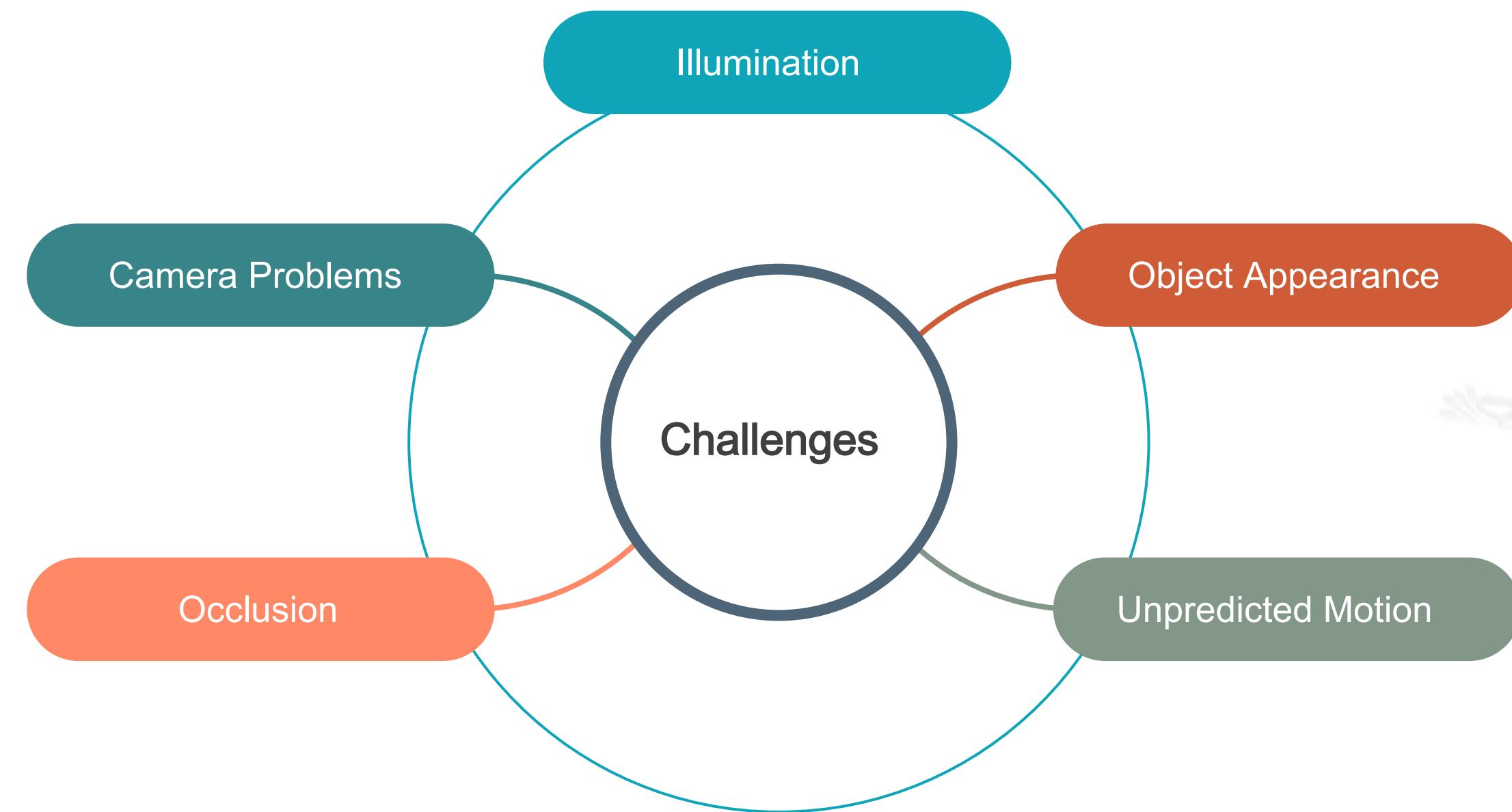
Height of the bounding box

An algorithm provides the coordinates of the object as the output is based on the picture in the bounding box.

Challenges in Self-Driving

Challenges in Self -Driving

Detecting objects is a challenging task since images of objects in the real -world environment are affected by various factors.



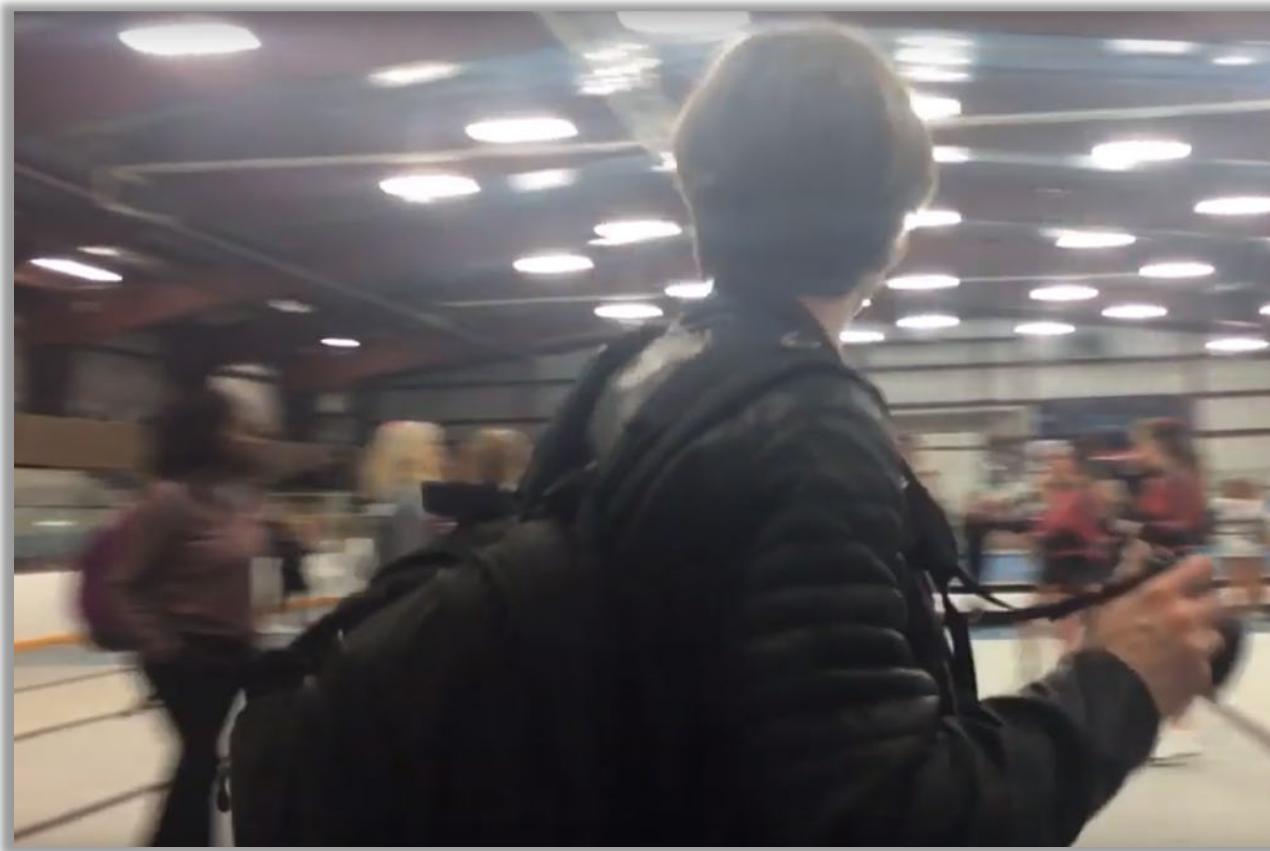
Illumination

Changes in lighting can lead to false positive object detection.



Appearance of Moving Objects

3D objects may change their shape and appearance when in motion.



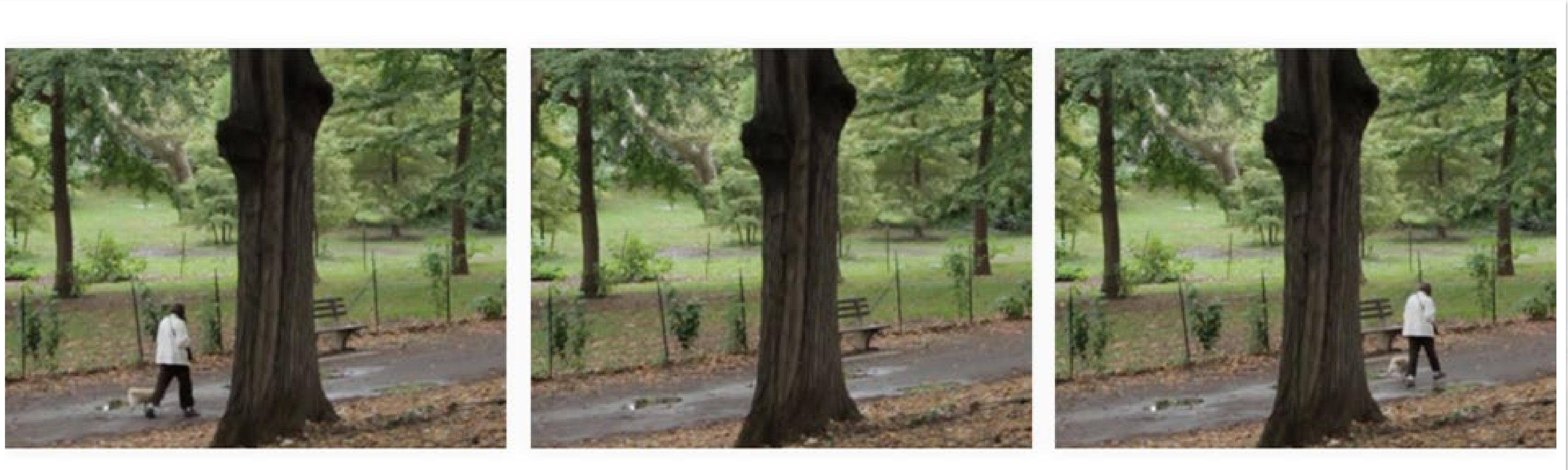
Presence of Unpredicted Motion

Detecting objects with abrupt motion may cause a tracker to lose the object or cause an error in the tracking algorithm.



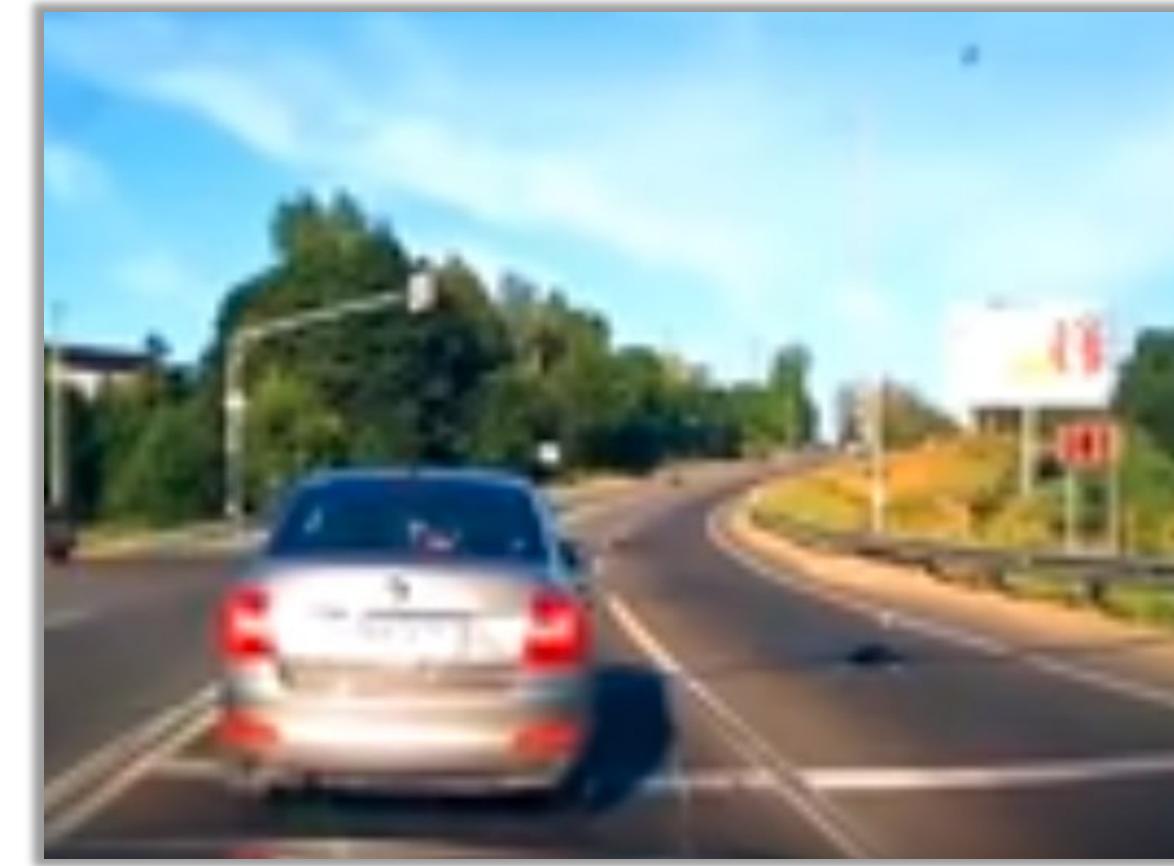
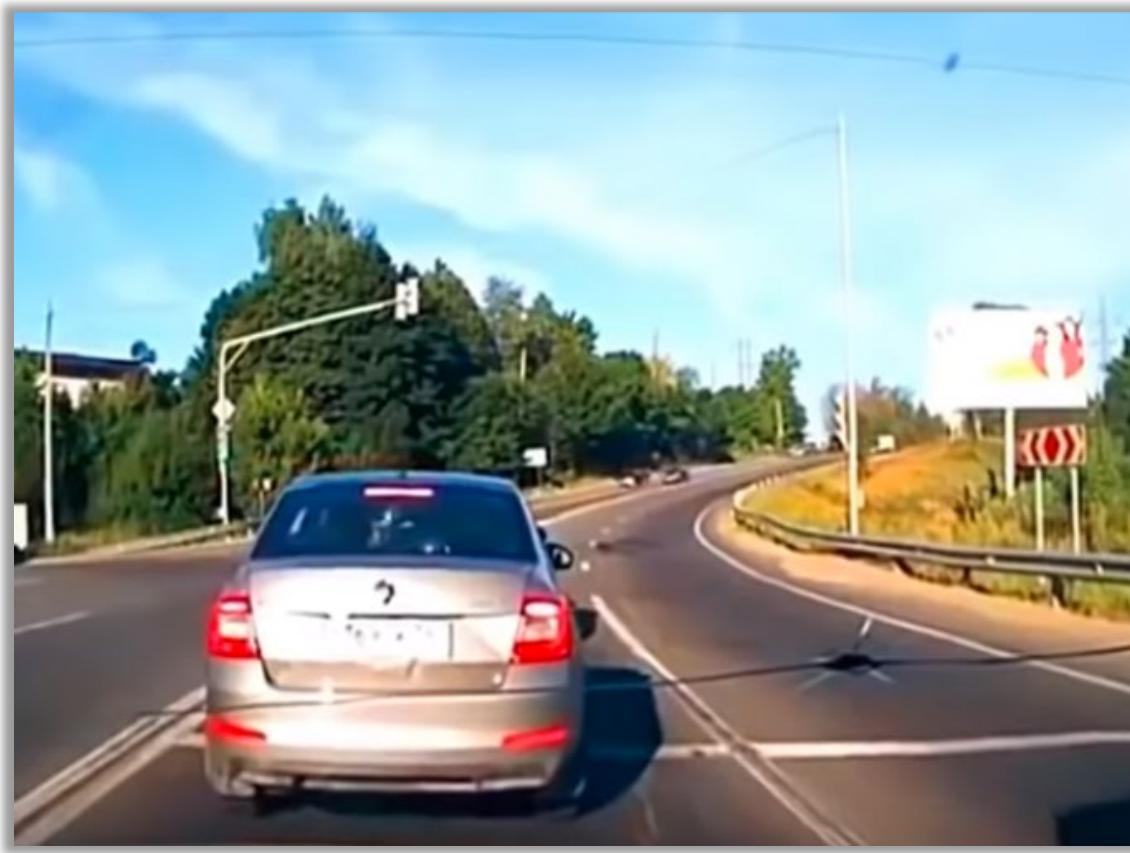
Occlusion

Objects in a video stream may be hidden fully or partially.



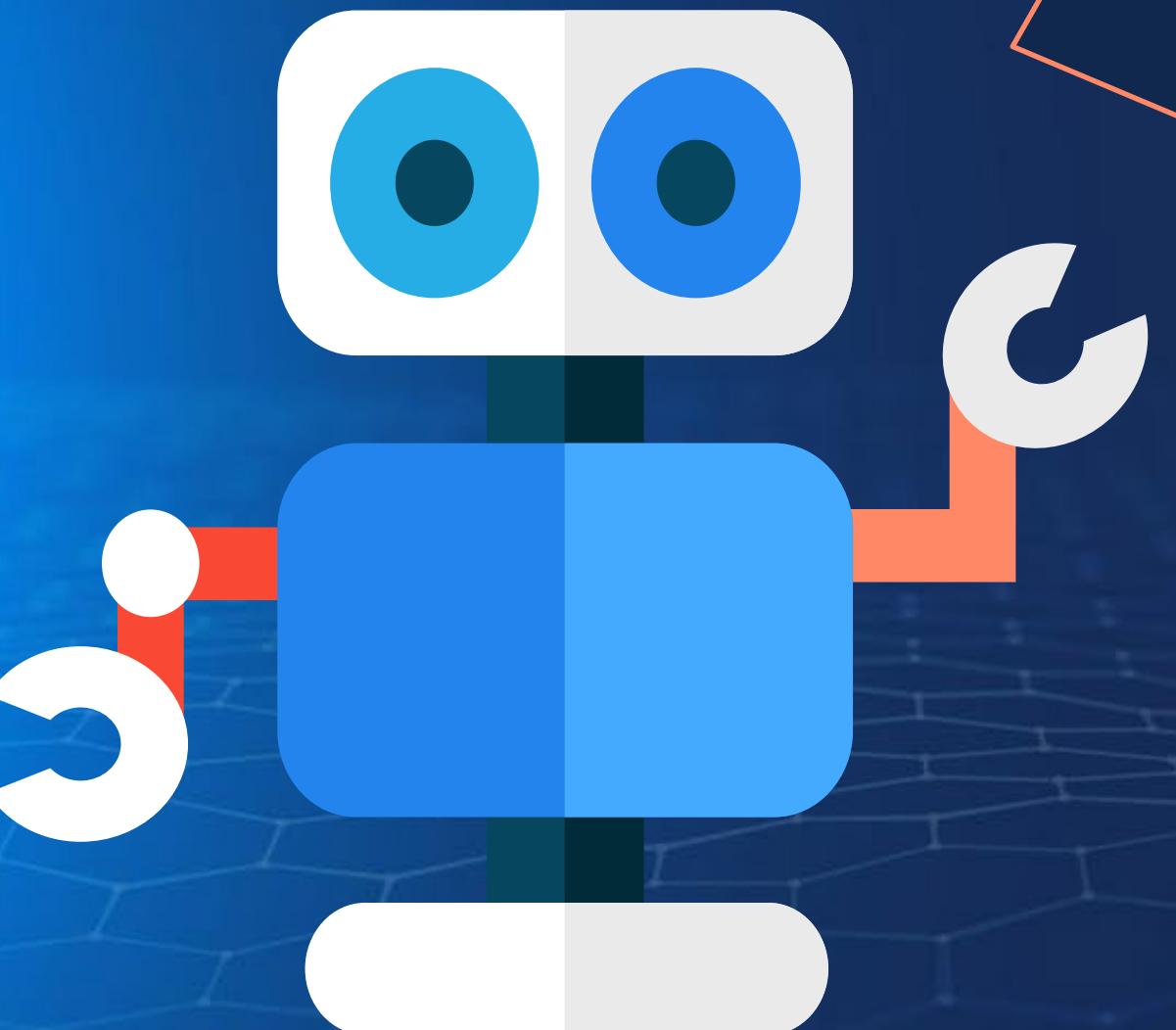
Camera Problems

The captured video may be of low resolution having limited color information.



As a result, a video sequence may not be processed properly due to compression or blur.

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Good News !!

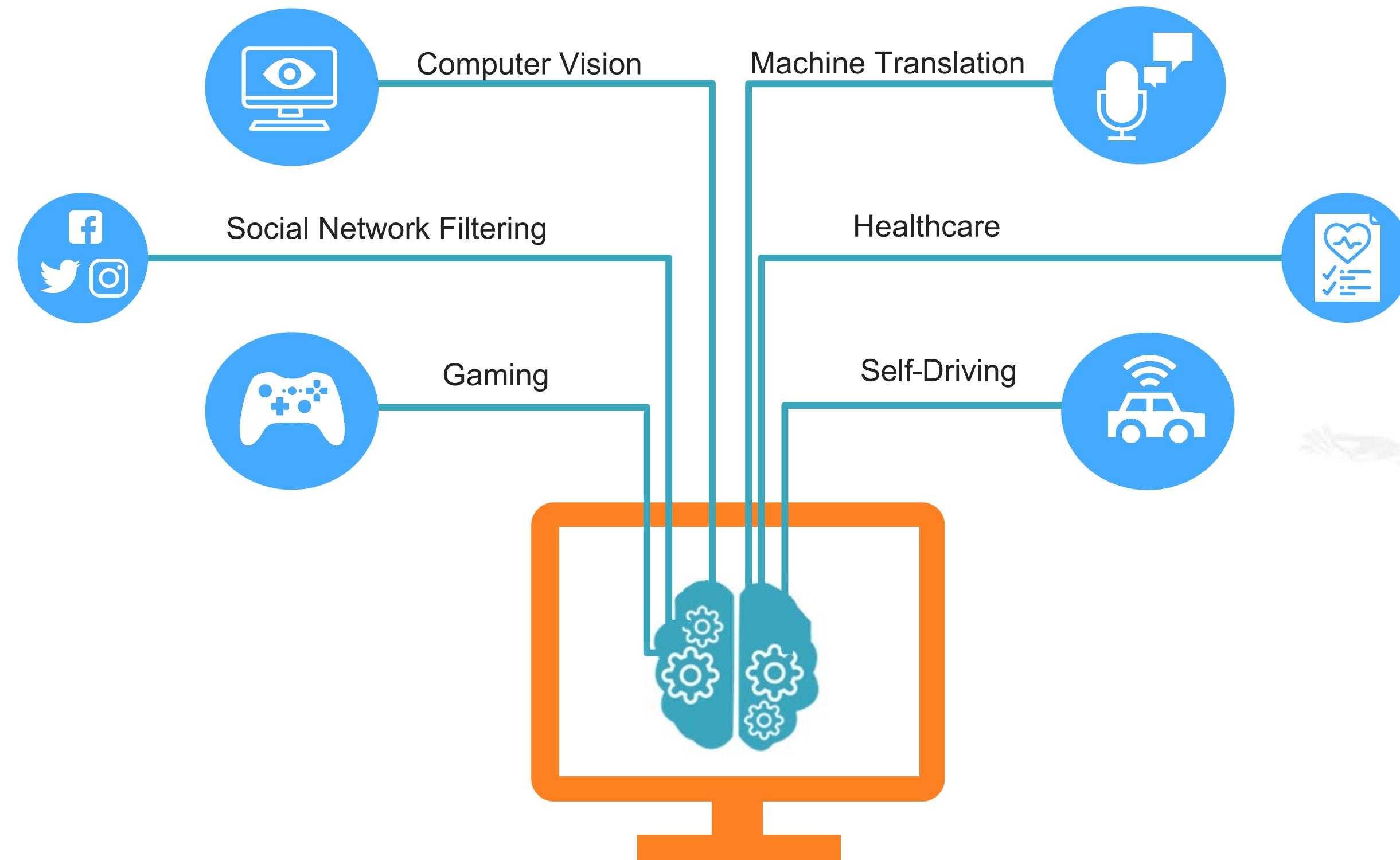
Fortunately, neural networks provide you with many possibilities to improve the accuracy of moving object detection as they provide access to greater **computational resources** .

In recent years, many classification-after-localization methods based on Convolutional Neural Networks (CNN) have improved detection results in various conditions.

We will look into these concepts in chapter 5.

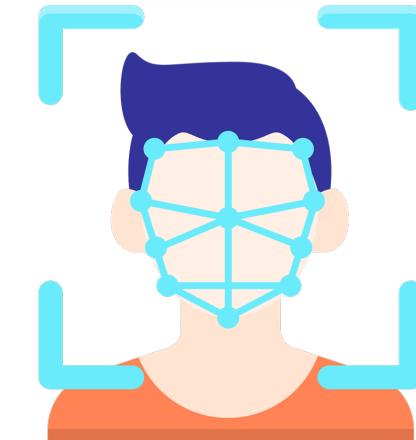
Applications of Deep Learning

Applications



Computer Vision

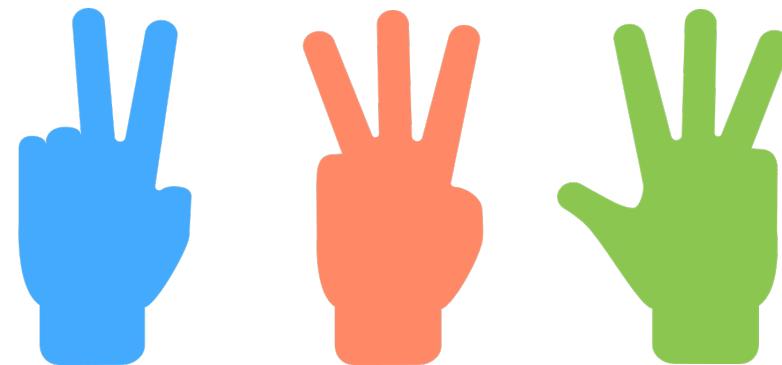
The field of computer vision uses deep learning neural network methods to solve challenging problems such as:



Facial Recognition



Augmented Reality



Gesture Recognition

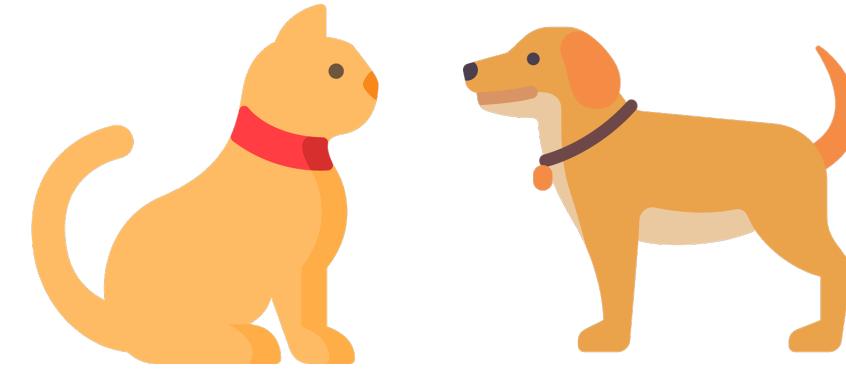
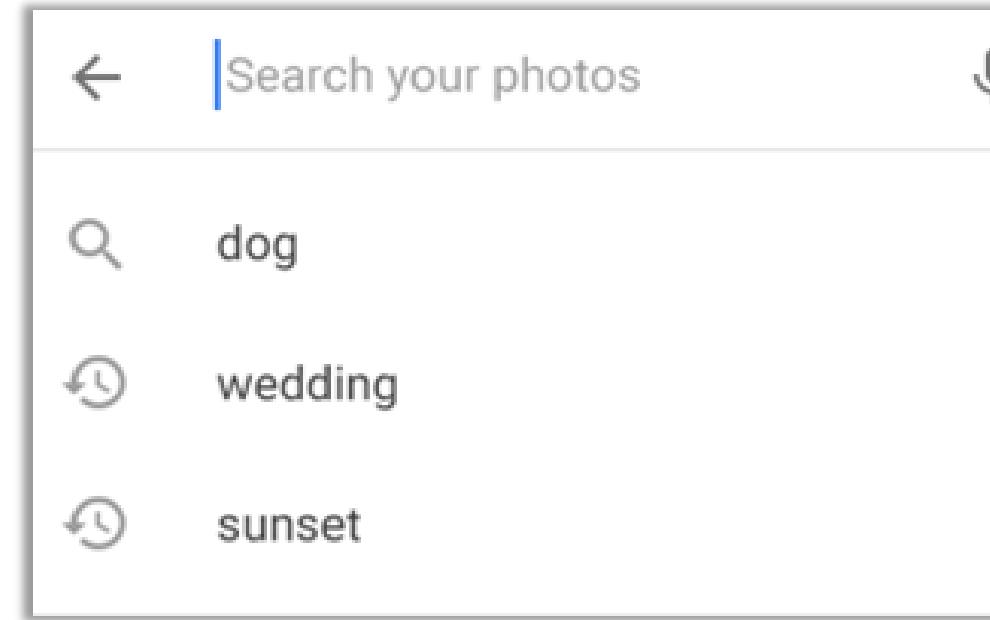


Image Classification

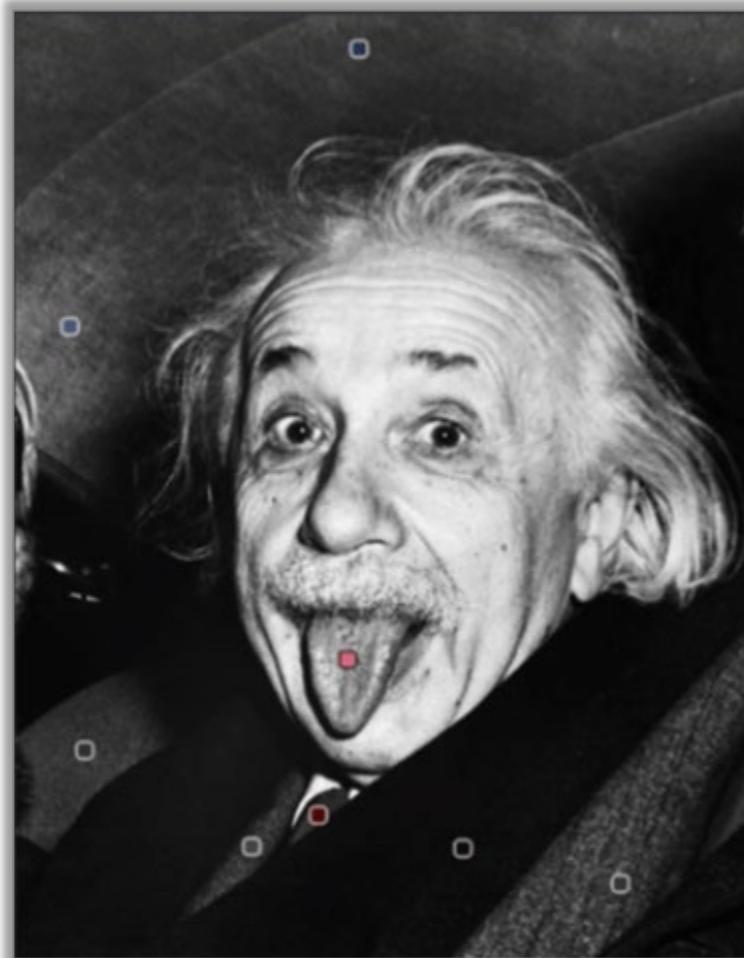
Computer Vision

Advances in image recognition have made it easy to search or automatically organize collections of photos with no identifying tags.



Computer Vision

It is now possible to restore old, black and white images and generate artificial videos with accurate lip syncs.



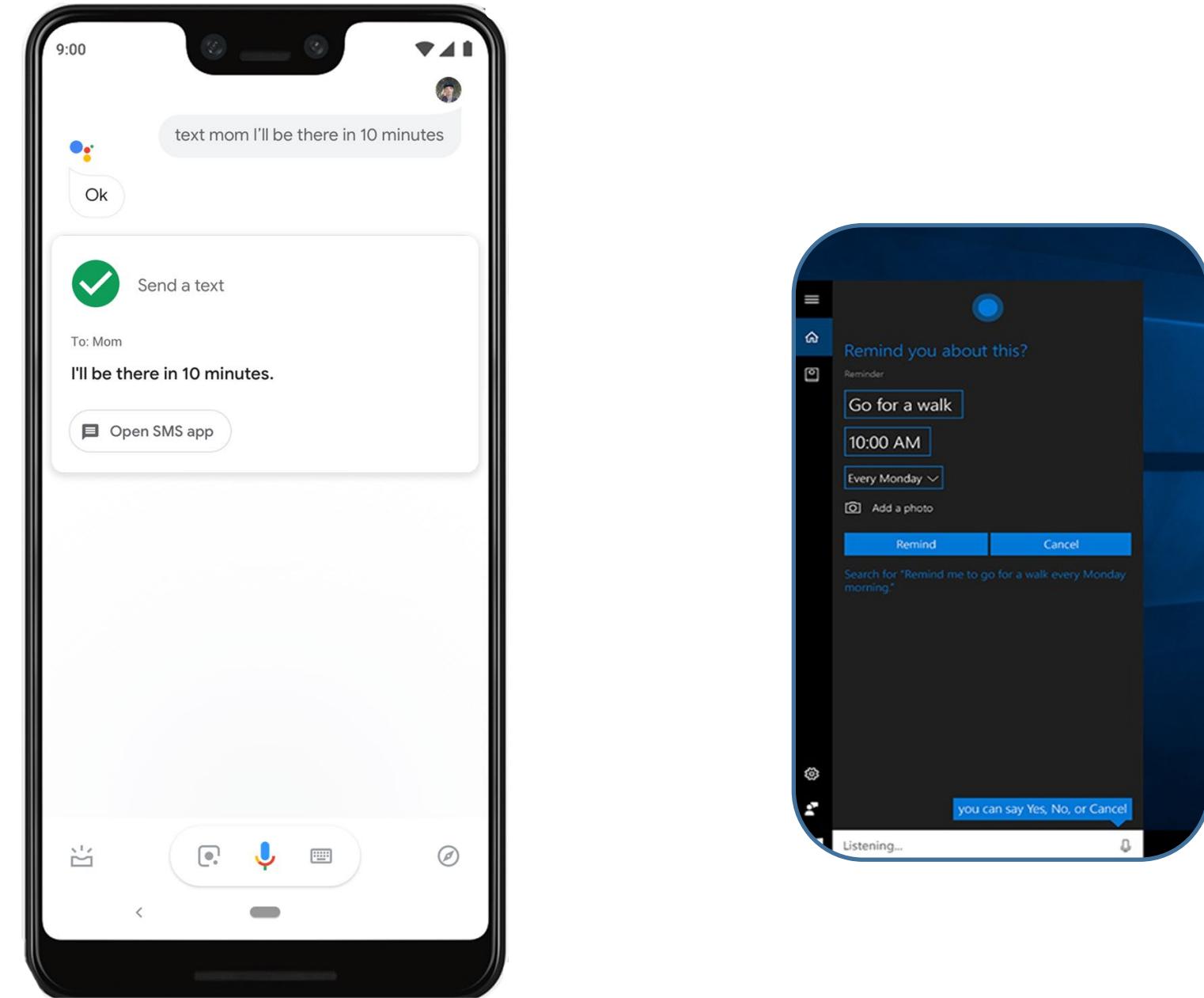
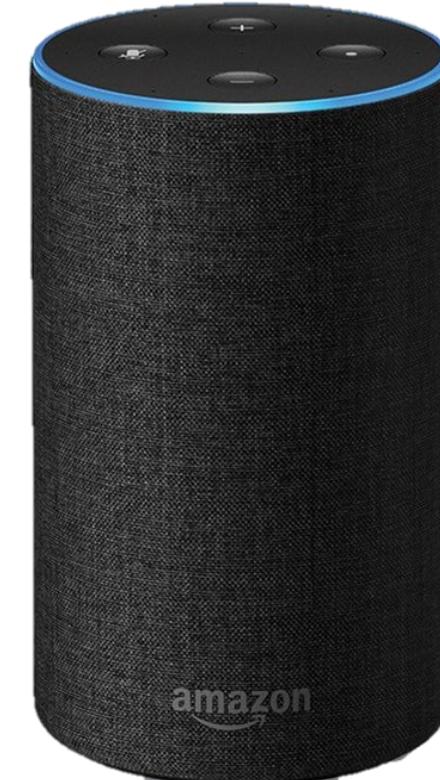
Automatic Colorization



Deep Fakes

Machine Translation

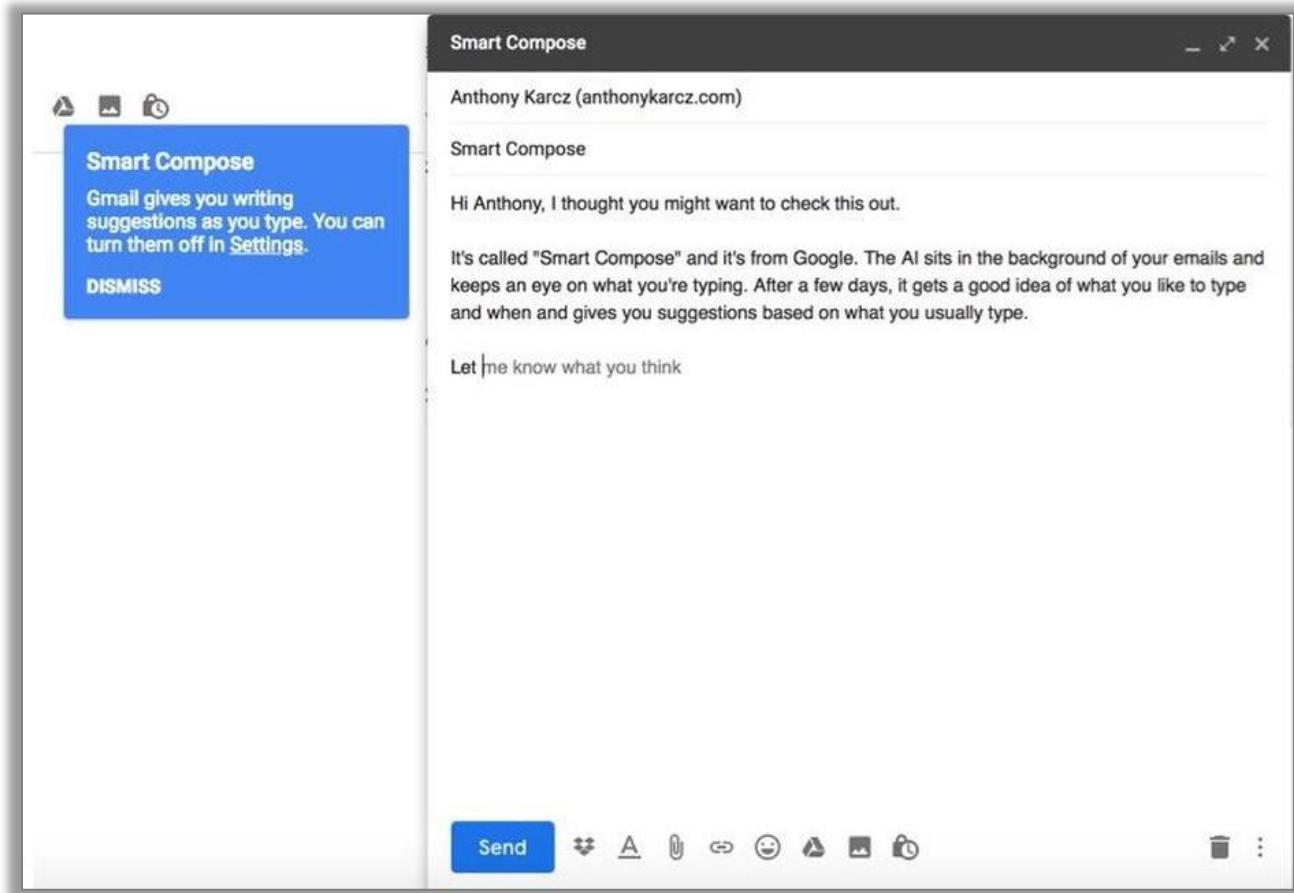
Advanced neural network algorithms are being used to synthesize text into a variety of voices and languages.



Recent stats shows that speech recognition functions on digital assistants work better than before and customers have almost tripled their use of speech interfaces.

Machine Translation

Automatic text generation is being used to generate customized texts and translate foreign languages.



Gmail Auto -complete



Auto -translate

Healthcare

DL methods can draw correlations by analyzing millions of data points and enable clinical physicians to keep pace with current research and treatment protocols.

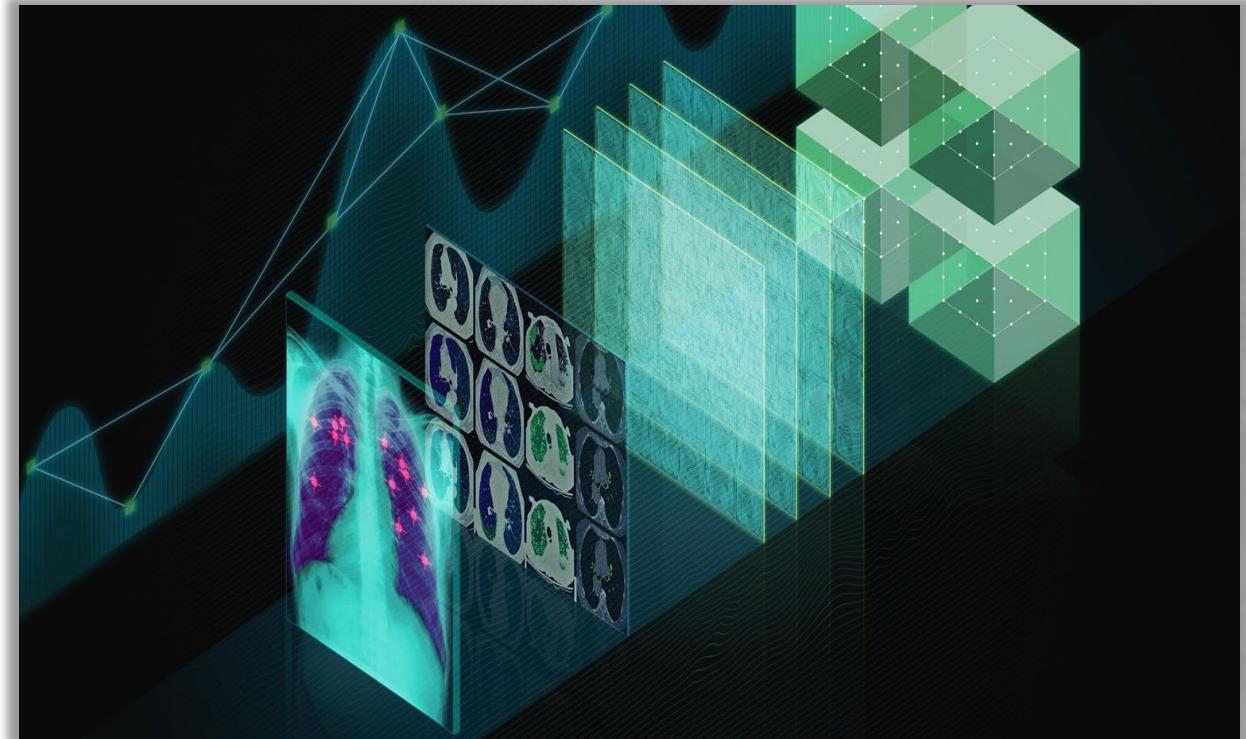


Healthcare

Deep learning will reshape the healthcare industry by providing computer -aided detection and diagnosis.



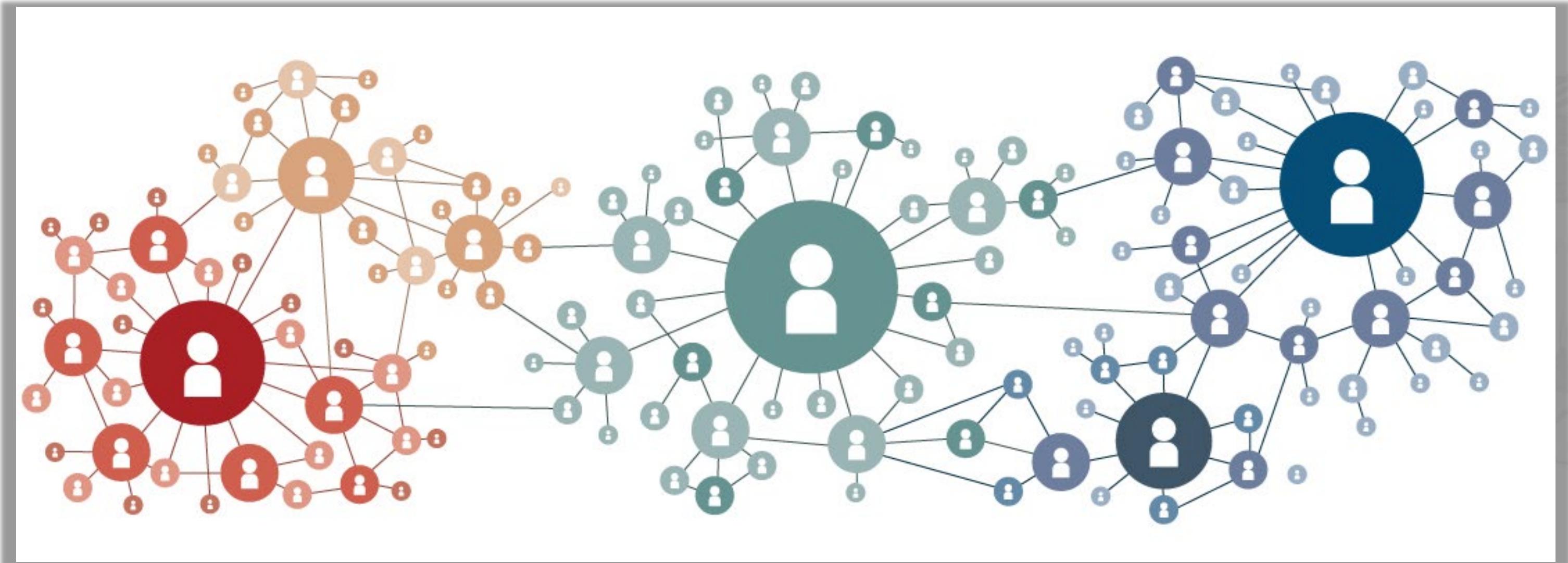
Drug discovery and precision medicine



Imaging analytics and diagnostics

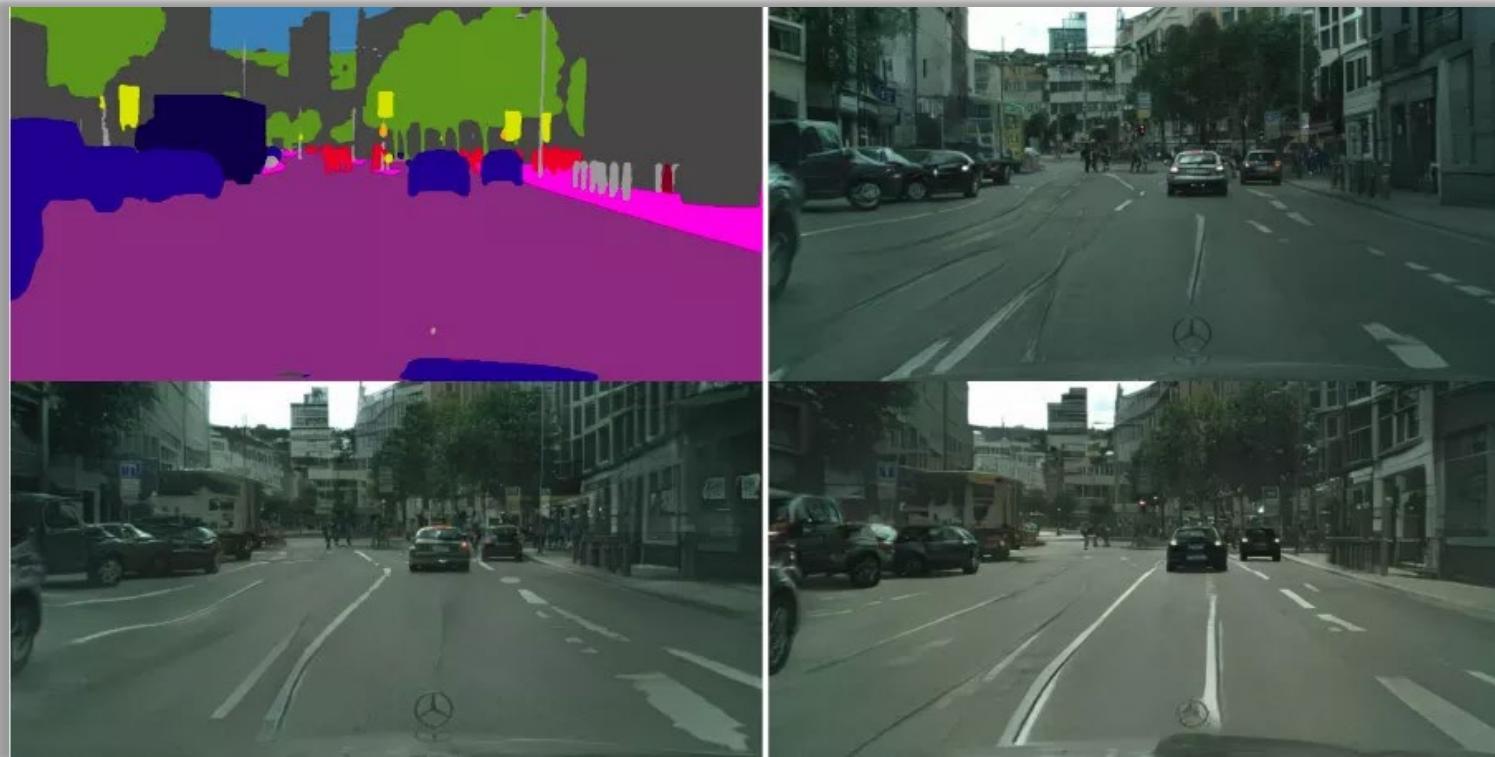
Deep Learning Meets Social Networks

The extensive use of social media platforms creates exciting potential for using neural network models to develop network representations.

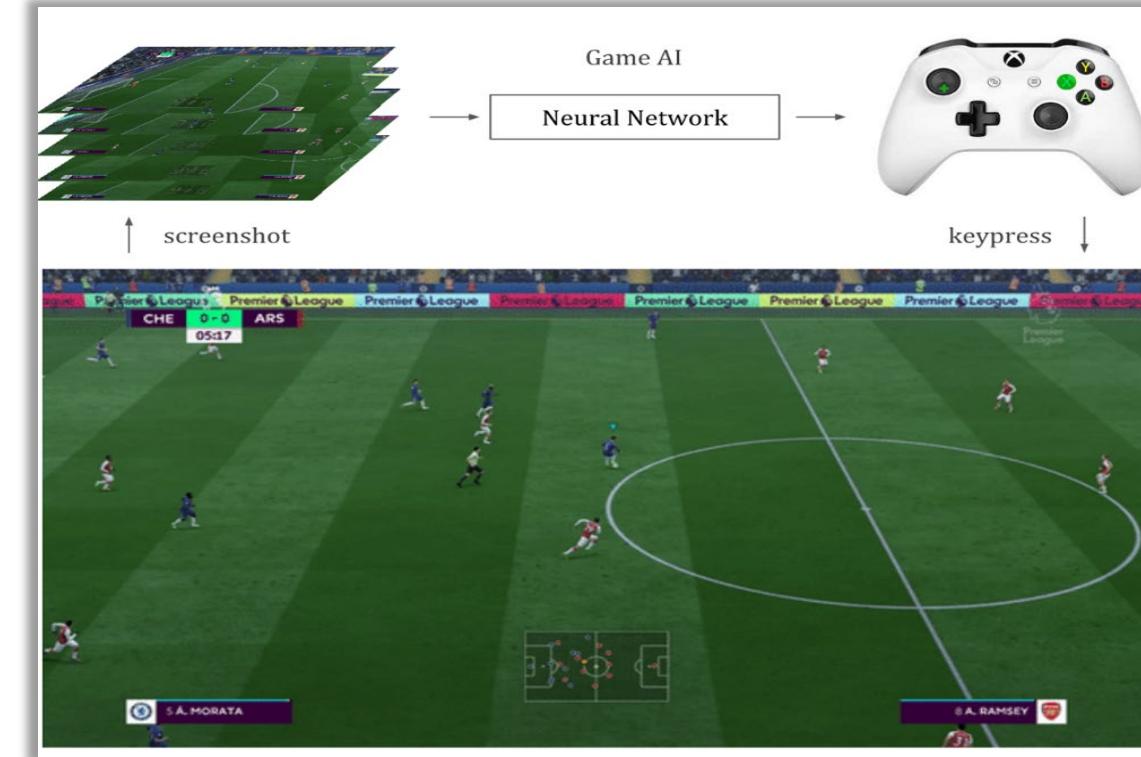


Gaming

DL is being used to dynamically render finer graphic details in games and help game developers to focus on effective storytelling rather than the game graphics.



Dynamic graphics rendering



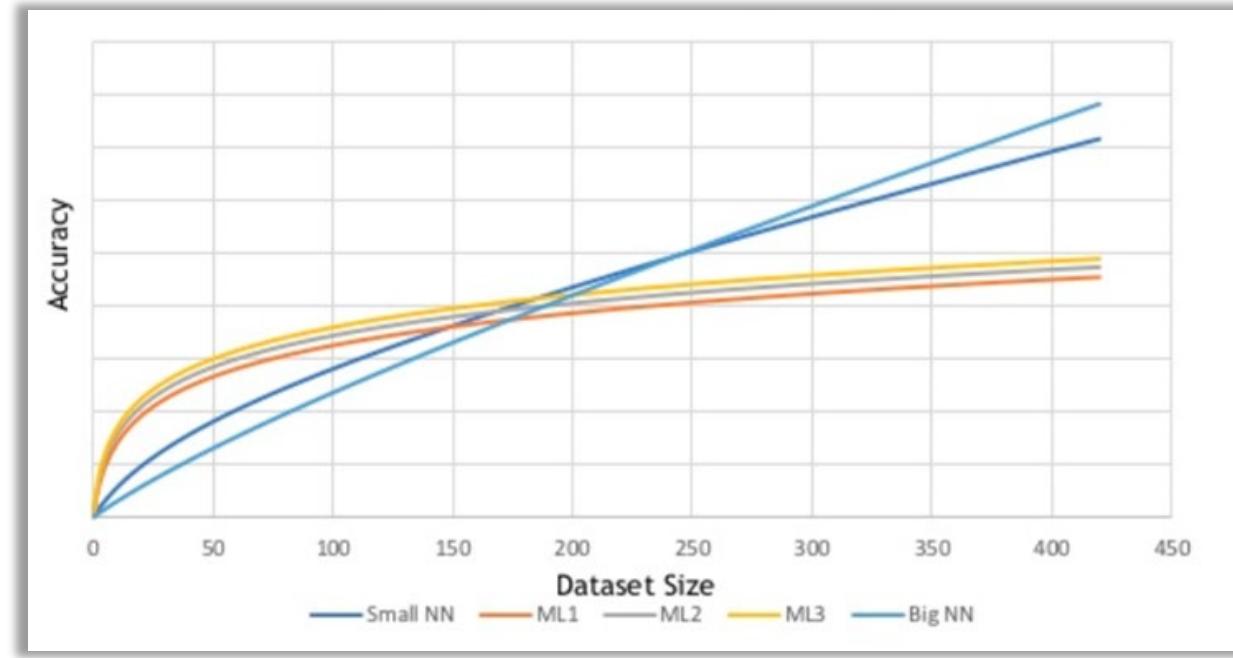
Neural net playing FIFA

Development of human-like bots is one of the promising DL tools to enrich the gaming experience.

Challenges in Deep Learning

Training Data

Deep learning gives accurate predictions with right quantity and quality of training data.

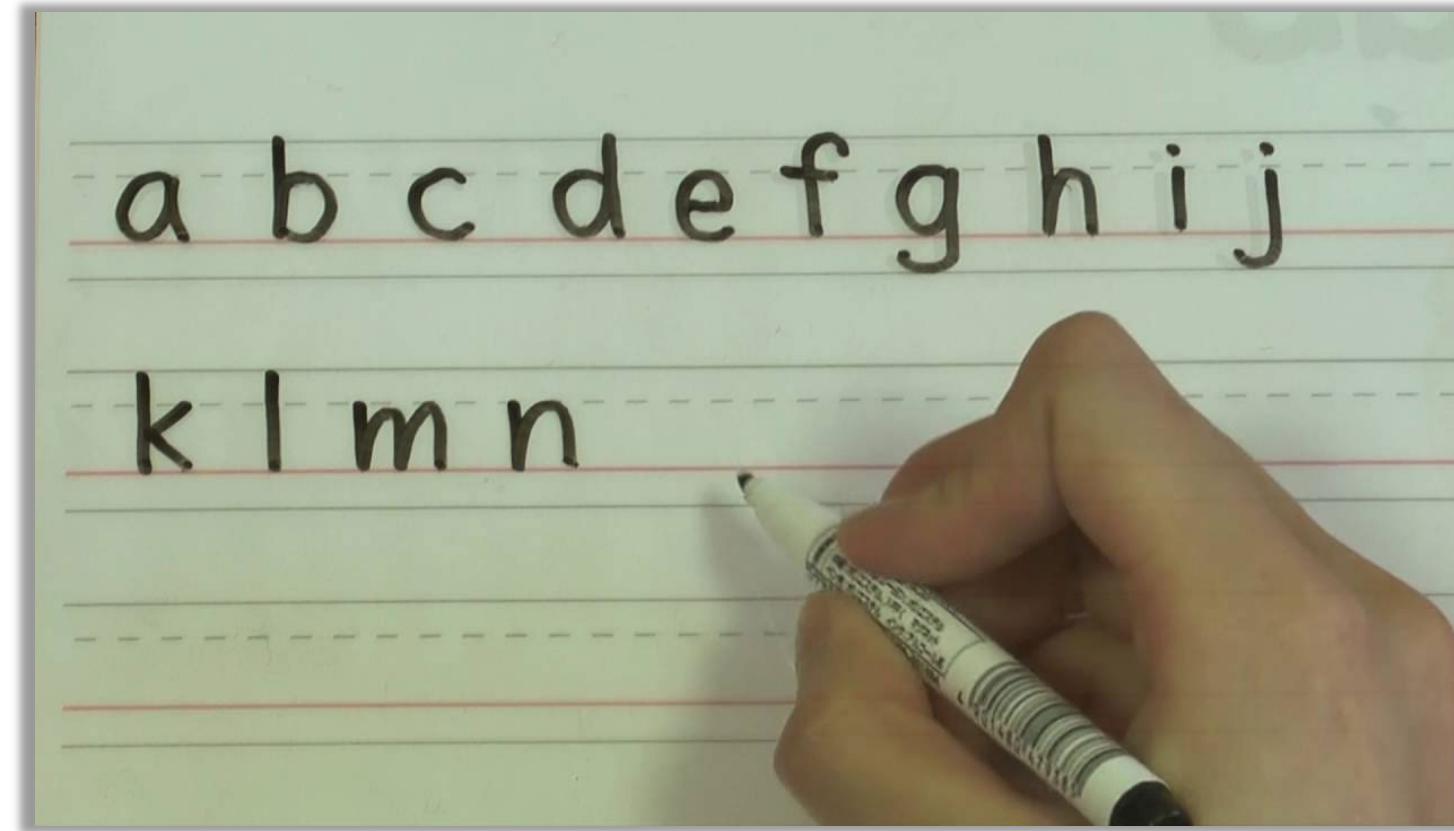


Accuracy increasing with dataset size

Building a DL model involves time -consuming tasks like collecting and labeling the training data.

Effective Learning and Teaching

Humans can learn from very few examples whereas machines need thousands or millions of examples.



We cannot give every possible labeled sample of a problem space to a DL model.
So, the DL model generalizes or interpolates to classify any data not contained in its original dataset.

Understanding Context

Deep learning doesn't understand context very well as it lacks pure perception.



What's on people's minds?

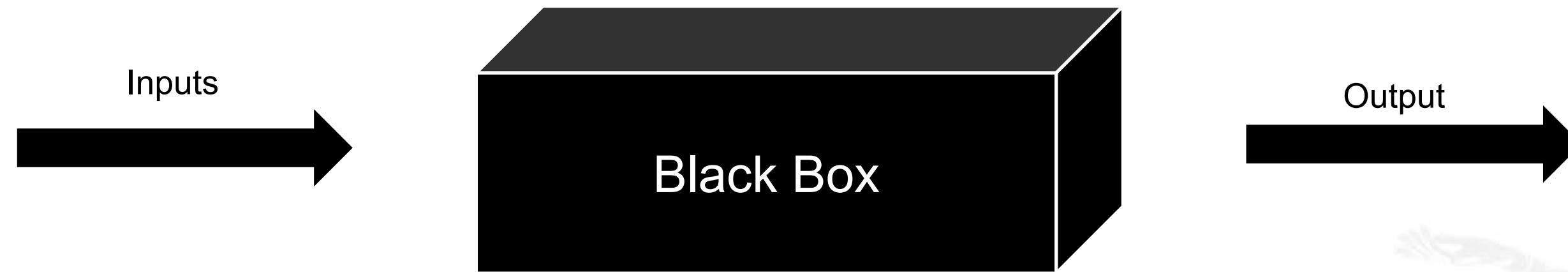


Mirrors

image classification ≠ scene understanding

The Black Box Problem

Neural networks do not rely on rules established in advance.
They find out patterns and correlations without exposing the reasons leading to them.



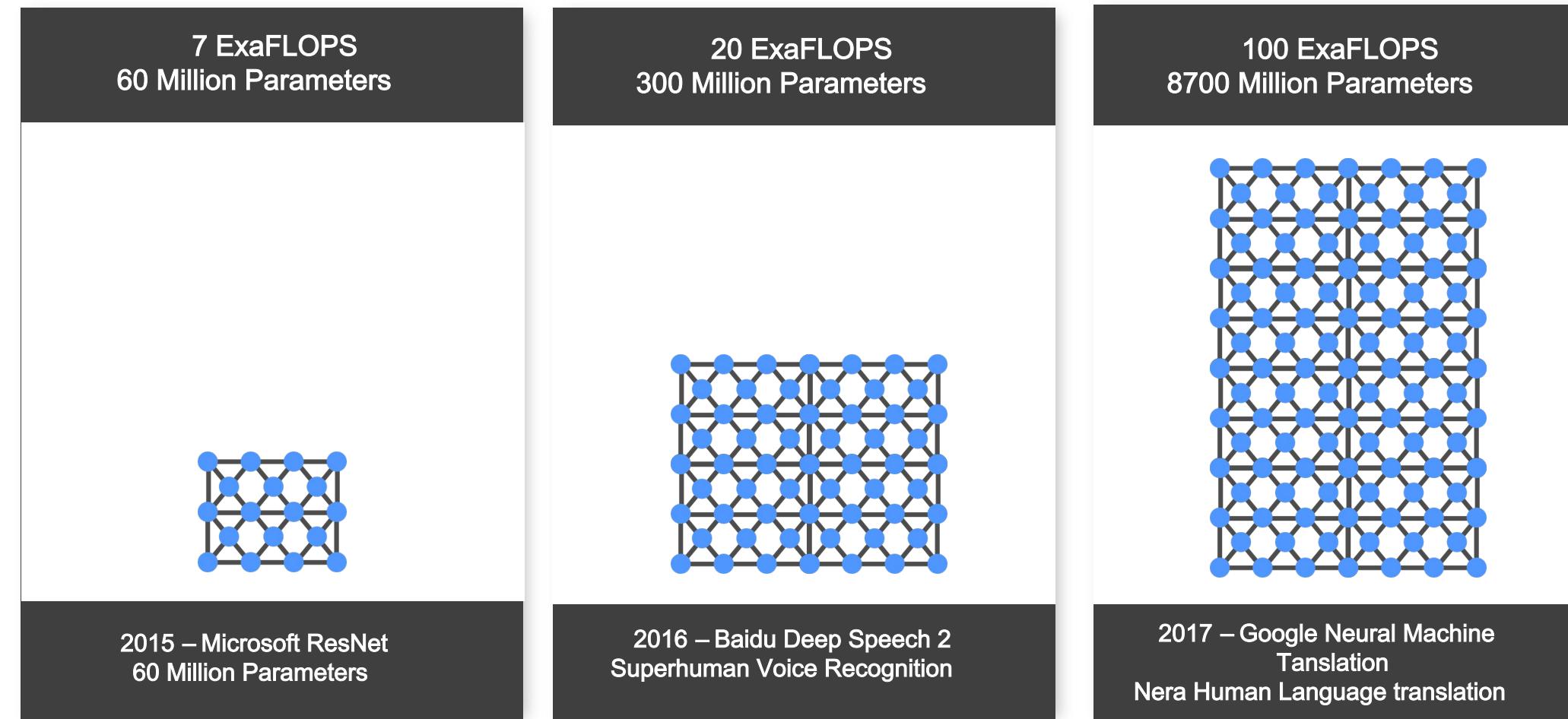
Implementation is "opaque" (black)

Human users like to understand how a system made a given decision, as decisions are potential liabilities for domains like finance and medicine.

Large Size Model and Complexity

State-of-the-art deep learning models are easily multi-gigabytes in size and are getting larger.

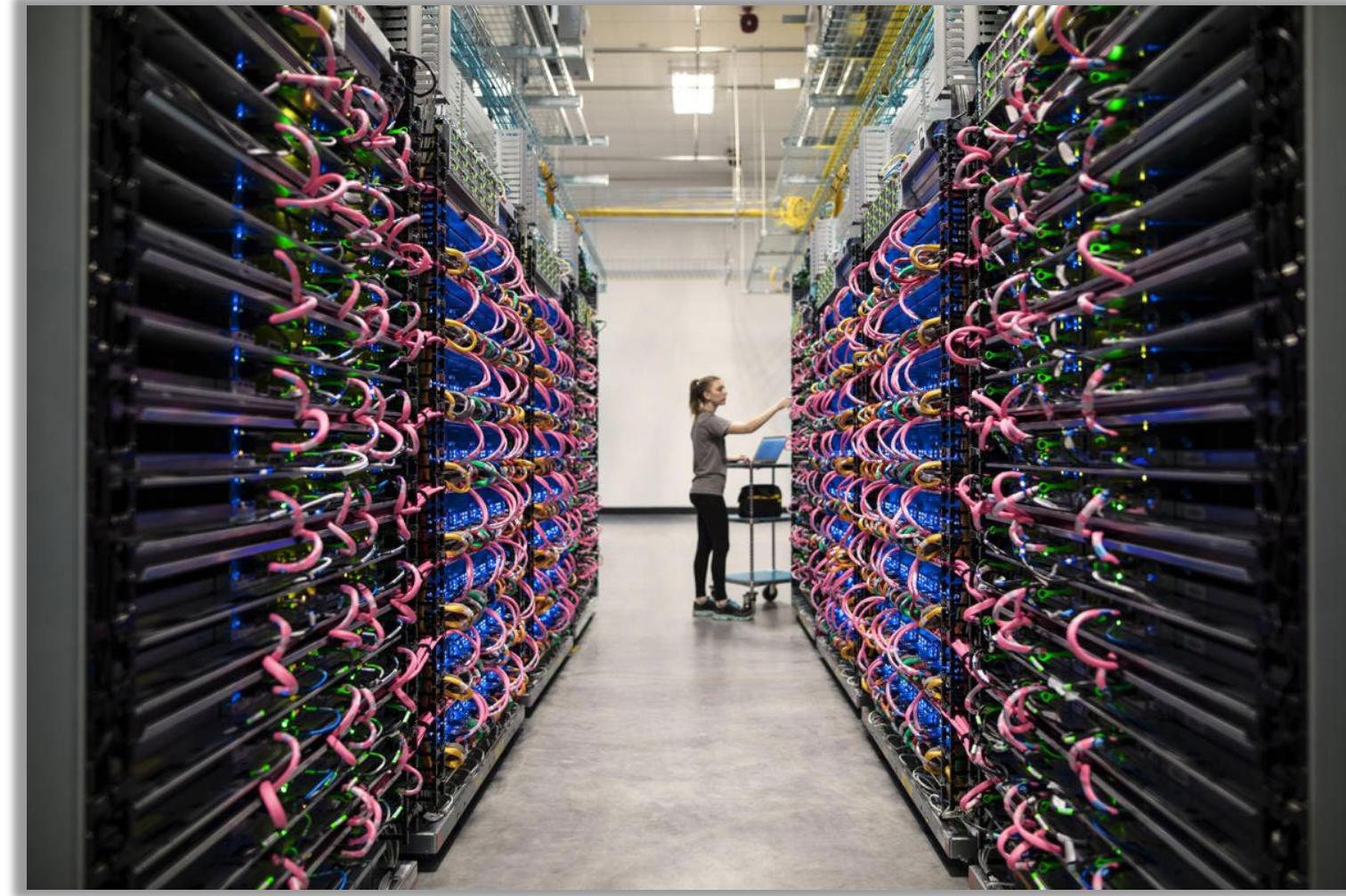
NEURAL NETWORK COMPLEXITY IS EXPLODING To Tackle Increasingly Complex Challenges



Number of parameters are directly proportional to the amount of information absorbed by the neural net.

Infrastructure

Majority of the useful deep learning problems activate the entire neural network for each batch size thereby blowing up the computation costs.

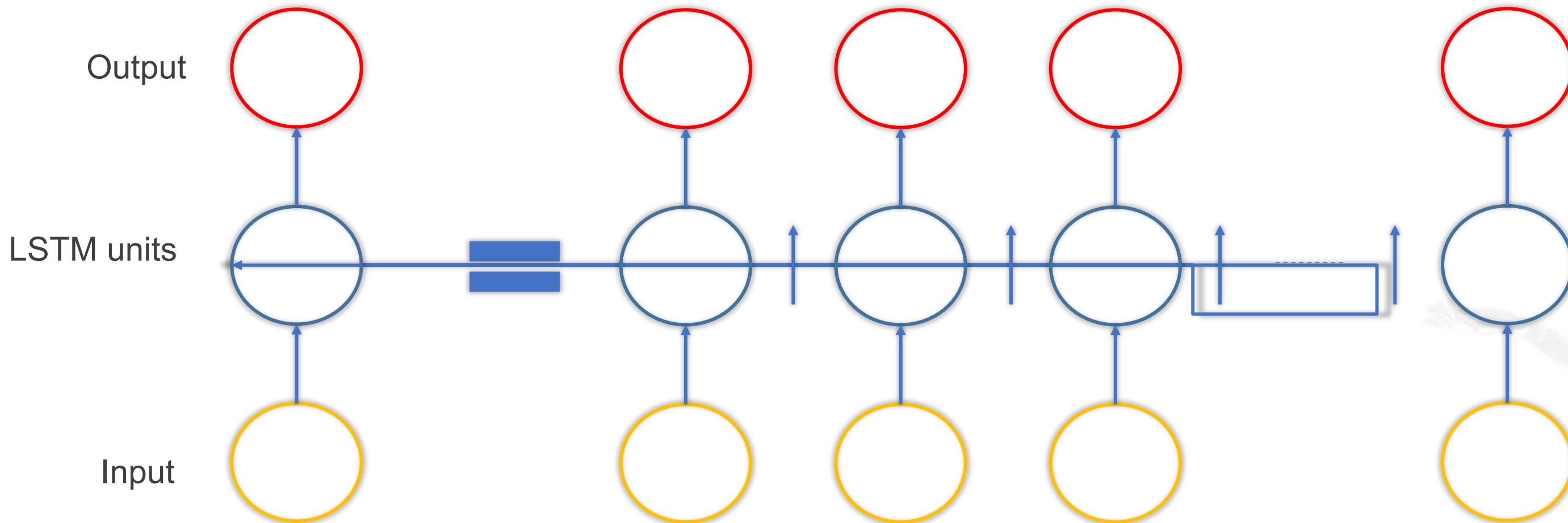


Therefore, models are loaded and scaled on multiple machines.

Long Short-Term Memory (LSTM)

Long Short -Term Memory (LSTM)

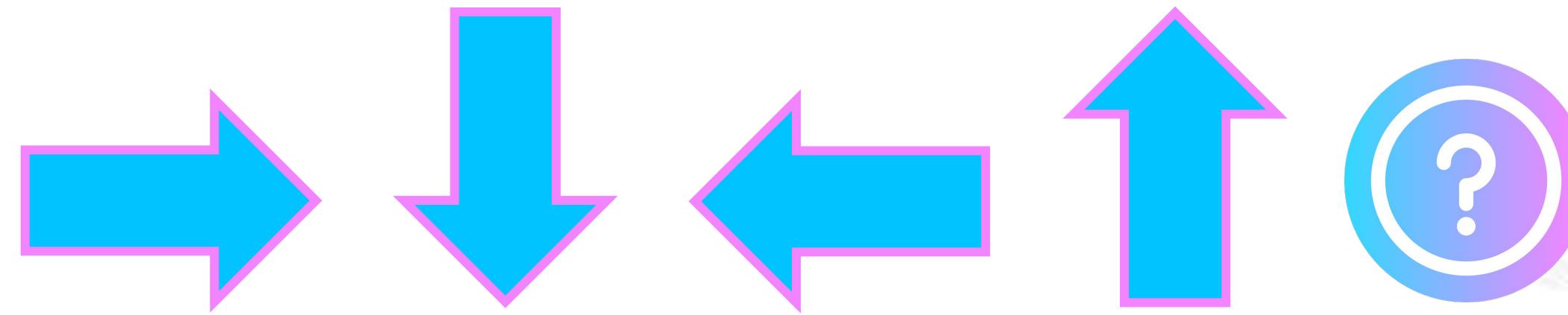
Long short -term memory (LSTM) is a recurrent neural network (RNN) that selectively remembers patterns for long durations of time.



LSTMs are mainly utilized in sequence prediction problems such as speech, images, and video.

Role of Memory

LSTMs have memory and take the order of observations into account.



What comes next?

LSTMs need to remember the past to predict the future.
Therefore, LSTMs learn any temporal dependence between observations.

Role of Context

Context Not Required

The largest living land animal is elephant.

It is obvious the next word is going to be elephant.

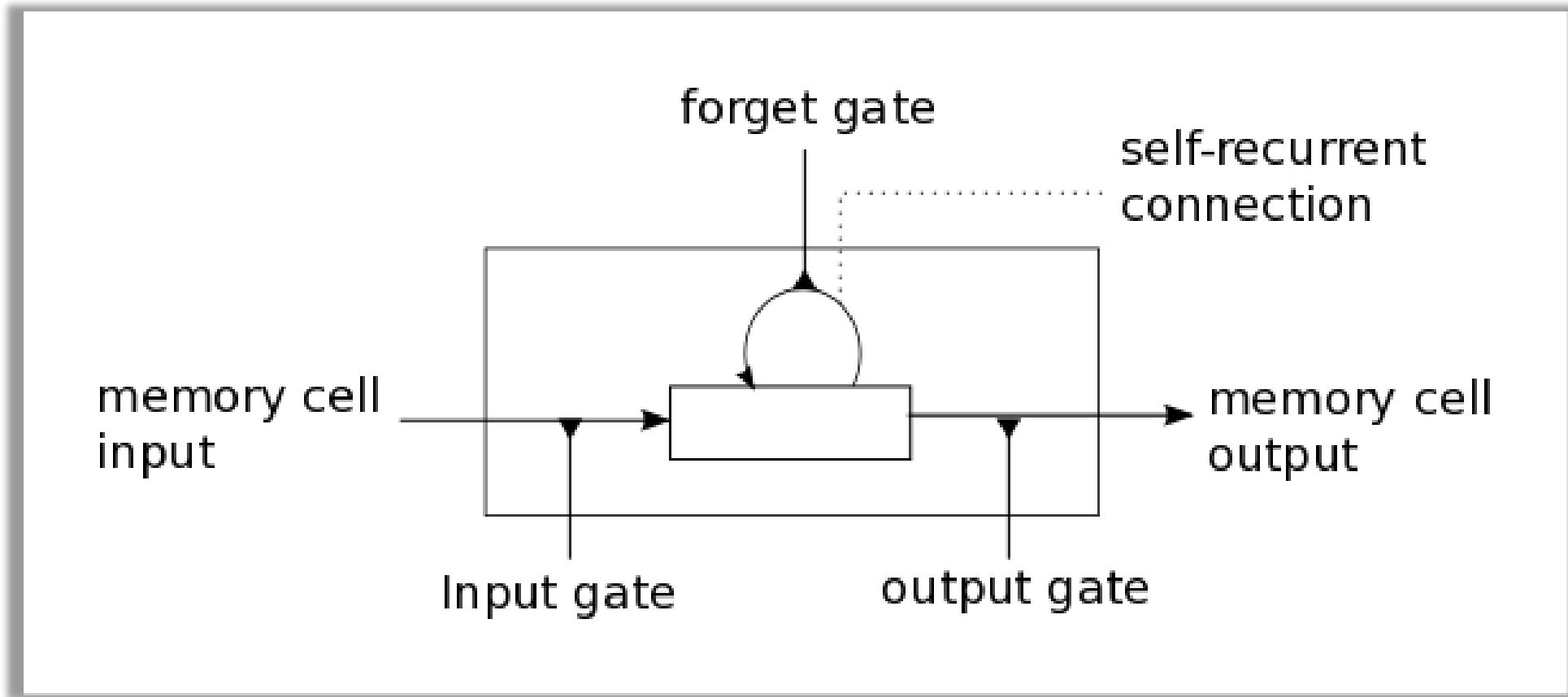
Context Required

I grew up in Germany. I speak fluent German.

Context is required to predict the language.

LSTM Unit

A LSTM unit is composed of a cell and three gates which control the flow of information.

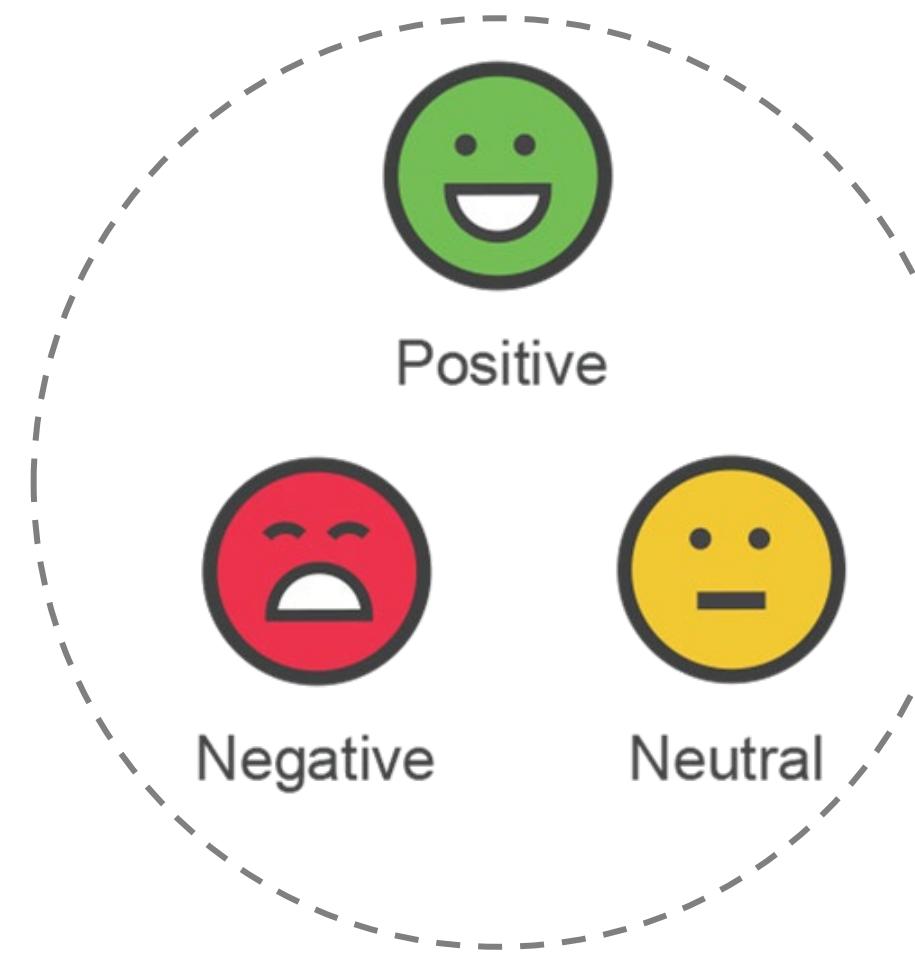


LSTM Cell

LSTM Applications: Sentiment Analysis

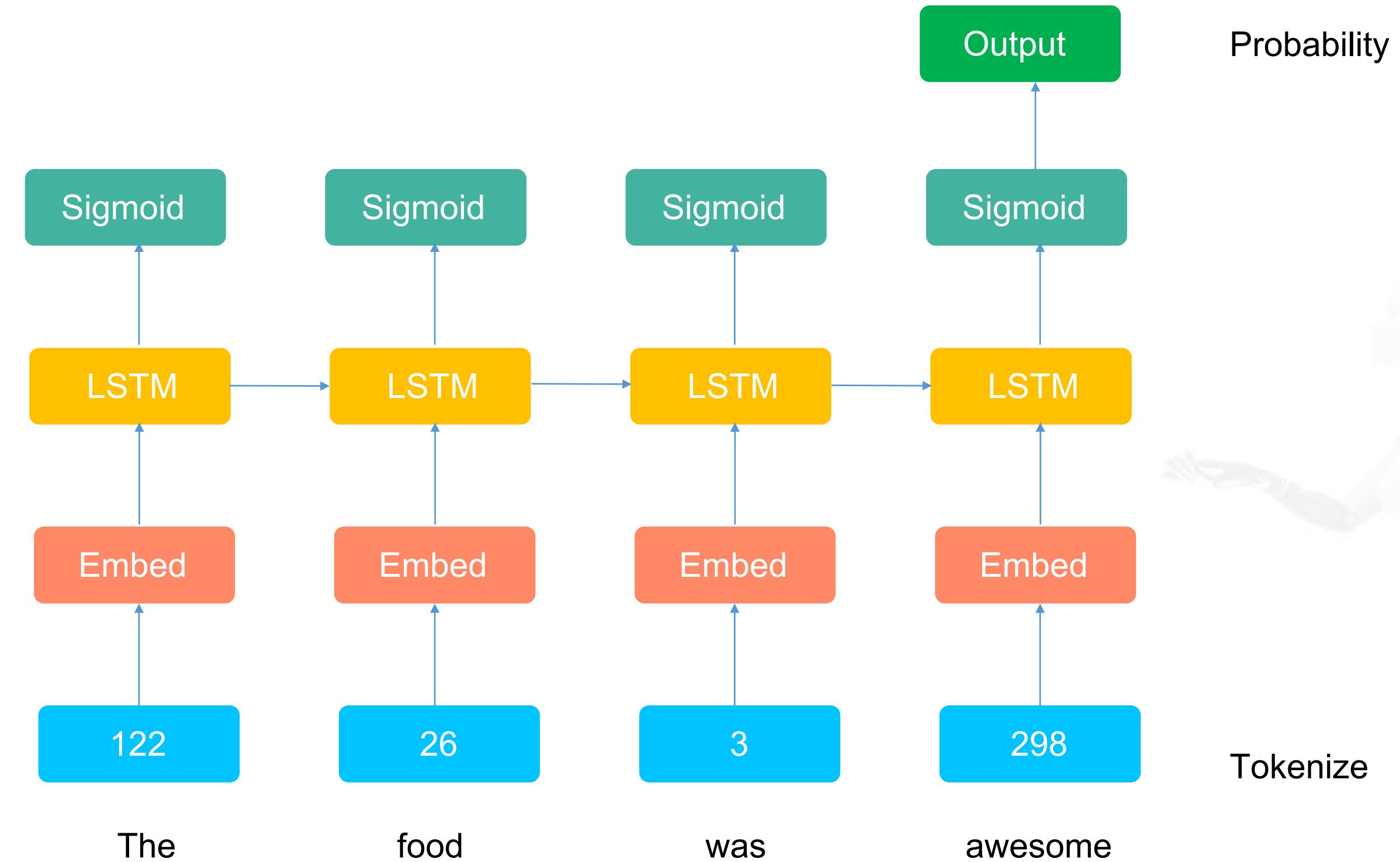
Sentiment Analysis

Sentiment analysis involves using computers to understand opinions about a subject from a given piece of text.



Sentiment analysis has become a key tool for making sense of huge amounts of data generated every day.

LSTM Architecture for Sentiment Analysis



Step 1: Tokenization

Tokenization consists of splitting the text into smallest meaningful units and converting them into tokens (integers).

122

26

3

298

_tokenize

The

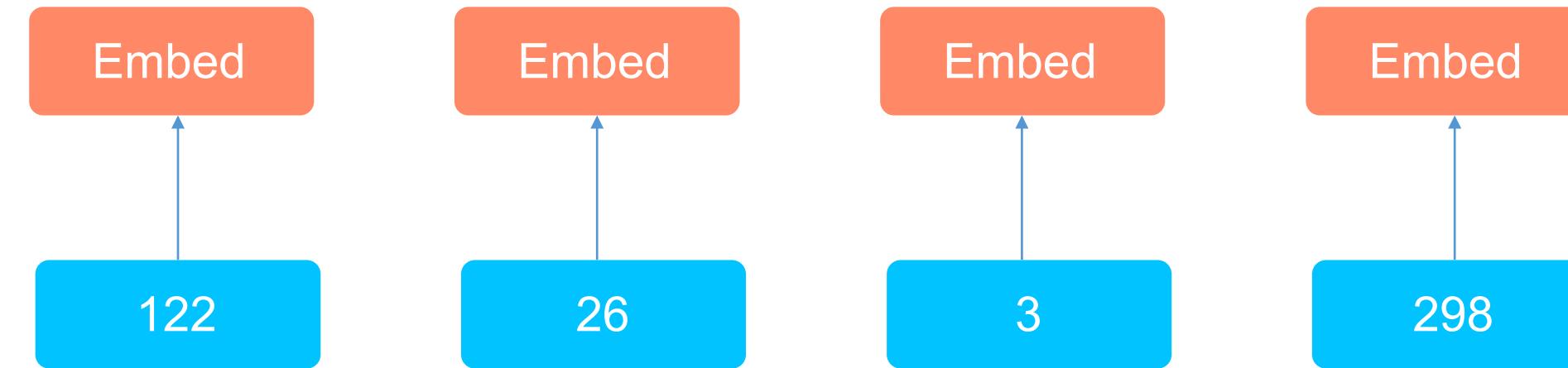
food

was

awesome

Step 2: Embedding

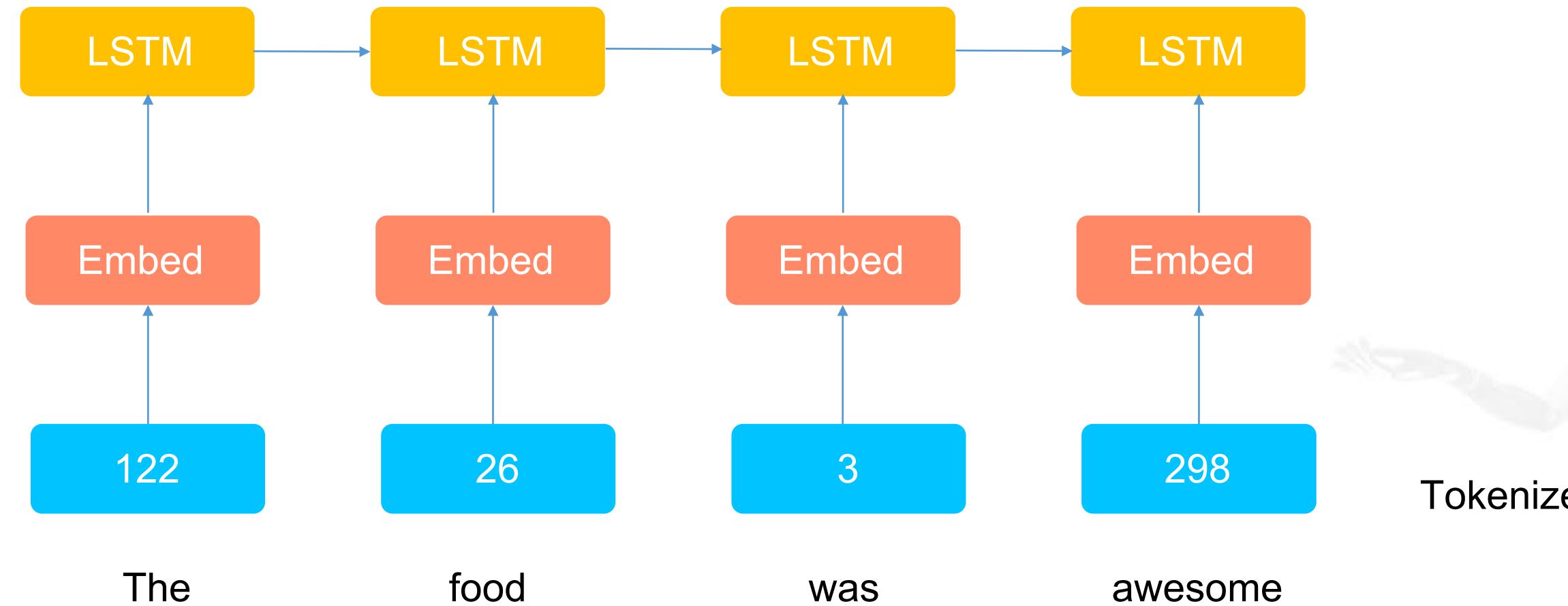
The embedding layer converts word tokens into embedding vectors of specific size.



The sequence of words encode lots of information that are useful to predict sentiment.

Step 3: LSTM

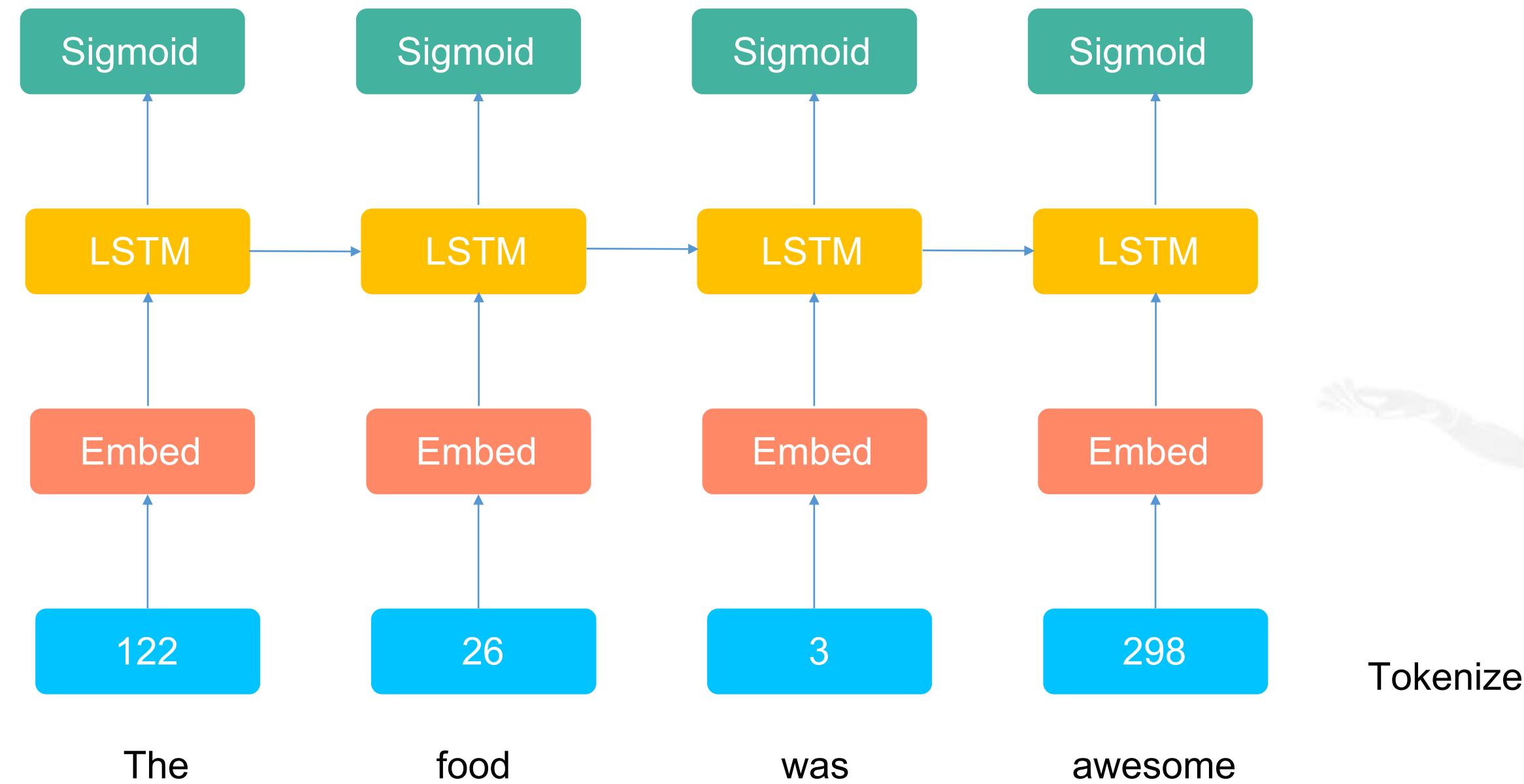
The embedding vectors are passed on to LSTM layers in a recurrent manner.



The layers add recurrent connections to the network to include information about the sequence of words in the data.

Step 4: Sigmoid Function

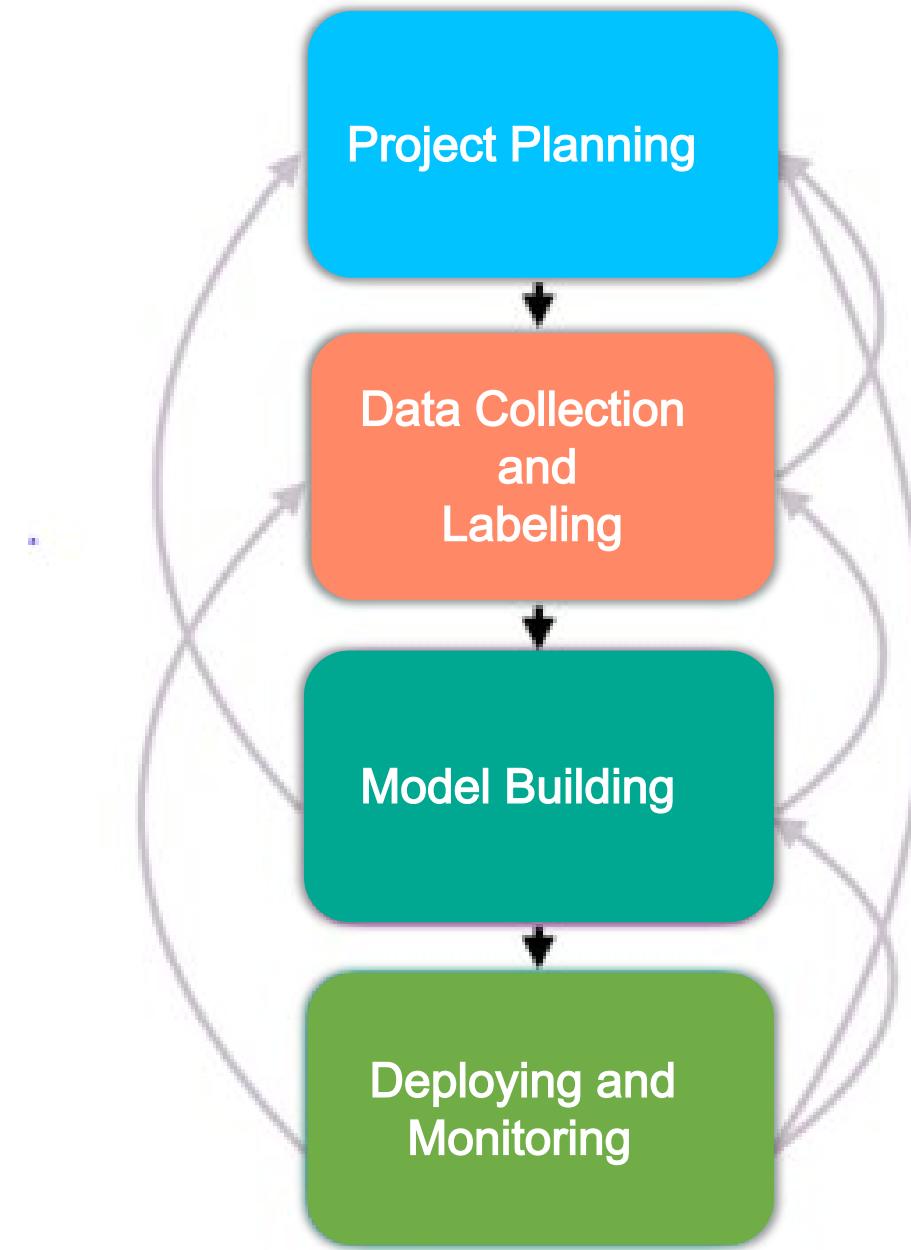
The sigmoid activation function outputs a binary value to classify the sentiment.
For example, positive or negative sentiment.



Life Cycle of a Deep Learning Project

Life Cycle

Deep learning projects are iterative in nature and consist of tasks given below.



It is advised to build smaller models with few data points and increase the complexity as time goes by.

Project Planning

Project planning includes defining goals, metrics, and baselines.

Reduce cost by
giving
cheap predictions

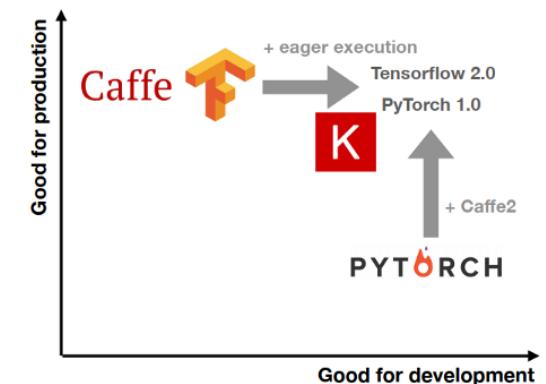
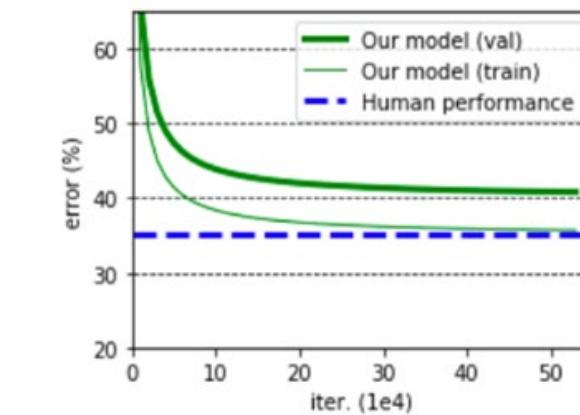
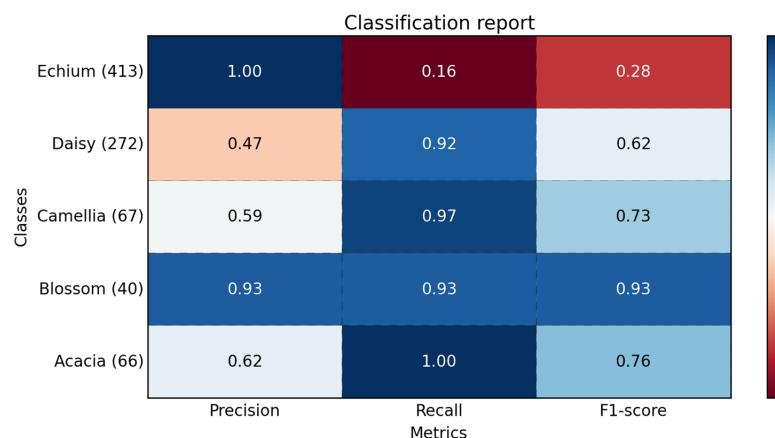
Define
project
goals

Choose
metrics

Evaluate
baselines

Set up
codebase

Automate
manual
software
pipeline



Questions to Ask

01

Problem Difficulty

- Any good published work on similar problems?
- Are resources available for training and deployment?

Accuracy Requirement

- How costly are wrong predictions ?
- How frequently does the system need to be right to be useful?

02

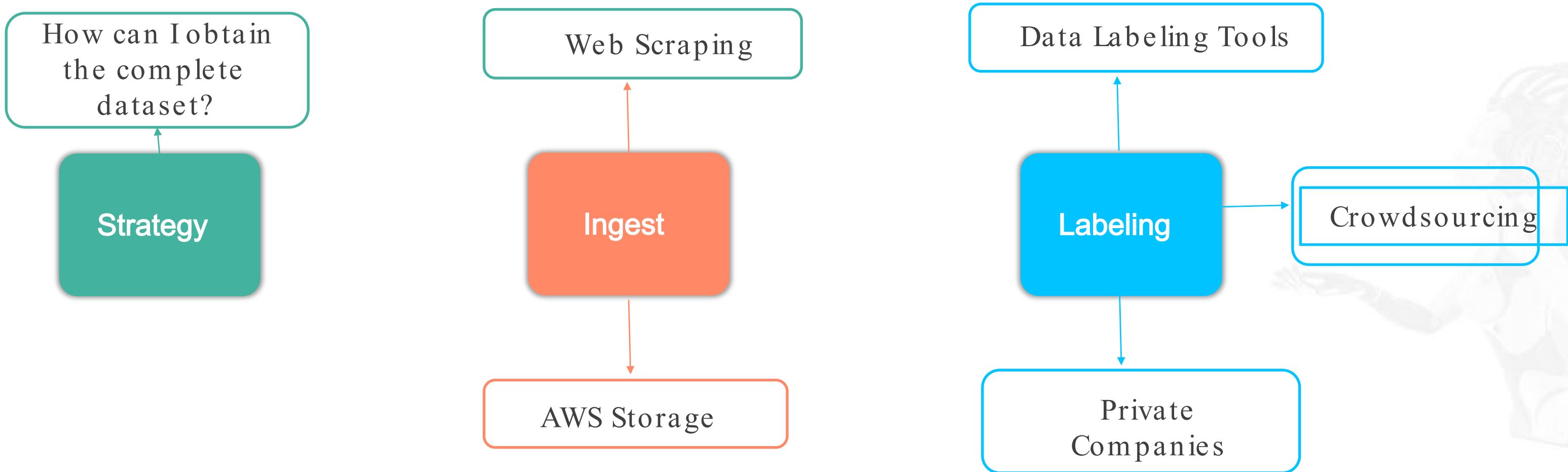
Data Availability

- How hard is to acquire data ?
- How expensive is data labeling?
- How much data will be needed?

03

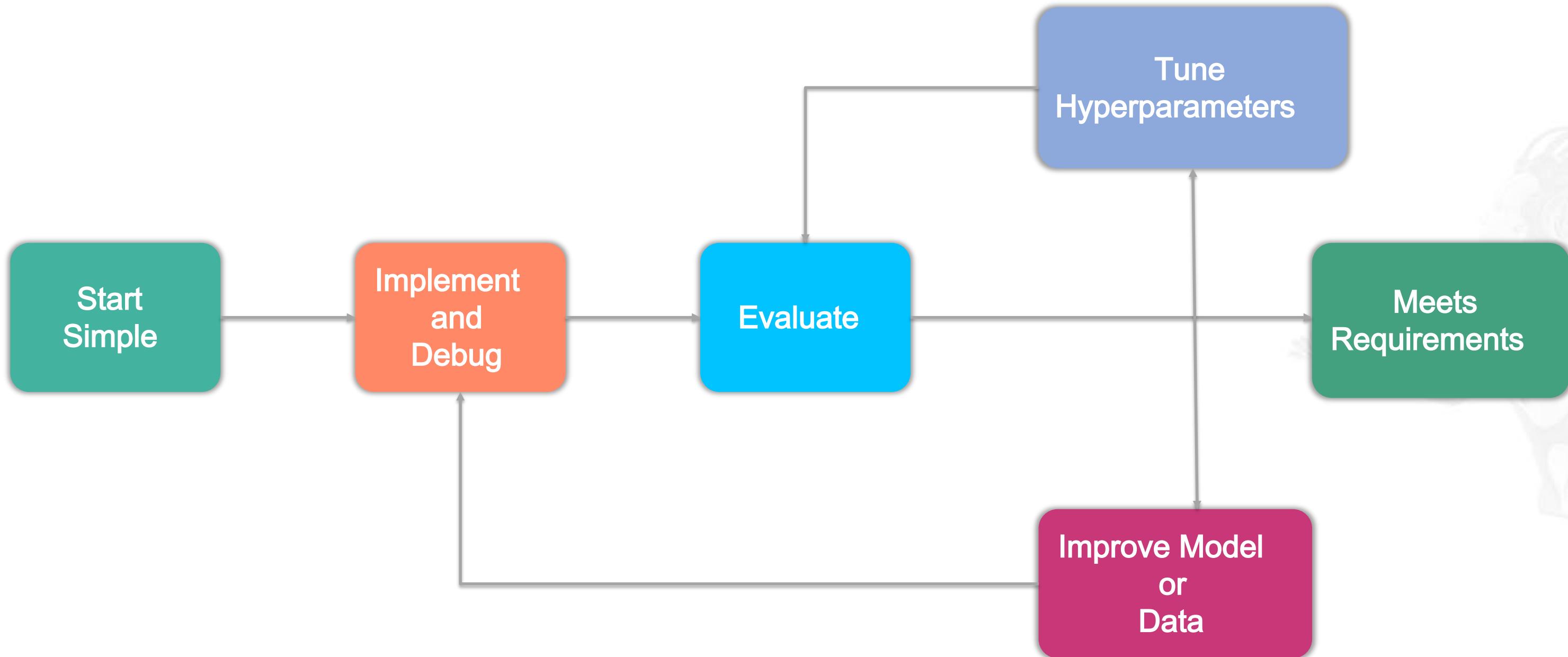
Data Collection and Labeling

In this step, data is collected, stored, and labeled using various tools.



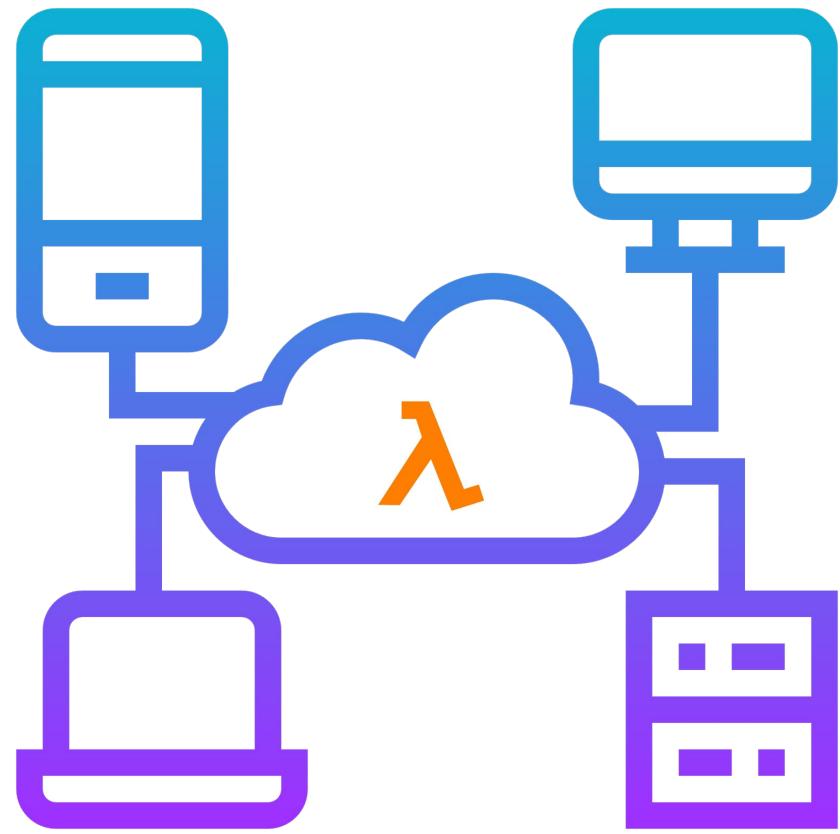
Model Building

Model building activities include training, testing, and debugging.

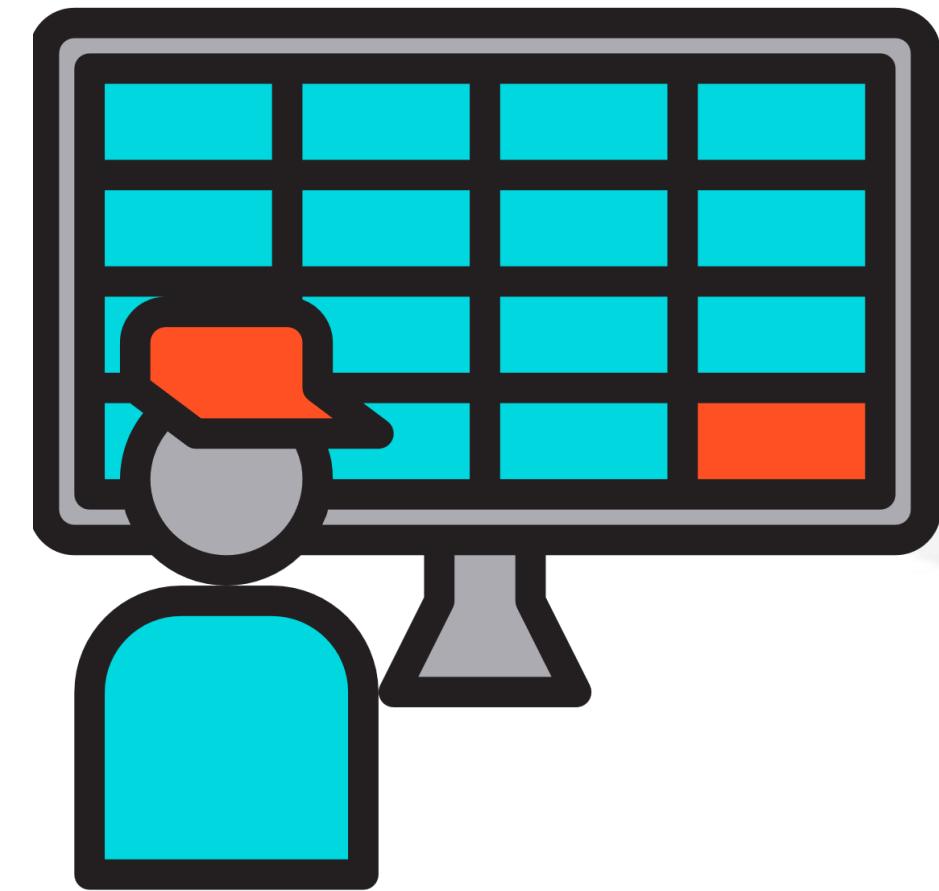


Deployment and Monitoring

Once the model meets the requirements, it is deployed and monitored using the desired interface.



Web Server Deployment



Monitoring

Key Takeaways

Now, you are able to:

- Describe artificial intelligence and deep learning
- Outline the history of artificial intelligence
- List successes of deep learning
- Discuss object detection using self -driving cars
- Discuss the applications of deep learning
- Outline the full cycle of a deep learning project



DATA AND ARTIFICIAL INTELLIGENCE



Knowledge Check

Knowledge Check

1

In which of the following problems can we use deep learning ?

- a. New drug discovery
- b. Self-driving
- c. Pattern classification
- d. All of the above



Knowledge Check

1

In which of the following problems can we use deep learning ?

- a. New drug discovery
- b. Self-driving
- c. Pattern classification
- d. All of the above



The correct answer is **d**

All of the mentioned problems can be solved using deep learning.

Knowledge Check

2

Which of the following best compares human and machine intelligence ?

- a. Humans have sense organs
- b. Humans have better IQ and intellect
- c. Humans perceive everything as a pattern while machines perceive it as data
- d. Humans have emotions



**Knowledge
Check**
2

Which of the following best compares human and machine intelligence ?

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- b. Humans have better IQ and intellect
- c. Humans perceive everything as a pattern while machines perceive it as data
- d. Humans have emotions



The correct answer is **c**

Humans have a tendency to see patterns and make decisions, while a machine makes its decision based on data.

**Knowledge
Check**
3

Which of these are reasons for increase in popularity of deep learning?

- a. Access to greater computational power
- b. Access to large amounts of data
- c. Significant improvements in image classification and recognition
- d. All of the above



**Knowledge
Check
3**

Which of these are reasons for increase in popularity of deep learning?

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- c. Significant improvements in image classification and recognition
- d. All of the above



The correct answer is **d**

In recent years, deep learning has become more popular due to access to large amounts of data and computational power along with significant improvements in image classification and recognition.

Knowledge Check

4

Which of the following statements are true ?

- a. Bringing more data to a model is almost always beneficial
- b. Big networks usually perform better than small networks
- c. Both a and b
- d. None of the above



Knowledge Check

4

Which of the following statements are true ?

- a. Bringing more data to a model is almost always beneficial
- b. Big networks usually perform better than small networks
- c. Both a and b
- d. None of the above



The correct answer is **c**

Increasing the training set size and the size of a neural network significantly improves the performance.

Knowledge Check

5

Which of the following algorithms is best suited to train a model to play chess ?

- a. Supervised Learning
- b. Unsupervised Learning
- c. Reinforcement Learning
- d. Deep reinforcement Learning



**Knowledge
Check**

5

Which of the following algorithms is best suited to train a model to play chess ?

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- b. Unsupervised Learning
- c. Reinforcement Learning
- d. Deep reinforcement Learning



The correct answer is **d**

Reinforcement algorithms that incorporate deep learning are best suited for training models to play games.

DATA AND ARTIFICIAL INTELLIGENCE

Thank You