Deep Learning with Keras and TensorFlow

DATA AND
ARTIFICIAL INTELLIGENCE

Course Introduction

Course Objectives

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

- Solve complex problems using neural networks
- Configure deep learning algorithms and learn how to train deep networks
- Use various frameworks required for creating neural networks along with their functionalities
- Perform image classification using CNNs
- Work on sequential data with LSTMs

Course Prerequisites

The course requires prior knowledge of the following technologies:

Python

Machine Learning

Course Outline

1

Artificial Neural Networks: Understand the functioning of neural networks

2

AI and Deep Learning Introduction: Get exposed to usages of deep learning at a use case level

3

Deep Neural Network and Tools: Get exposed to different frameworks for building a deep neural model in Python

4

Deep Neural Net optimization, tuning, interpretability: Learn to optimize and tune your deep learning models for enhanced performance

Course Outline

5

Convolutional Neural Net: Understand the working of CNN and use it for image classification

6

Recurrent Neural Networks: Use RNNs to model sequential data

7

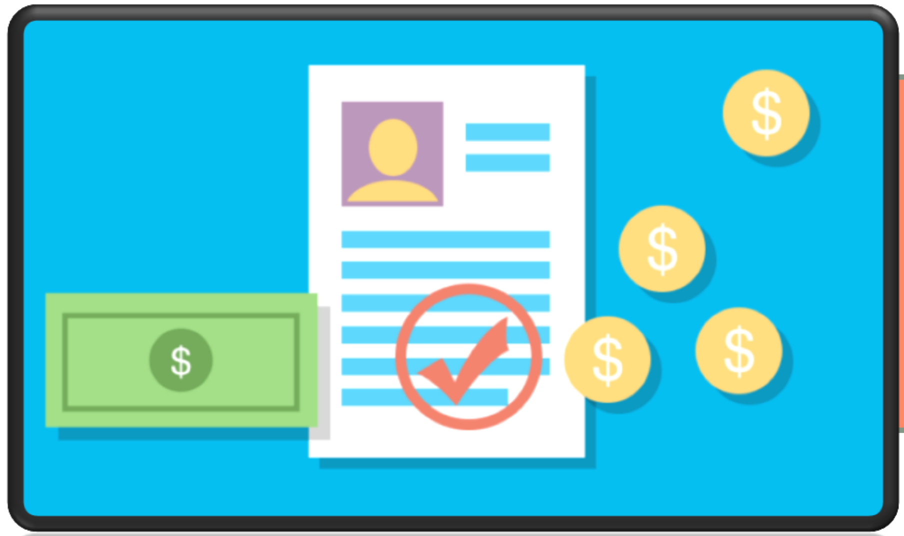
Autoencoders: Learn autoencoders to learn efficient data codings in an unsupervised manner

Project Highlights

Skills Covered:

1. ANN, CNN, and RNN
2. Autoencoders

PUBG Players Finishing Placement Prediction (Practice Project)

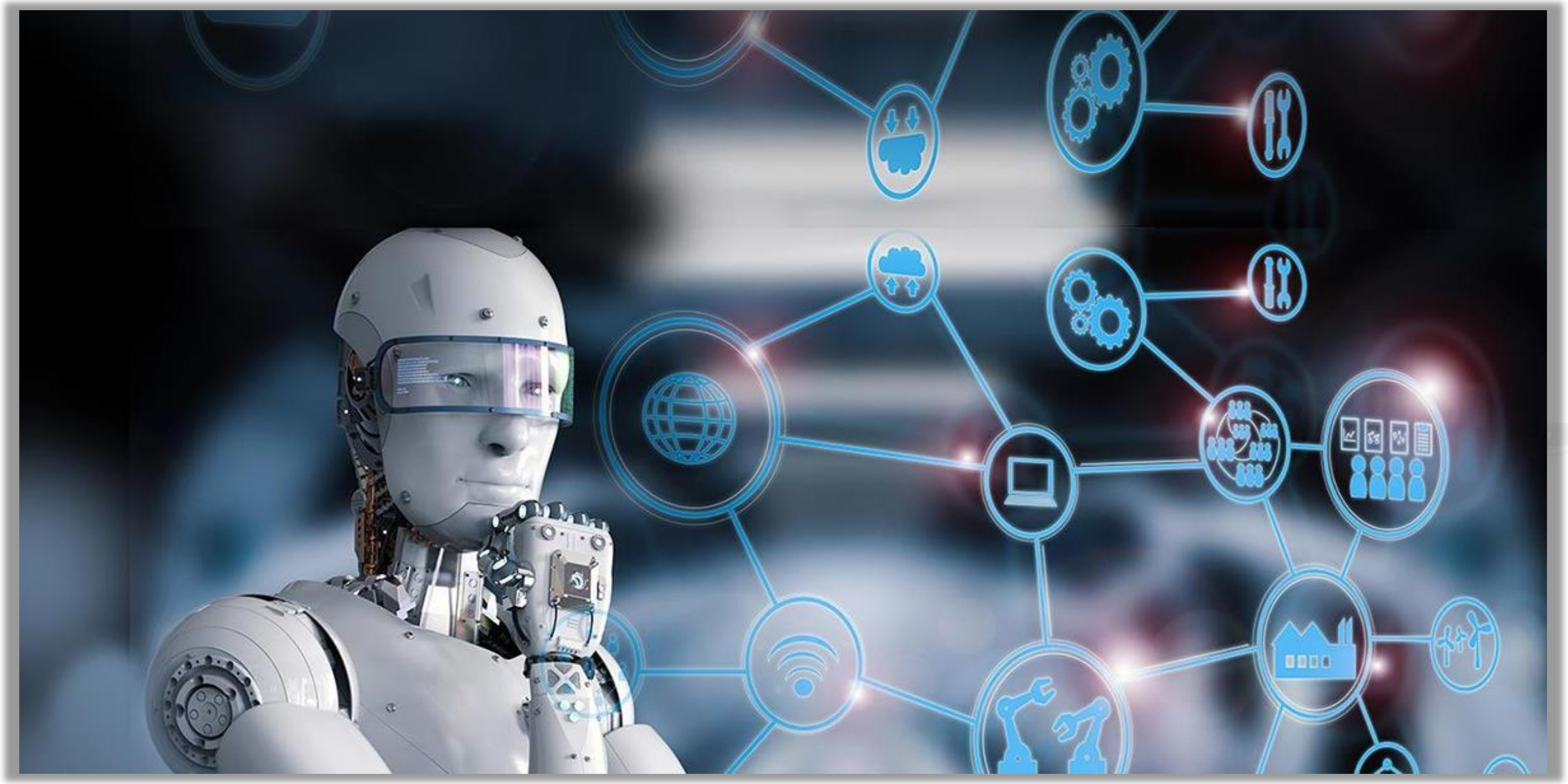


Lending Club Loan Data Analysis

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:

Learn

Acquire data and rules

Reason

Draw conclusions using the rules

Self Correct

Correct itself without external assistance

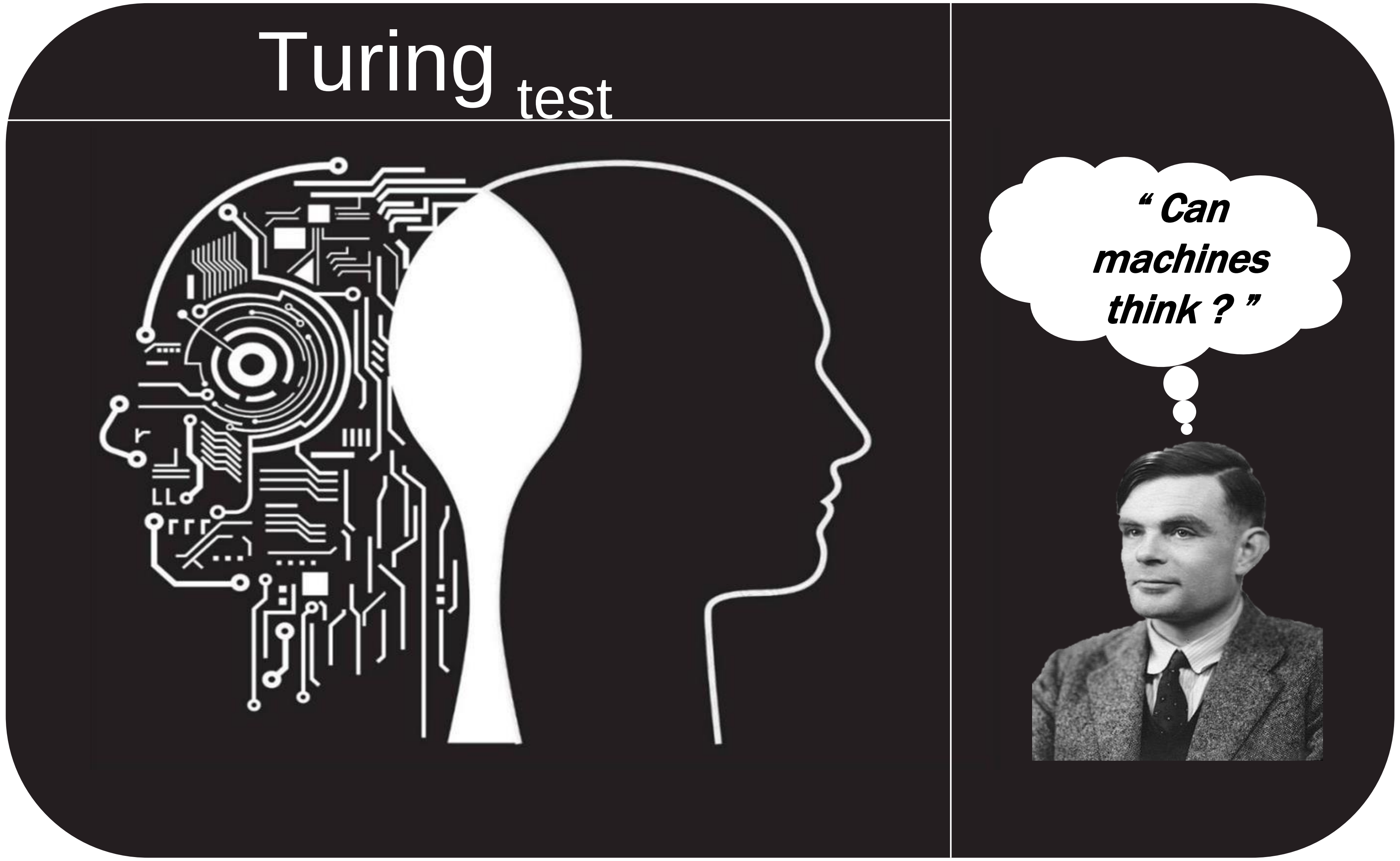
DATA AND ARTIFICIAL INTELLIGENCE

History of AI

simplilearn

The Turing Test

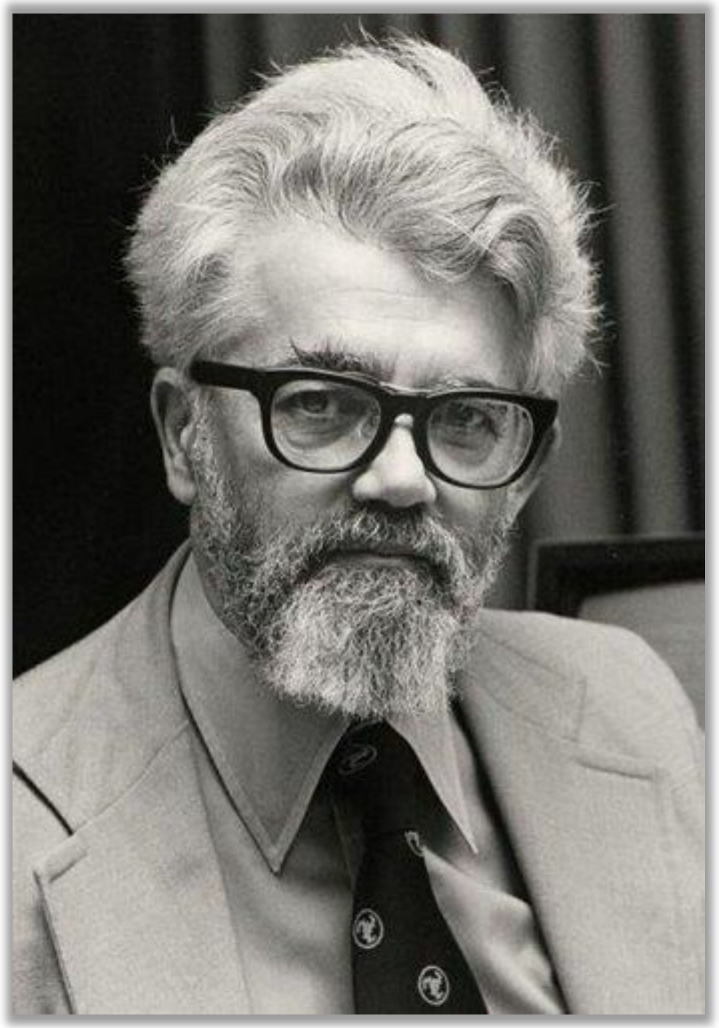
In 1950, Alan Turing wrote a paper proposing a test that looked at whether a computer can think like a human being.



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.

1980s–2000s

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

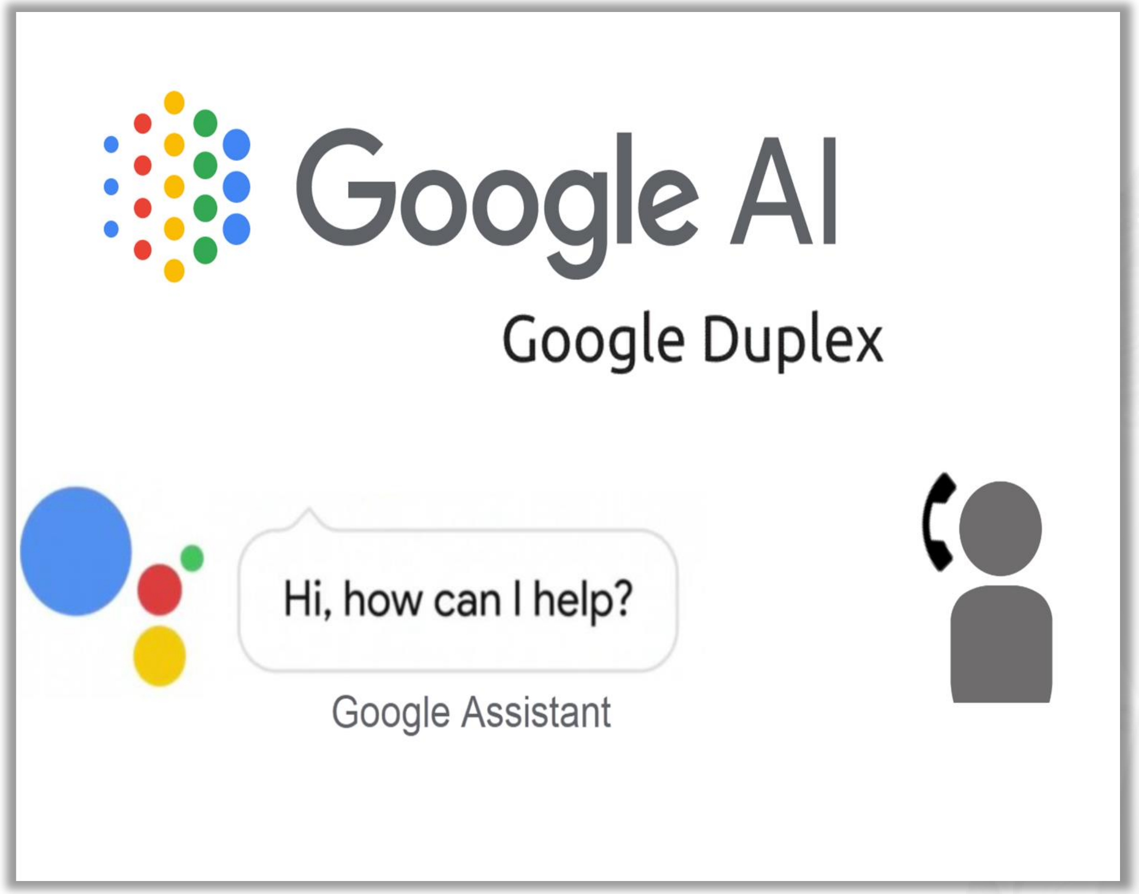
Man vs. Machine

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

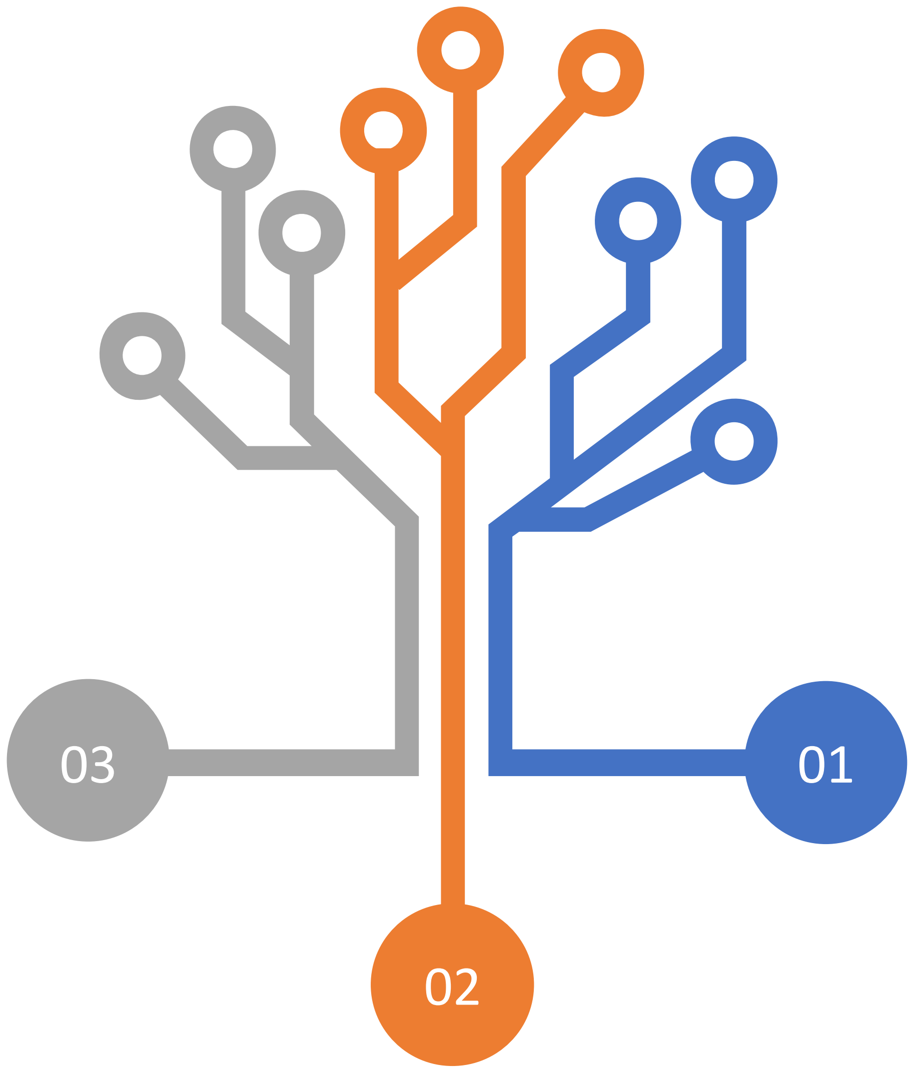
Google Duplex

Can make reservations or appointments, over the phone

simplilearn

What Can AI Do?

Here are some problems best suited for AI to solve:



Superhuman Tasks

Tasks that are very challenging for humans but easy for machines

Data-Intensive Tasks

Tasks involving analyzing large amounts of data and looking for patterns and anomaly

Repetitive Tasks

Manual tasks that follow logical steps to lead to a conclusion

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

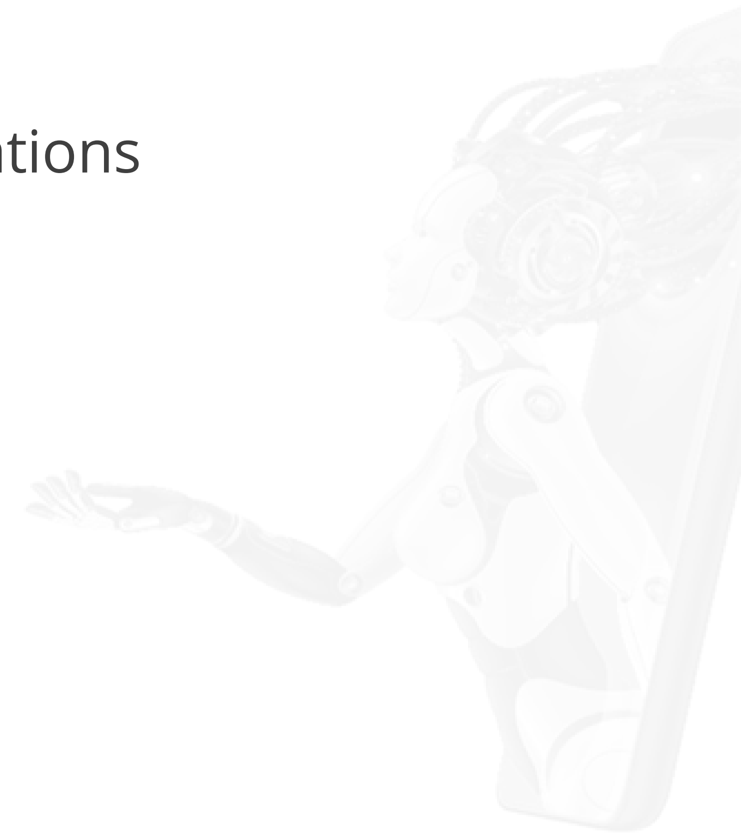
Machines think faster than humans and can perform repetitive jobs swiftly.

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



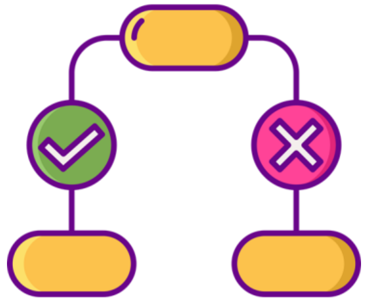
Recap: Machine Learning

Types of Machine Learning

Machine learning comprises three primary techniques:

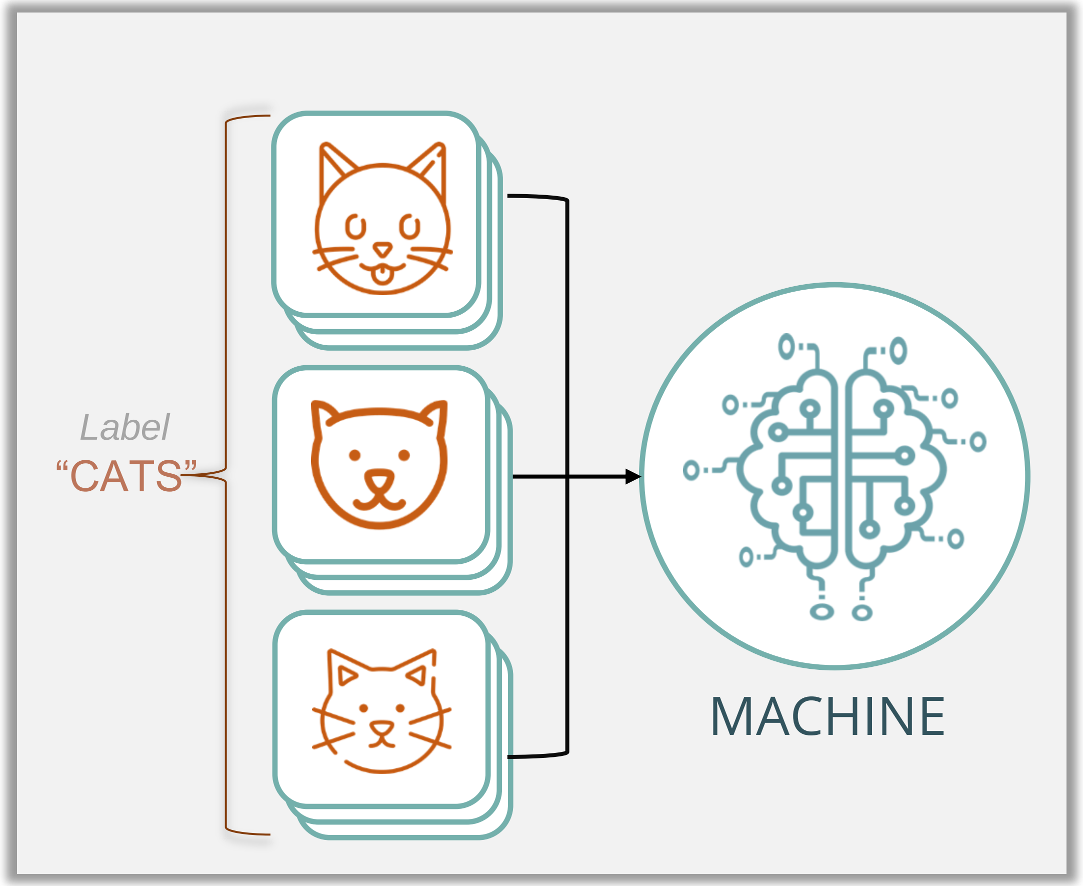
Machine Learning

Supervised	Unsupervised	Reinforcement
Task Driven (Predict Next Value)	**Data Driven (Identify Clusters)**	**Learn from Mistakes**

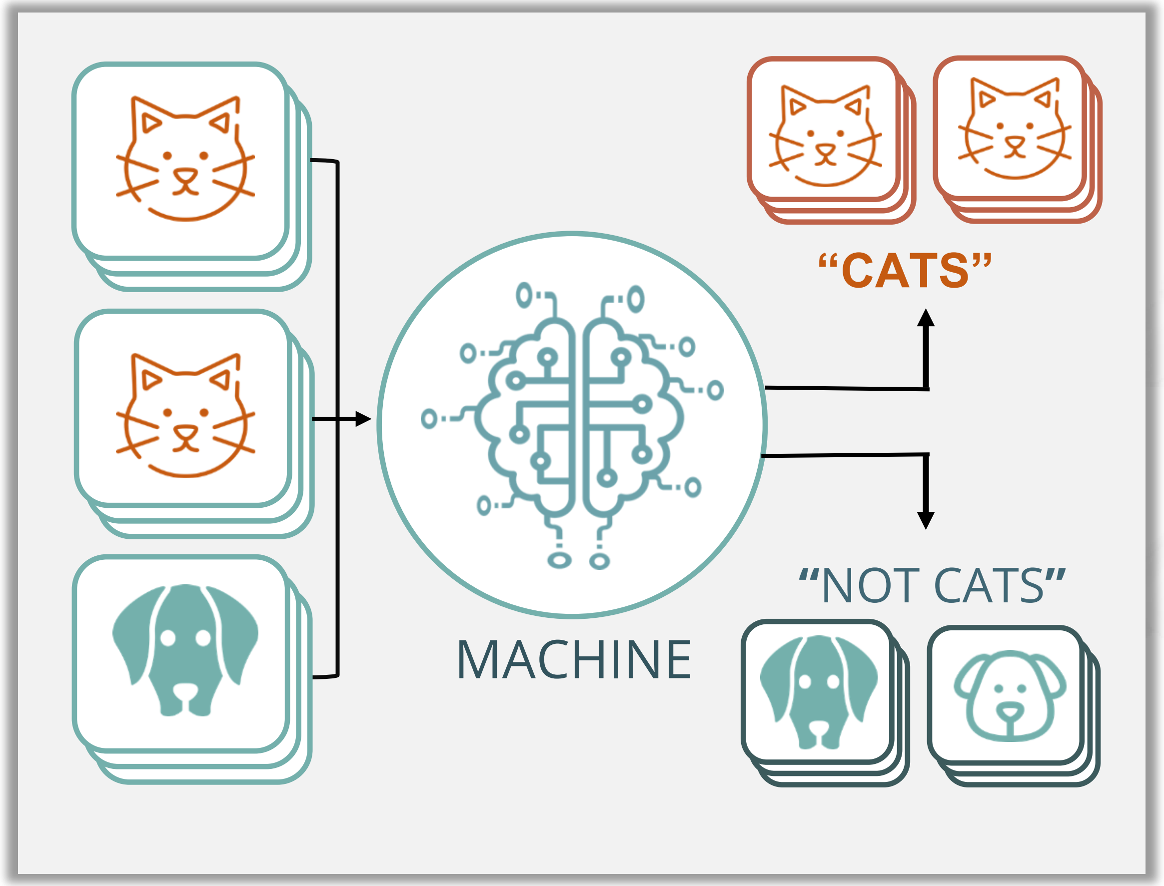


Supervised Learning

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



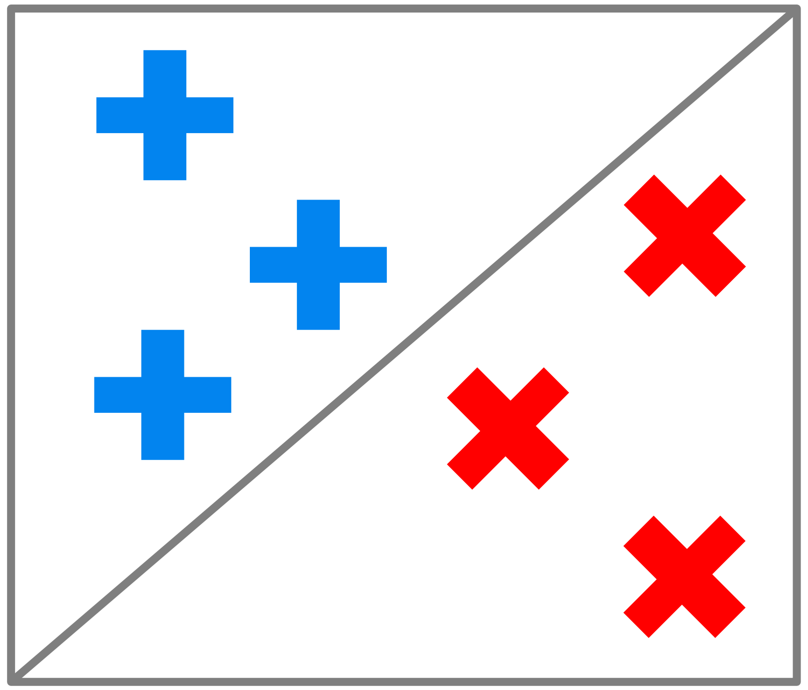
Step 2: Provide new unlabeled data to test

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

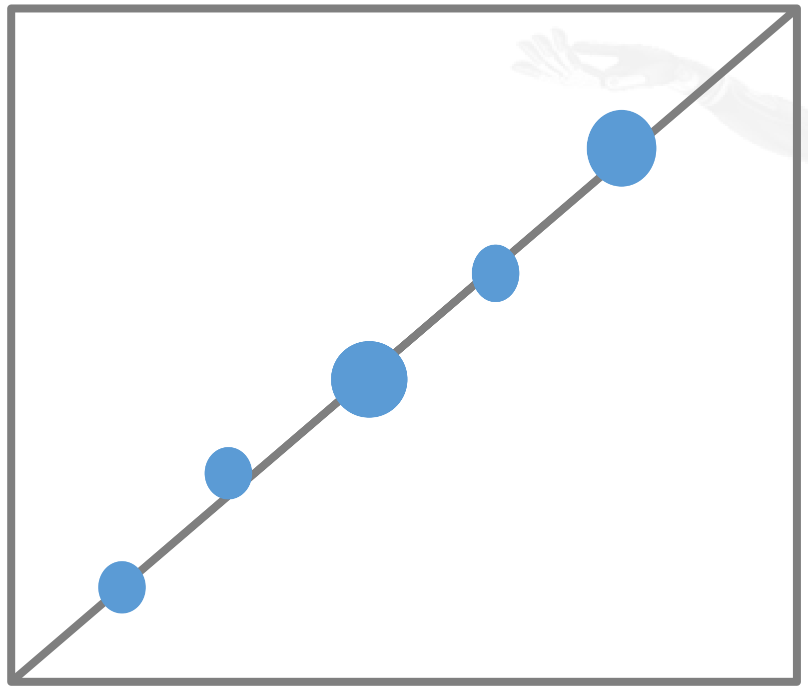
Types of Supervised Learning

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

Classification — Categorical — Output Variable — Numerical — Regression



Sorting items into categories



Identifying real values

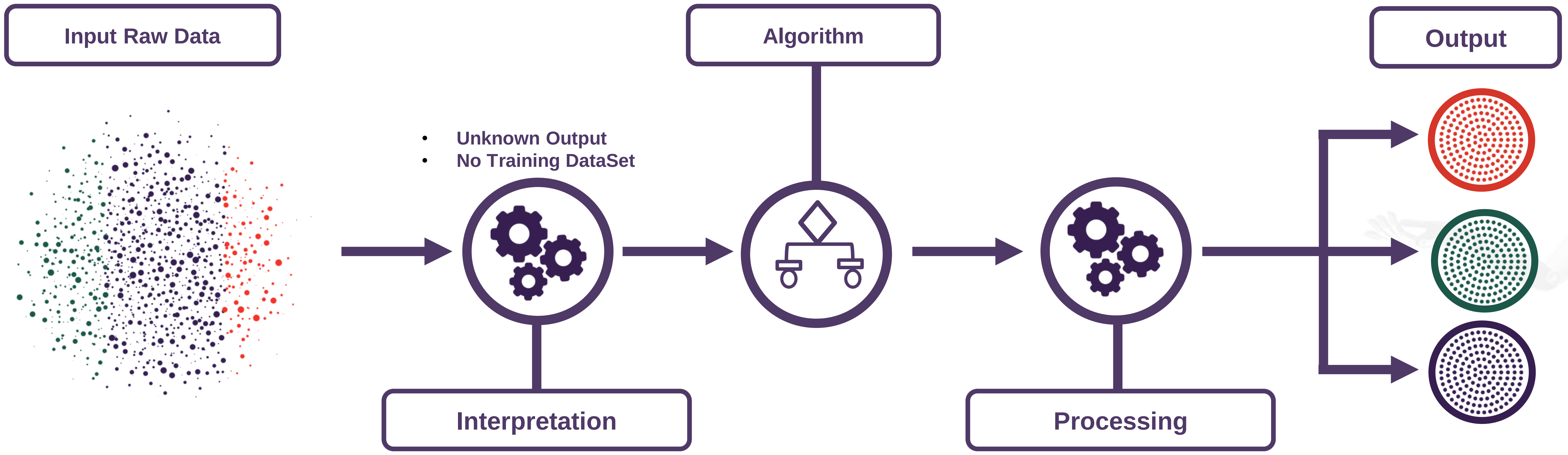
Supervised Learning Algorithms

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

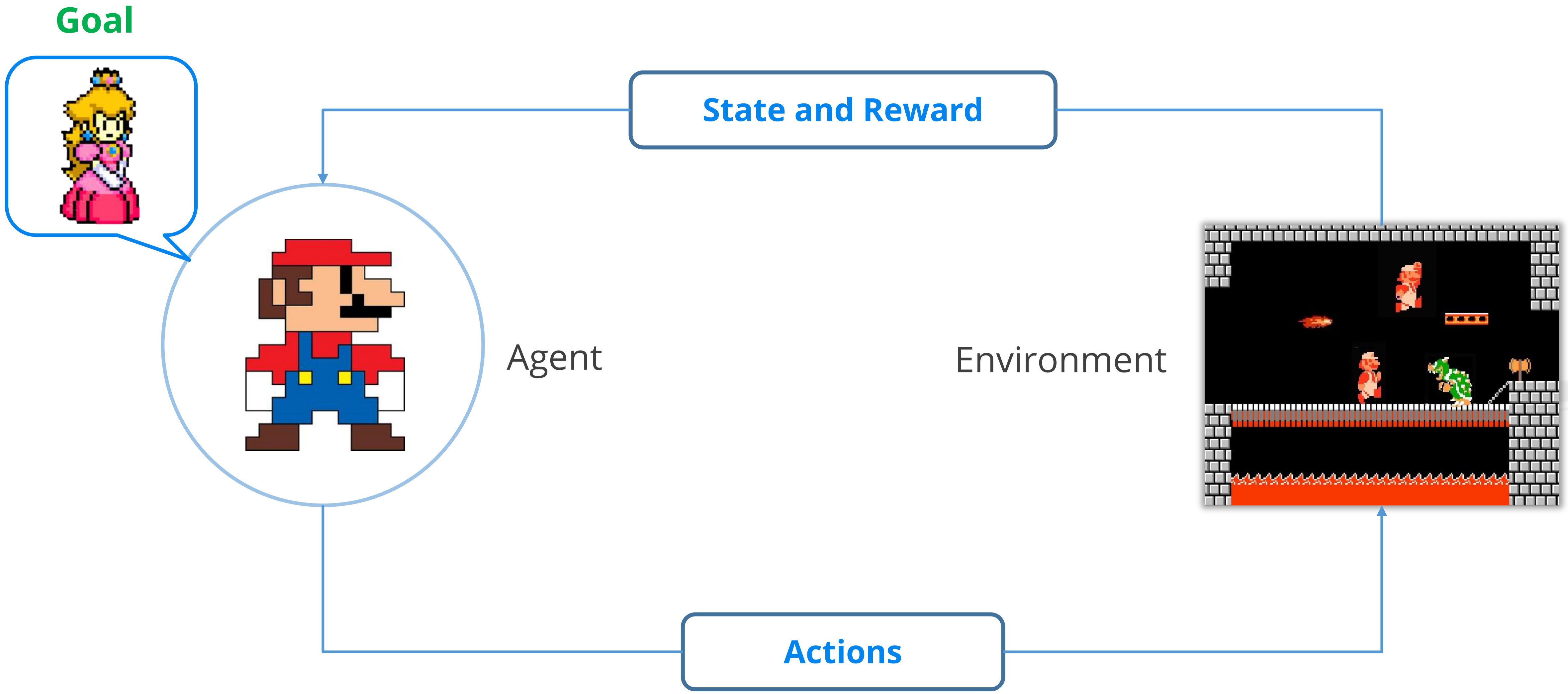
Unsupervised Learning Algorithms

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

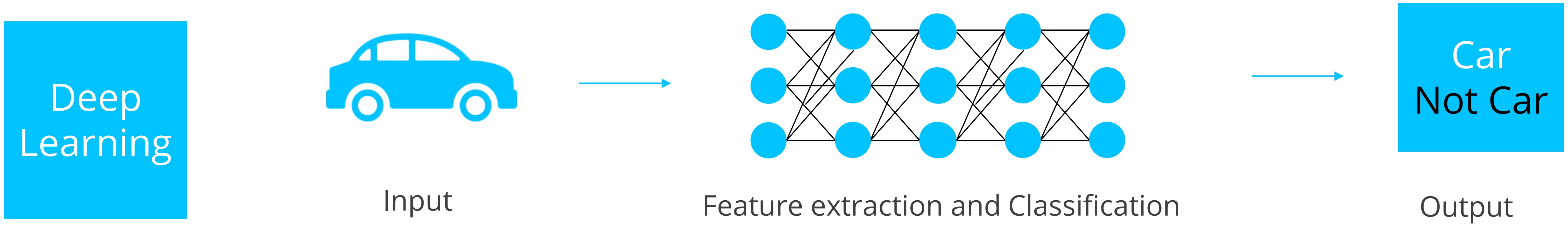
DATA AND
ARTIFICIAL INTELLIGENCE

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.

AI vs. ML vs. DL

ARTIFICIAL INTELLIGENCE

A technique which enables machines to mimic human behavior

MACHINE LEARNING

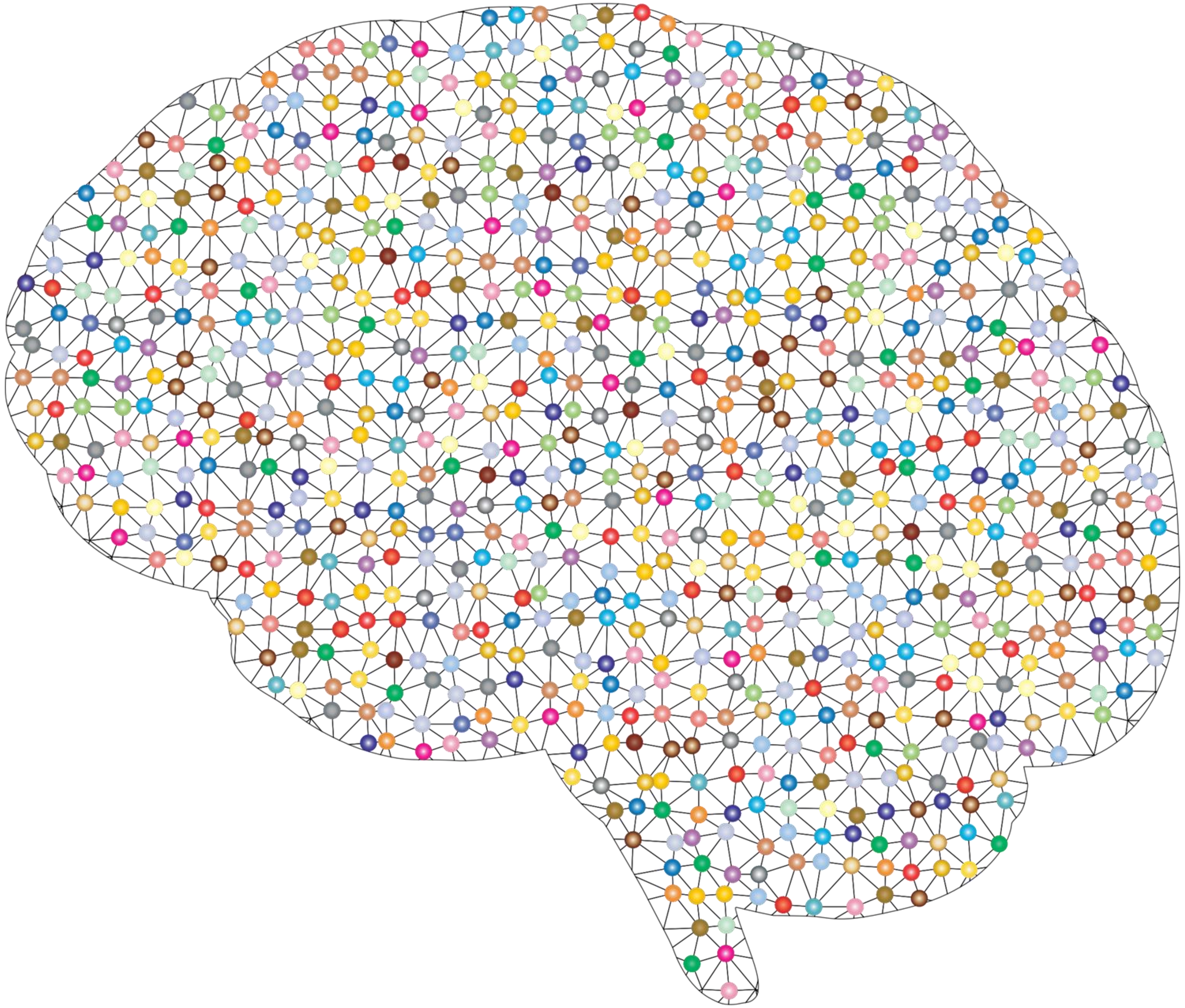
Subset of AI technique which use statistical methods to enable machines to improve with experience

DEEP LEARNING

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

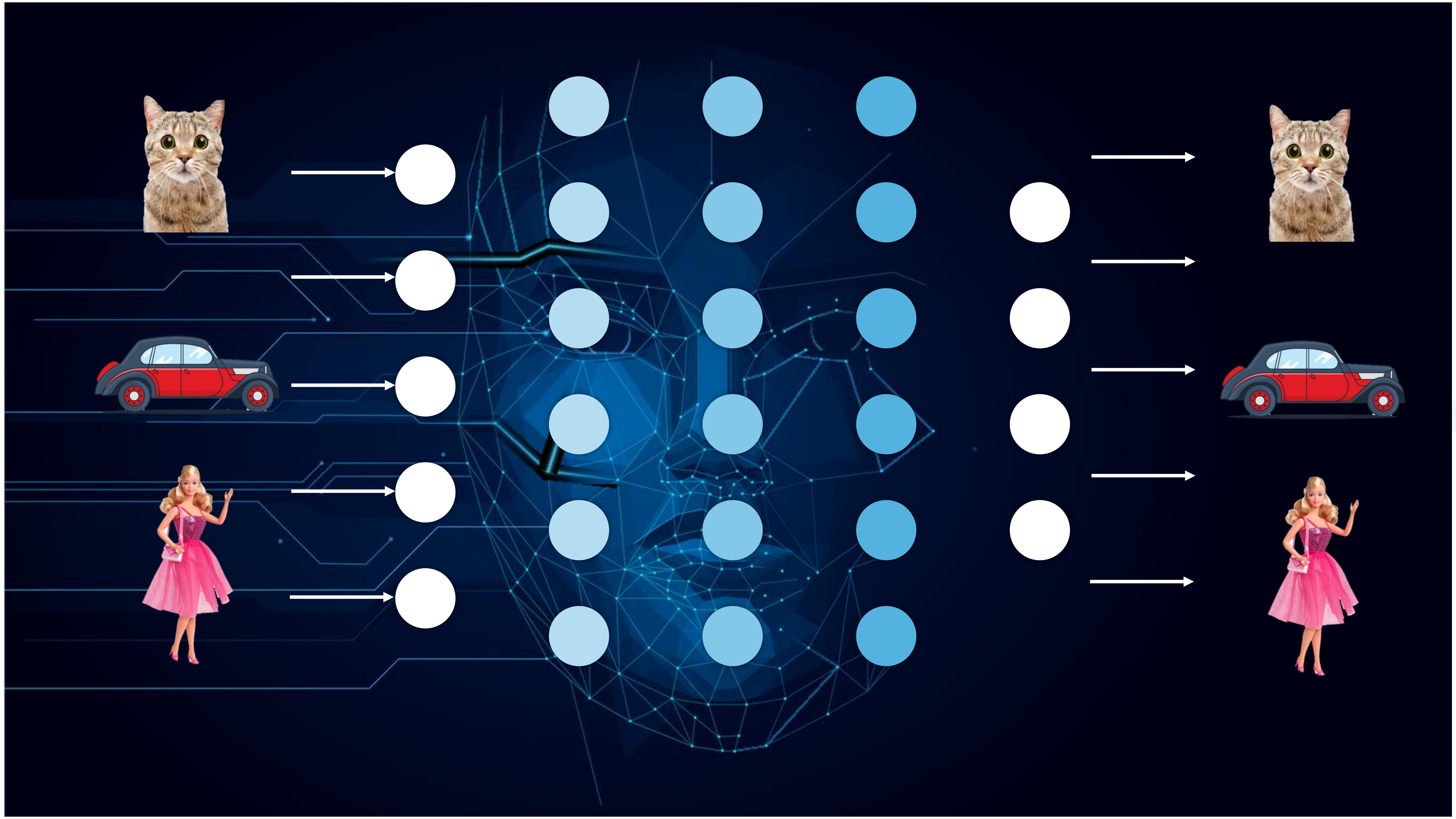
Neural Networks

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



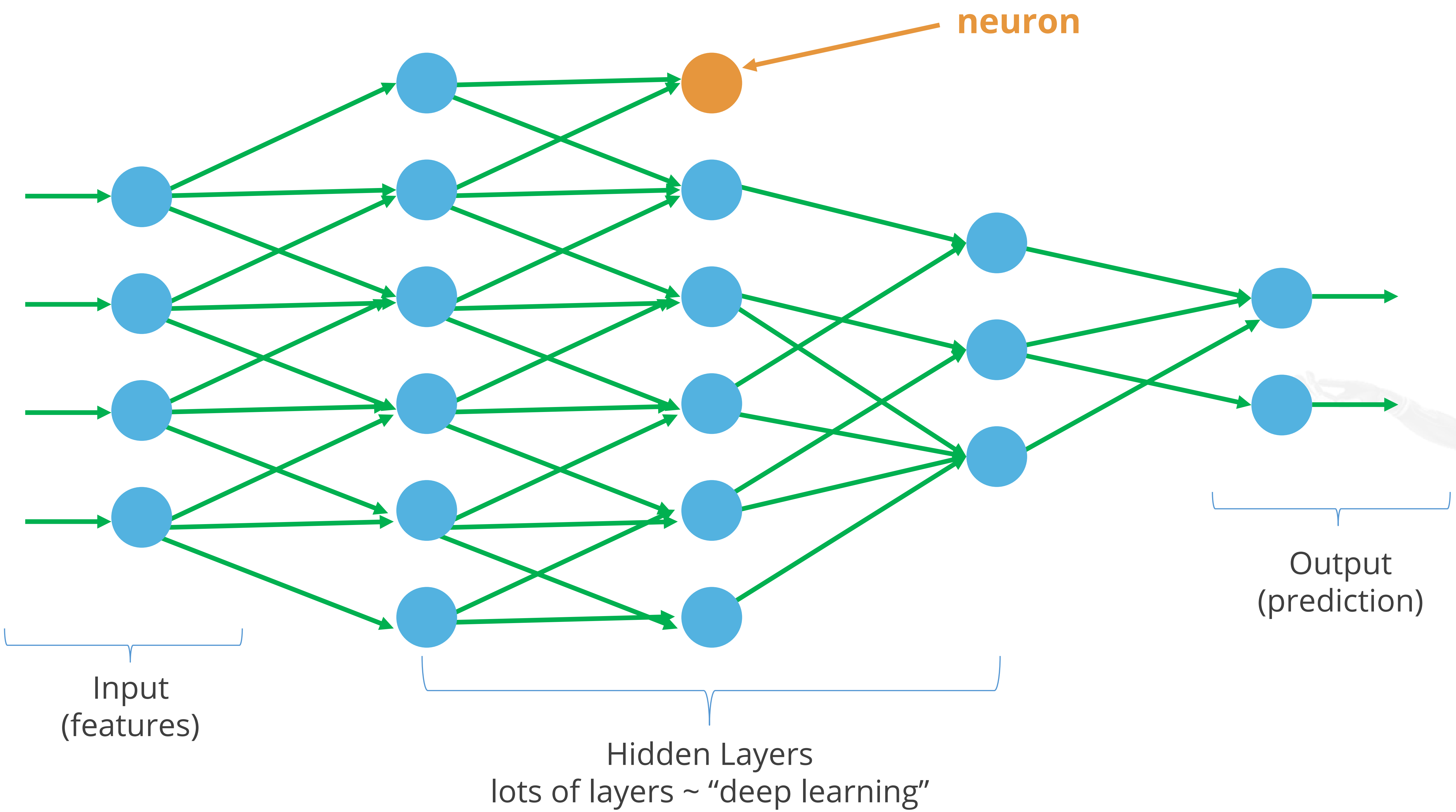
Artificial Neural Network (ANN)

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



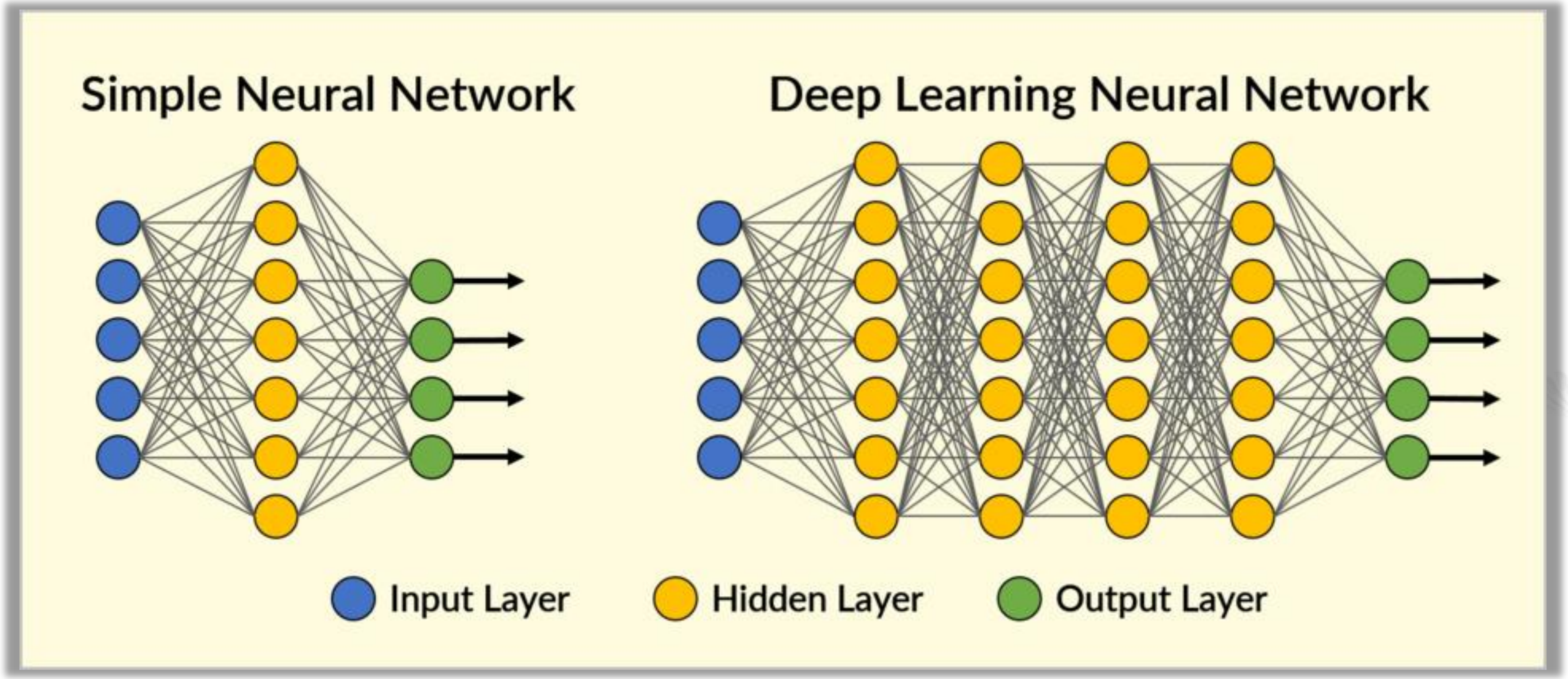
Deep Learning

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



Network Architecture

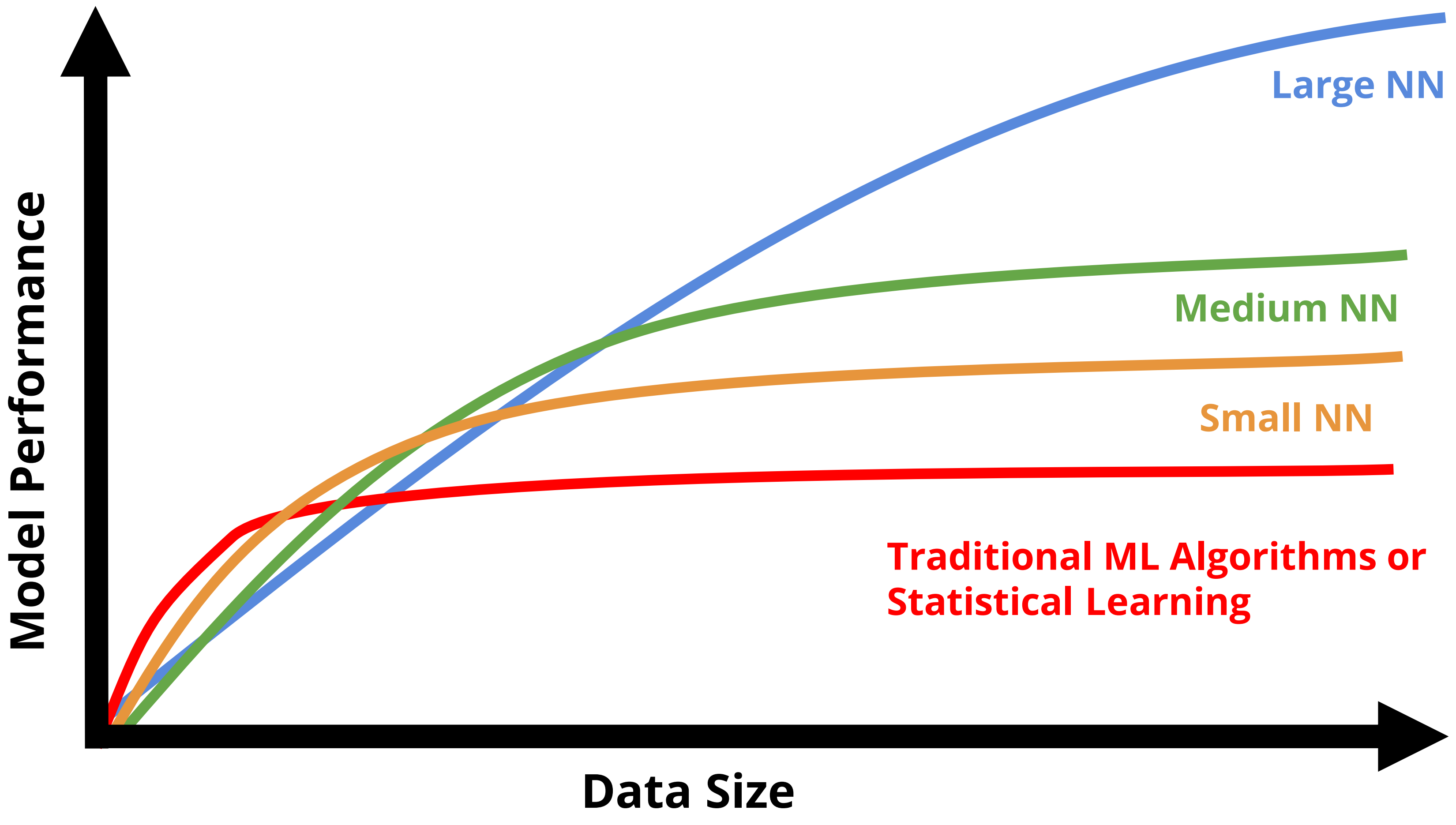
One can programmatically set the number and type of neural layers and the number of neurons comprising each layer.



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.



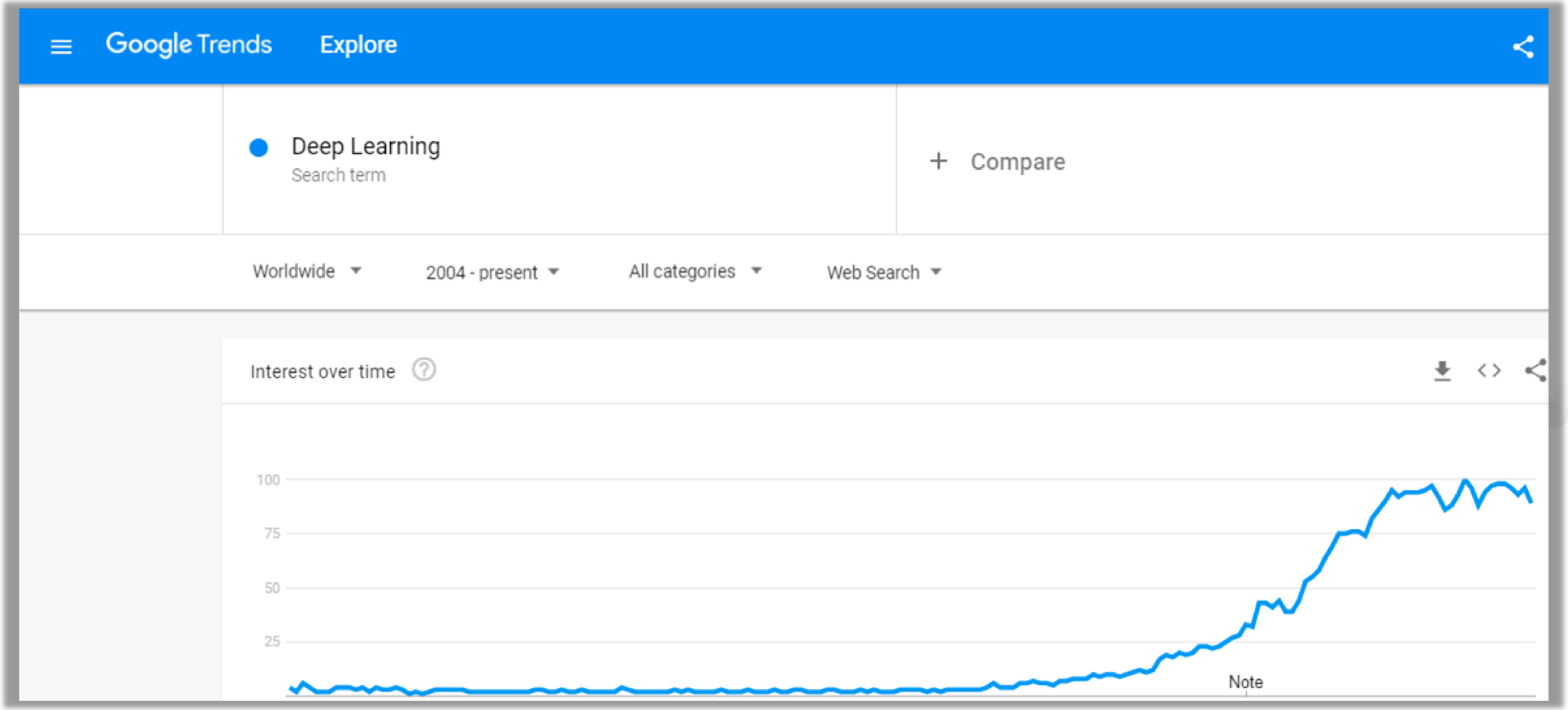
DATA AND
ARTIFICIAL INTELLIGENCE

Deep Learning: Success Stories from the Last Decade

simplilearn

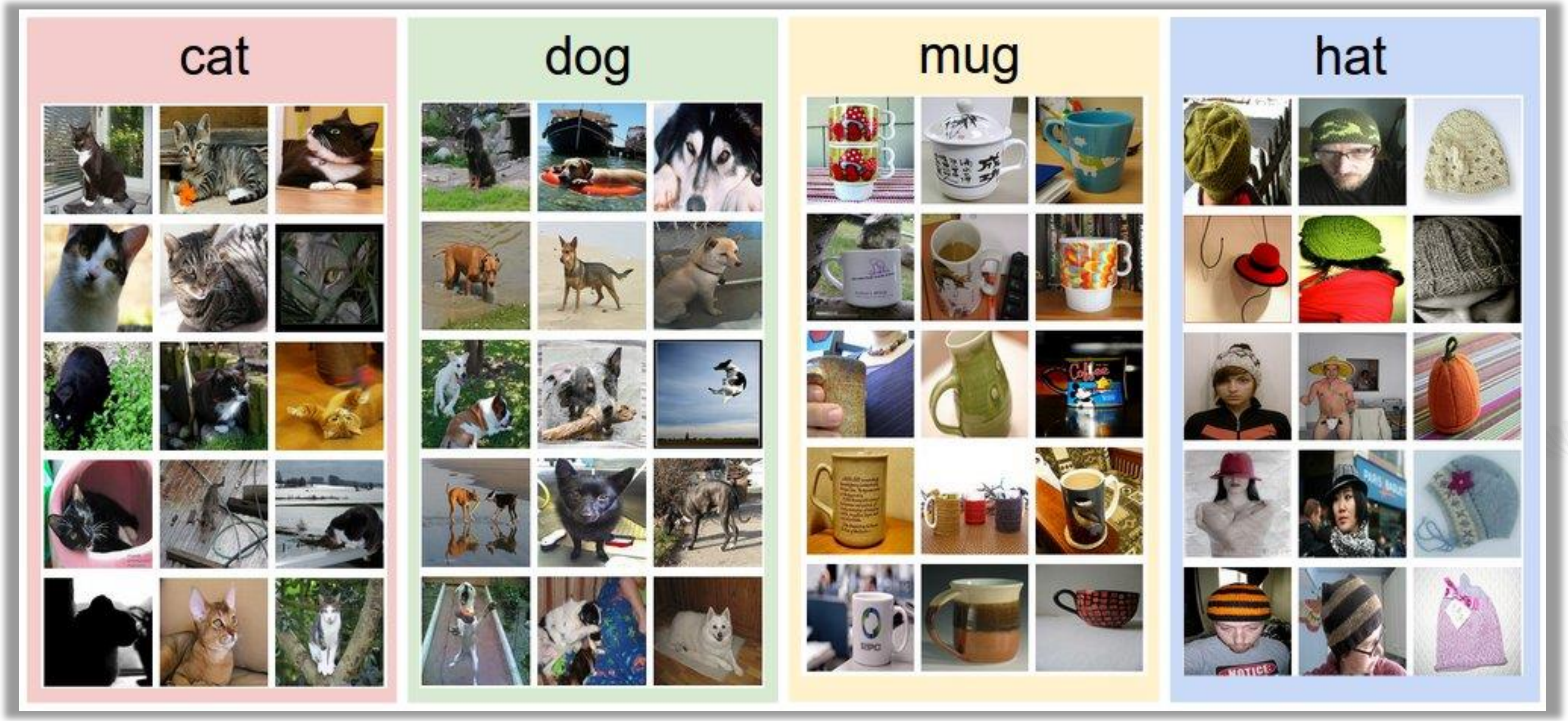
Deep Learning Search Trends

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

Alex Krizhevsky
University of Toronto
kriz@cs.utoronto.ca

Ilya Sutskever
University of Toronto
ilya@cs.utoronto.ca

Geoffrey E. Hinton
University of Toronto
hinton@cs.utoronto.ca

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.

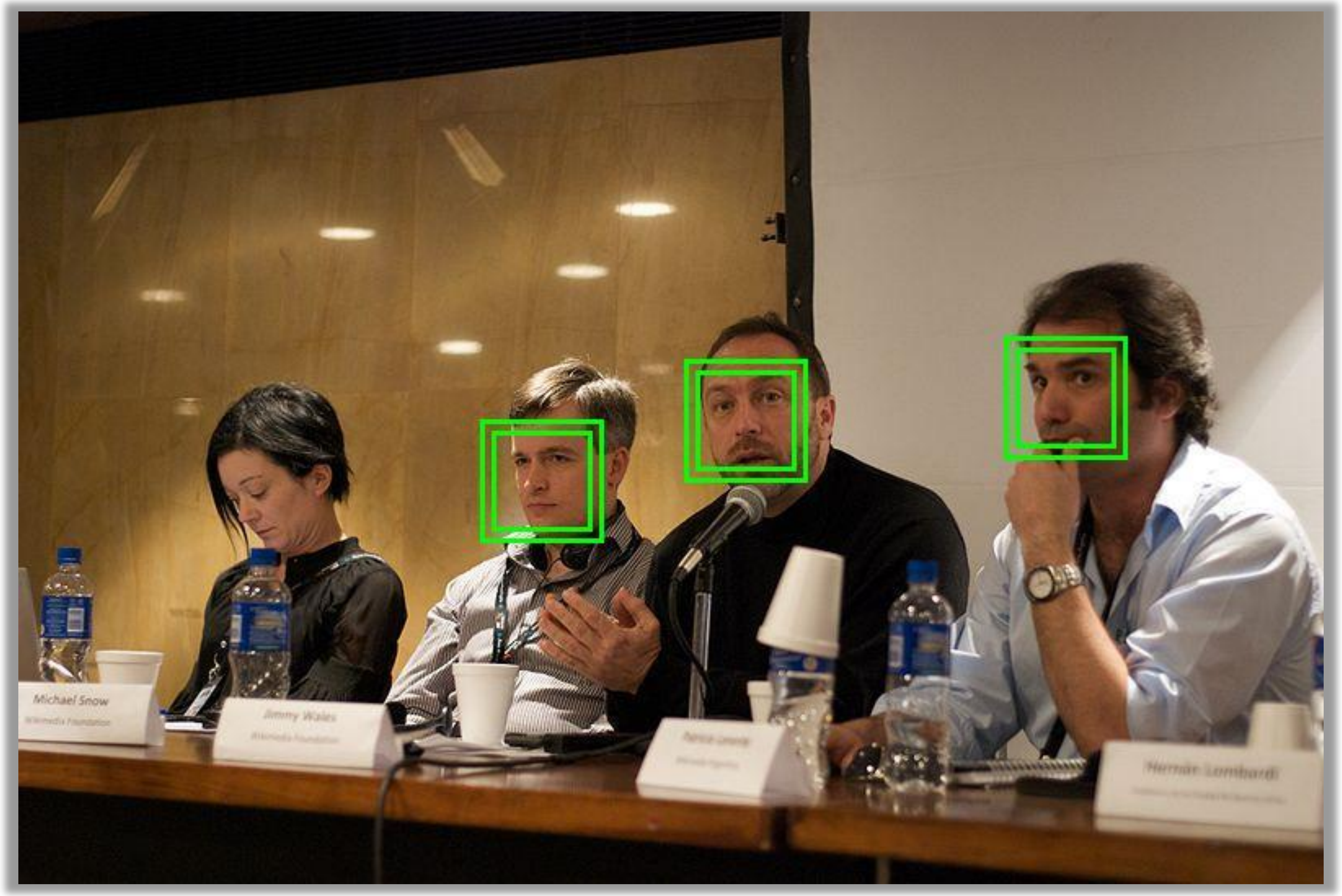
Recognizing Cats on YouTube

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.

simplilearn

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.

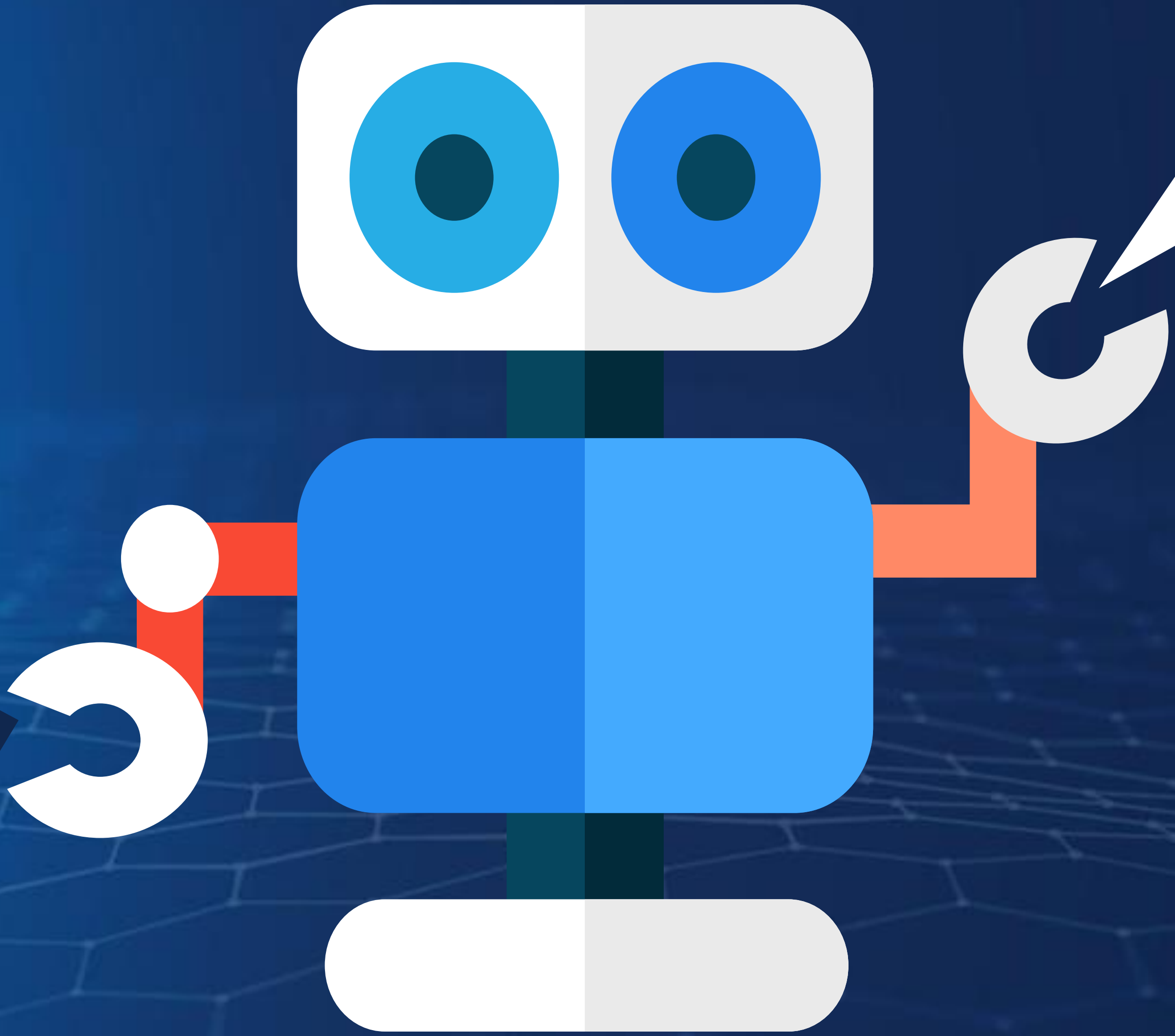
Video Games

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.

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.



This prompts you to ask the question…

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

Let’s find out!

DATA AND

ARTIFICIAL INTELLIGENCE

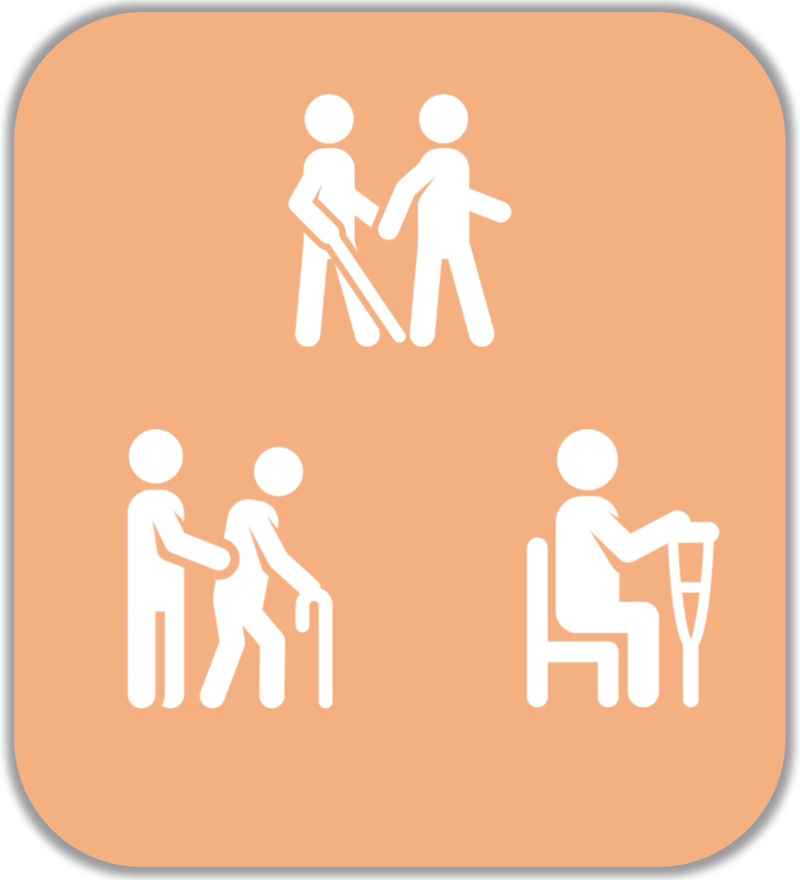
Self-Driving Cars

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

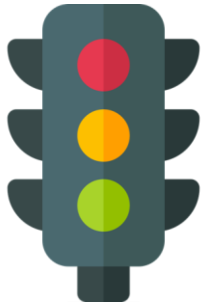
Automated lane changes, parking, and braking

Energy efficiency

Improved fuel efficiency

Reduced crash rates

Driver error causes 90% of all crashes



Ease traffic congestion

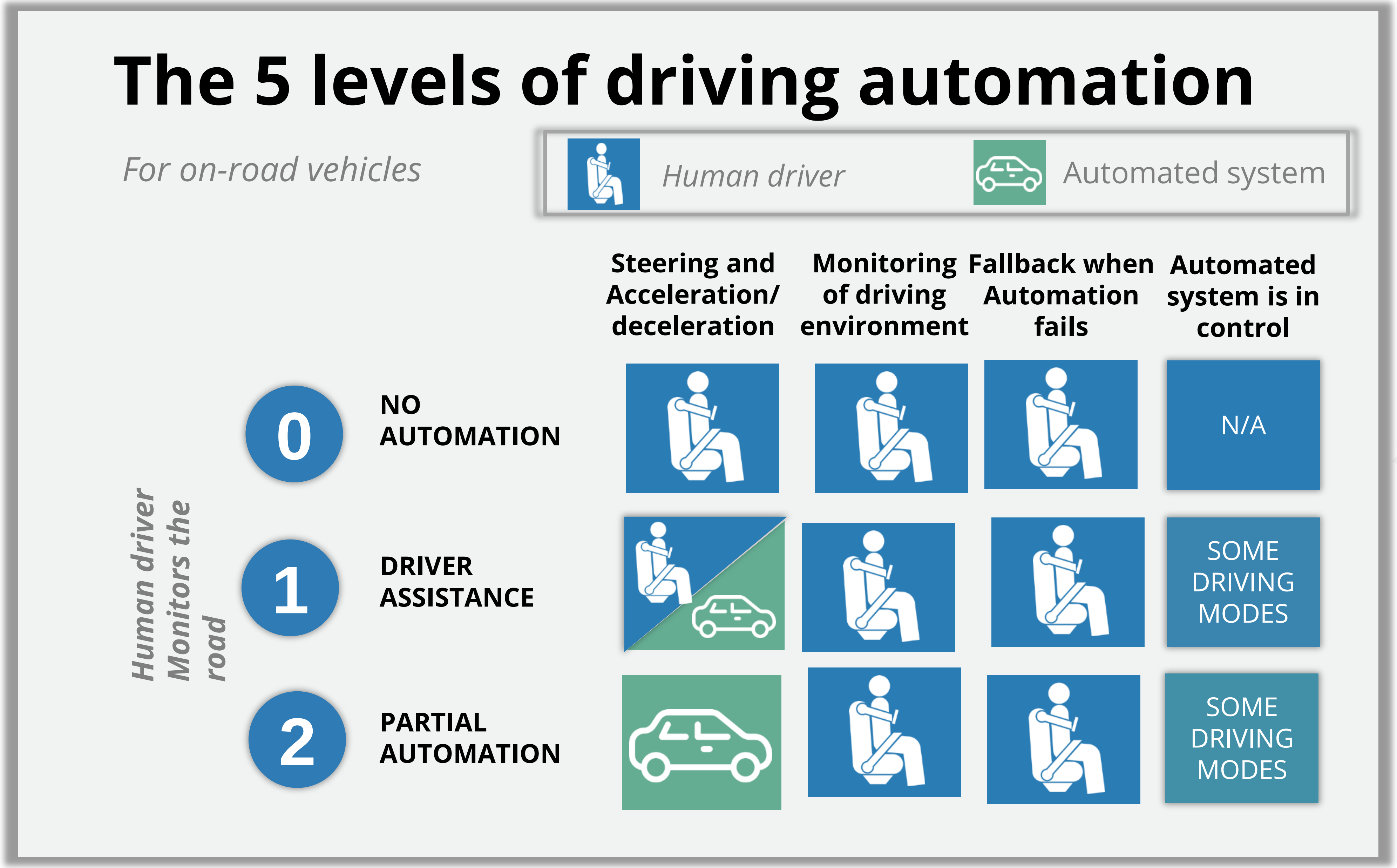
Better coordinated traffic leads to less congestion

Over the air updates

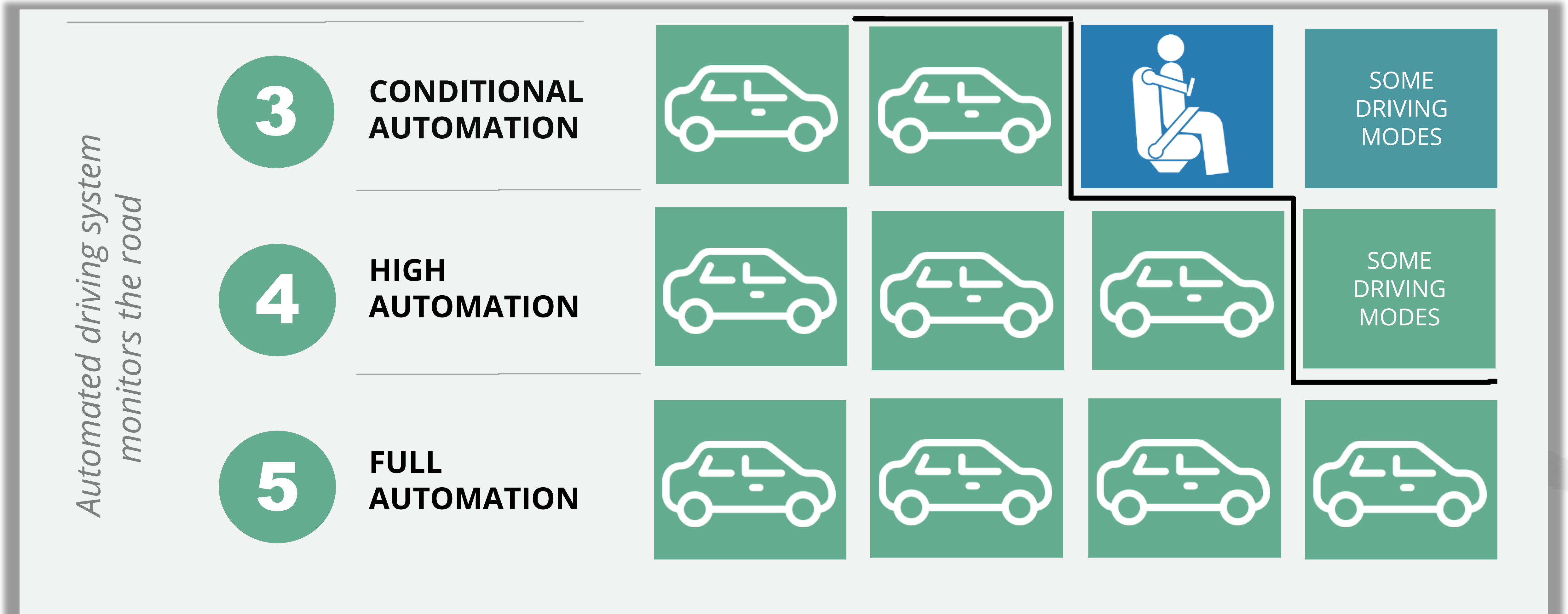
Neural nets get better with more data

Levels of Driving Automation

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



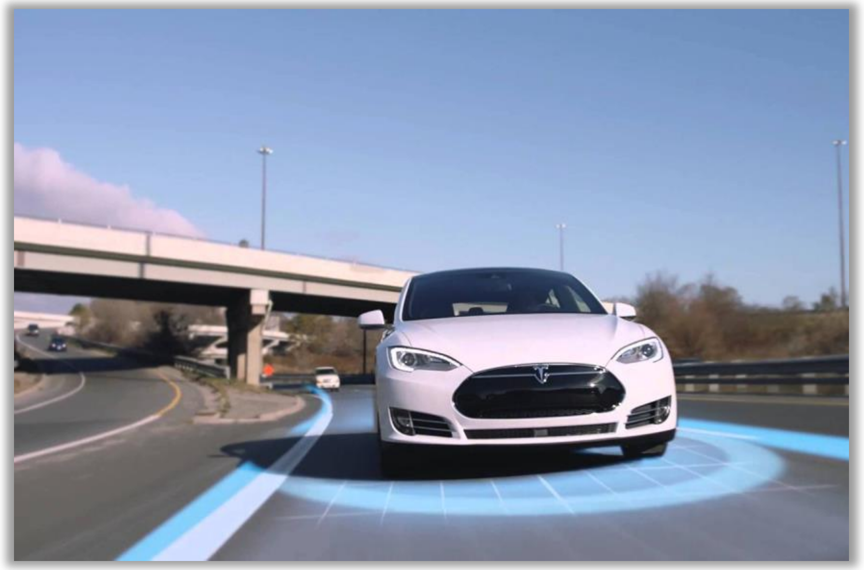
Levels of Driving Automation



Source: SAE International

Industry Trends

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



Tesla

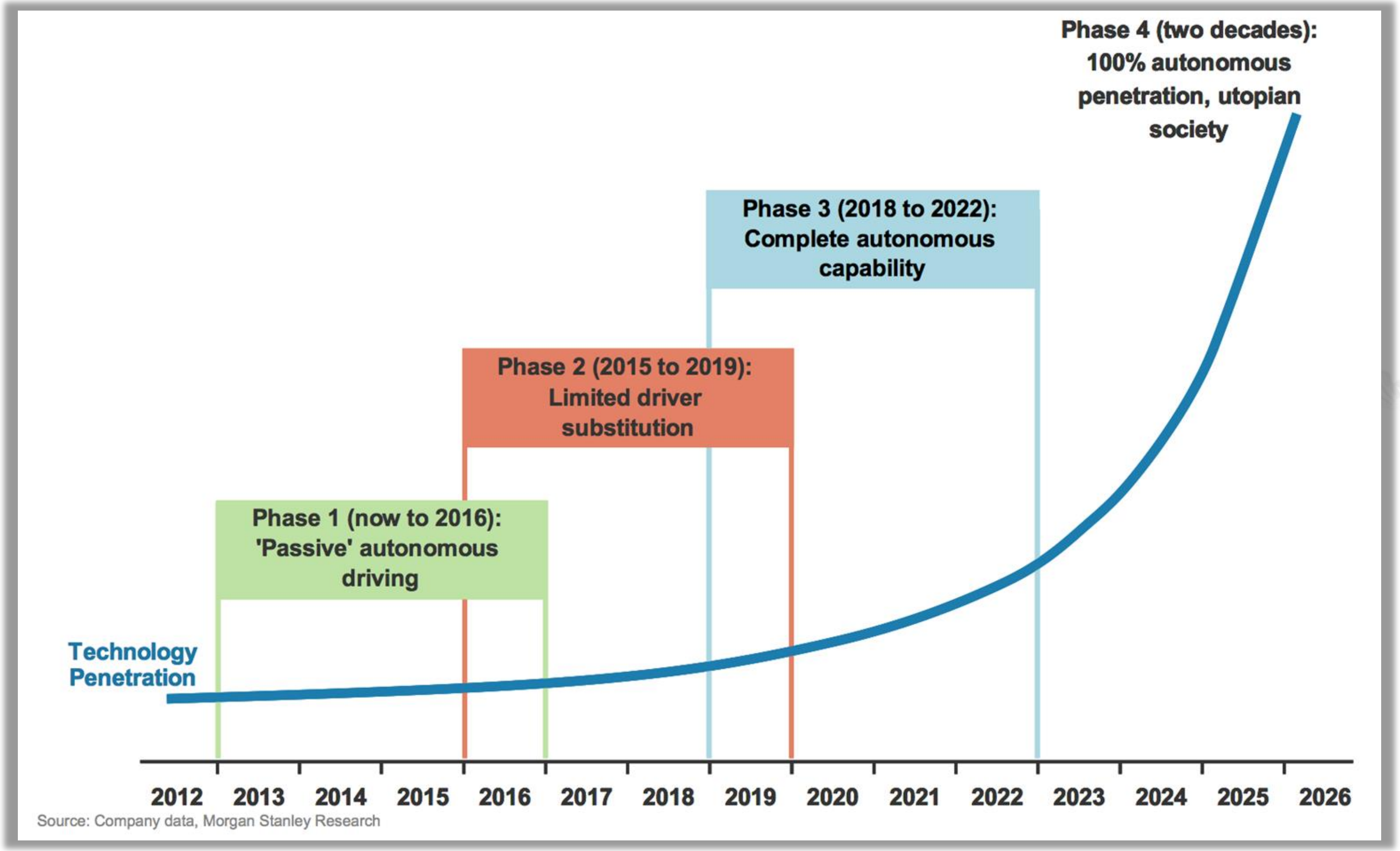
Nissan

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.

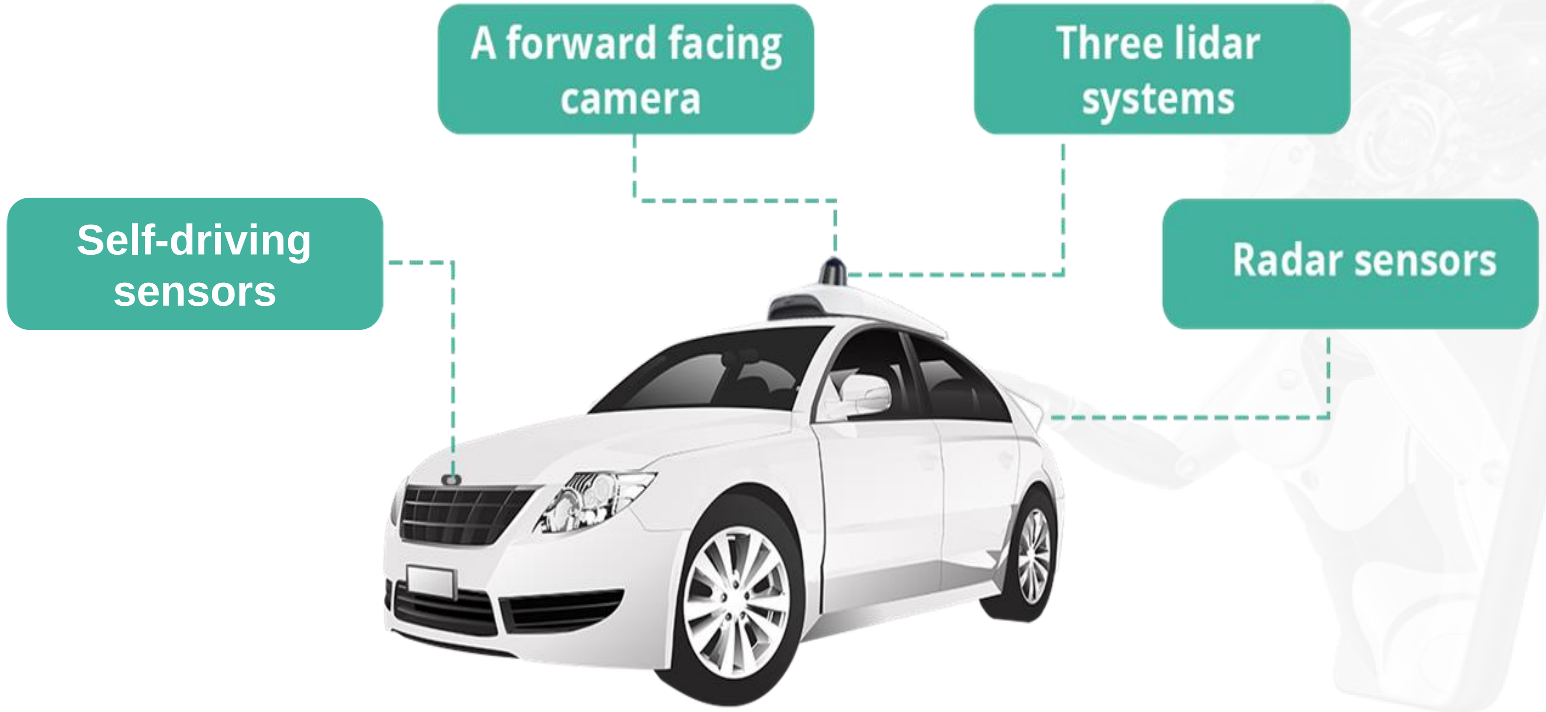


Working of Self-Driving Cars

How Does a Self-Driving Car See?

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

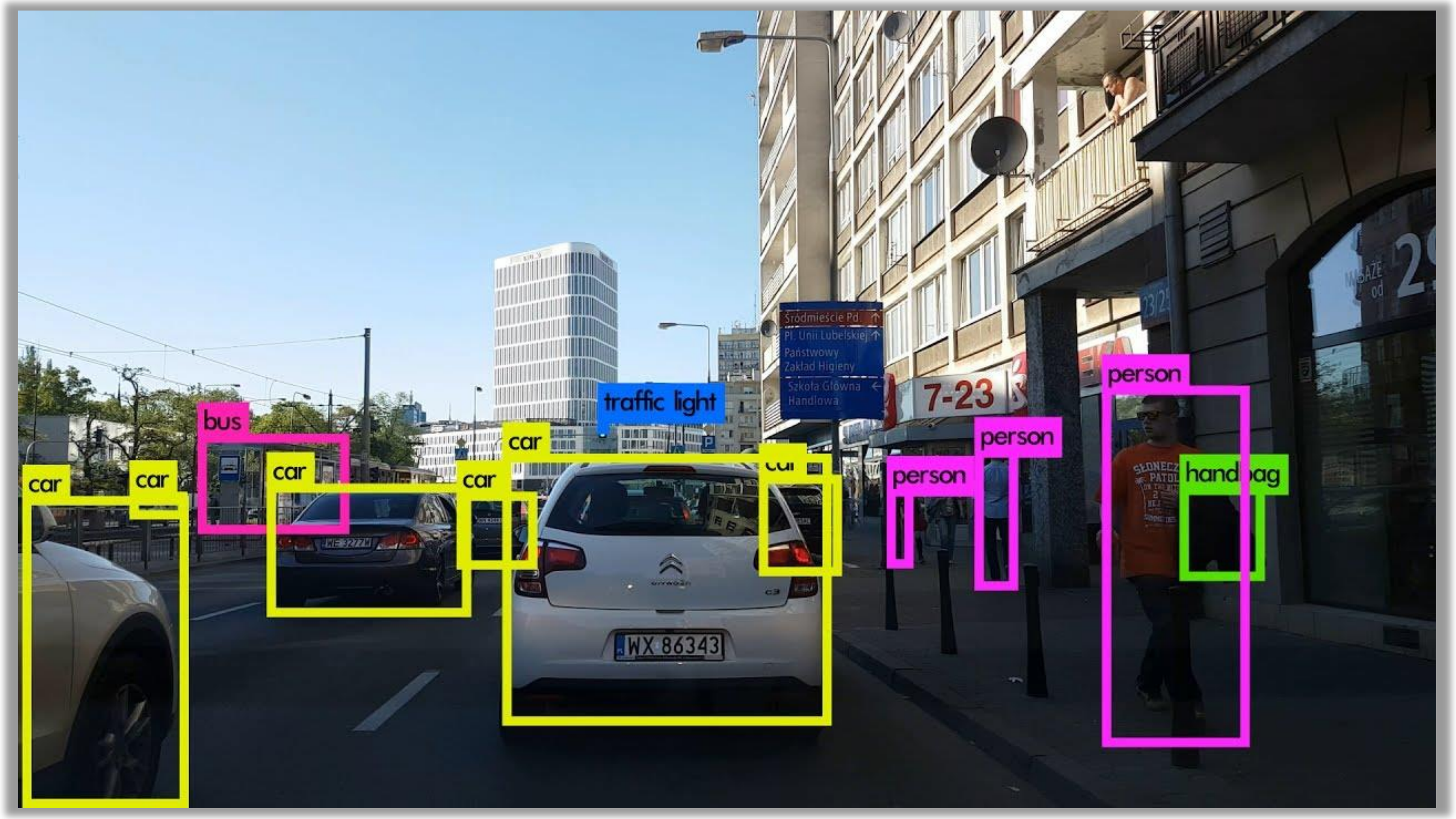
2. A powerful onboard computer processes the information in a matter of milliseconds using hard-coded rules and obstacle avoidance algorithms.



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

How Does a Self-Driving Car See?

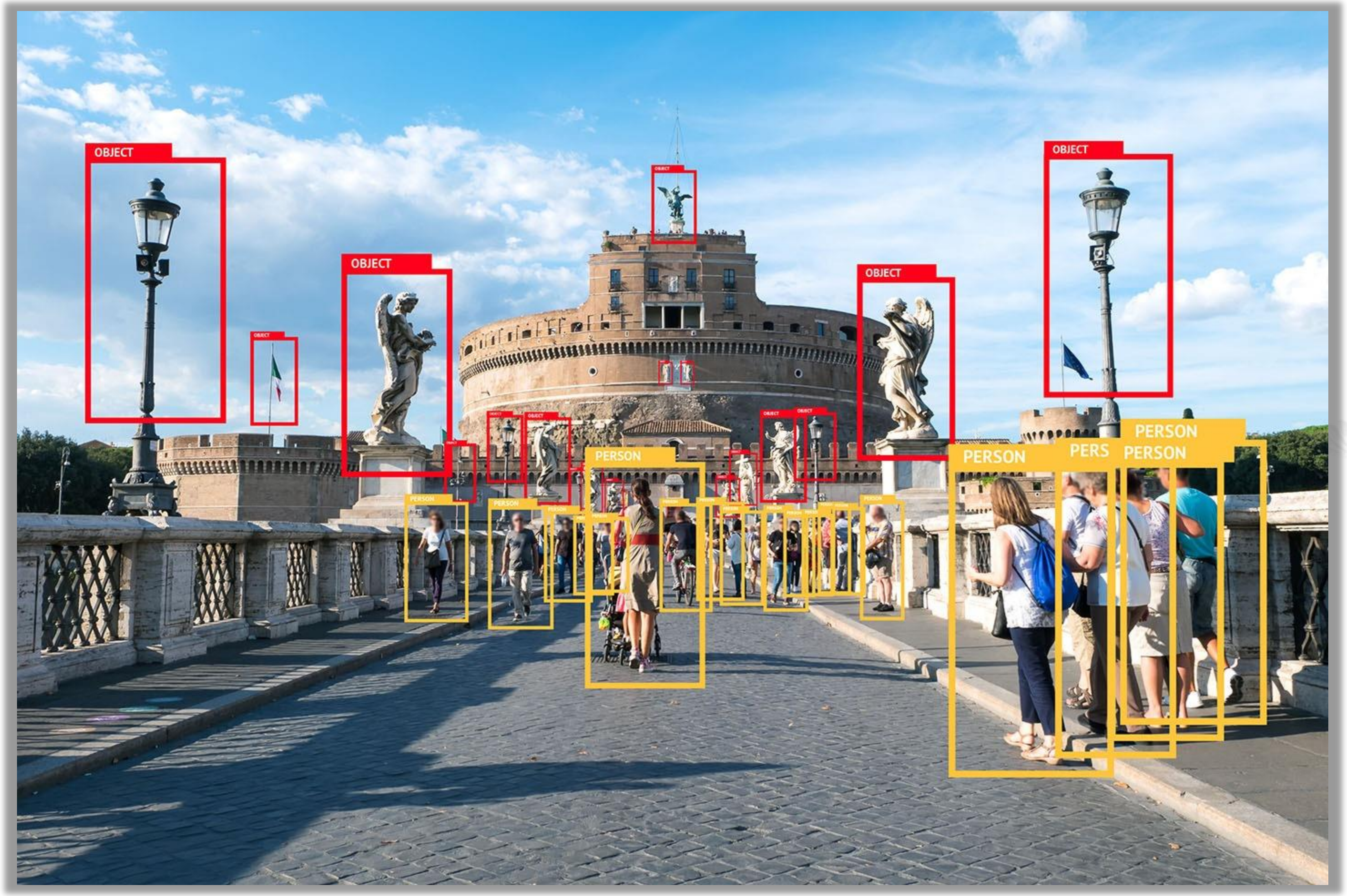
Precise detection of vehicles, pedestrians, and street signs help cars drive as safely as humans.



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

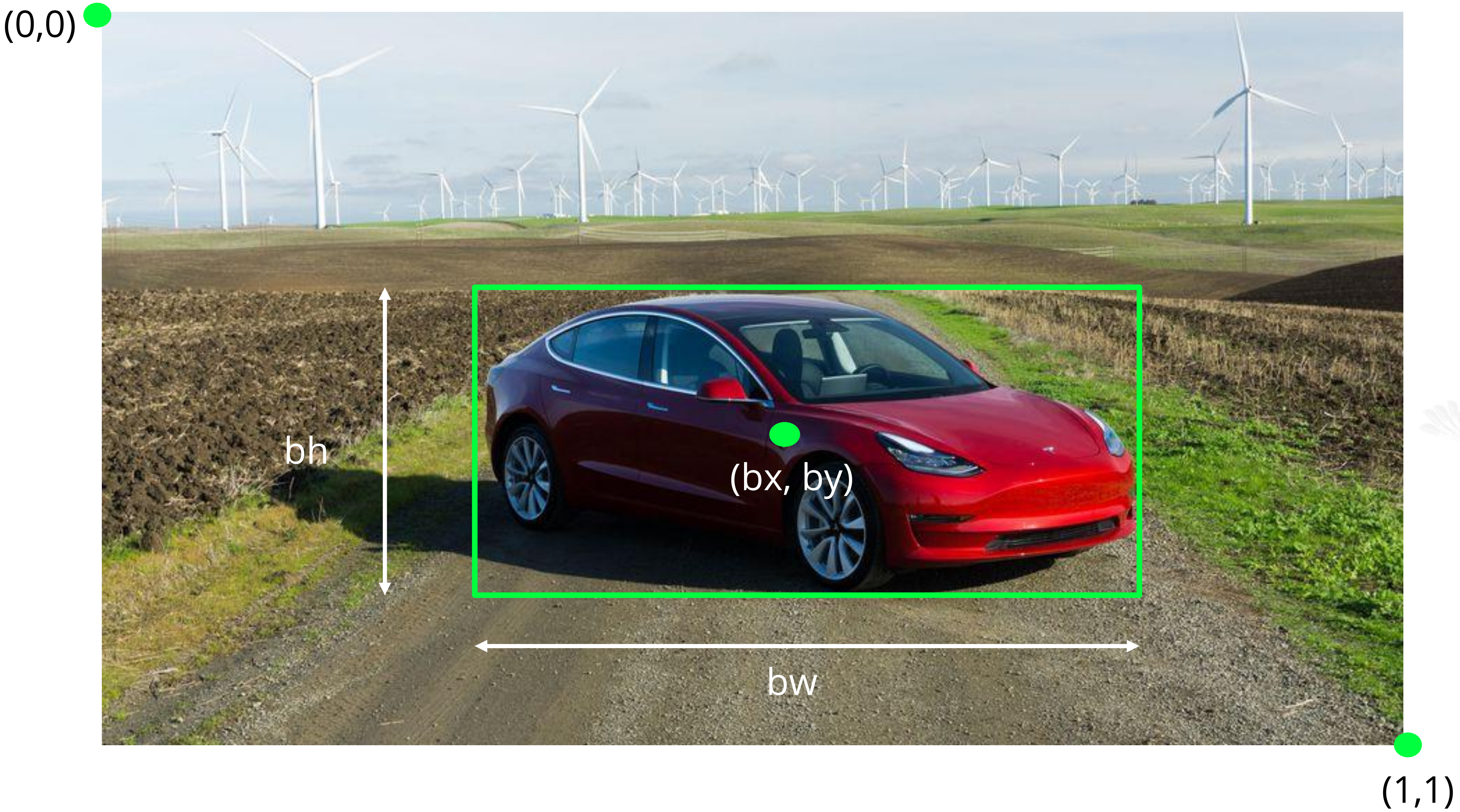
Object Detection

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:

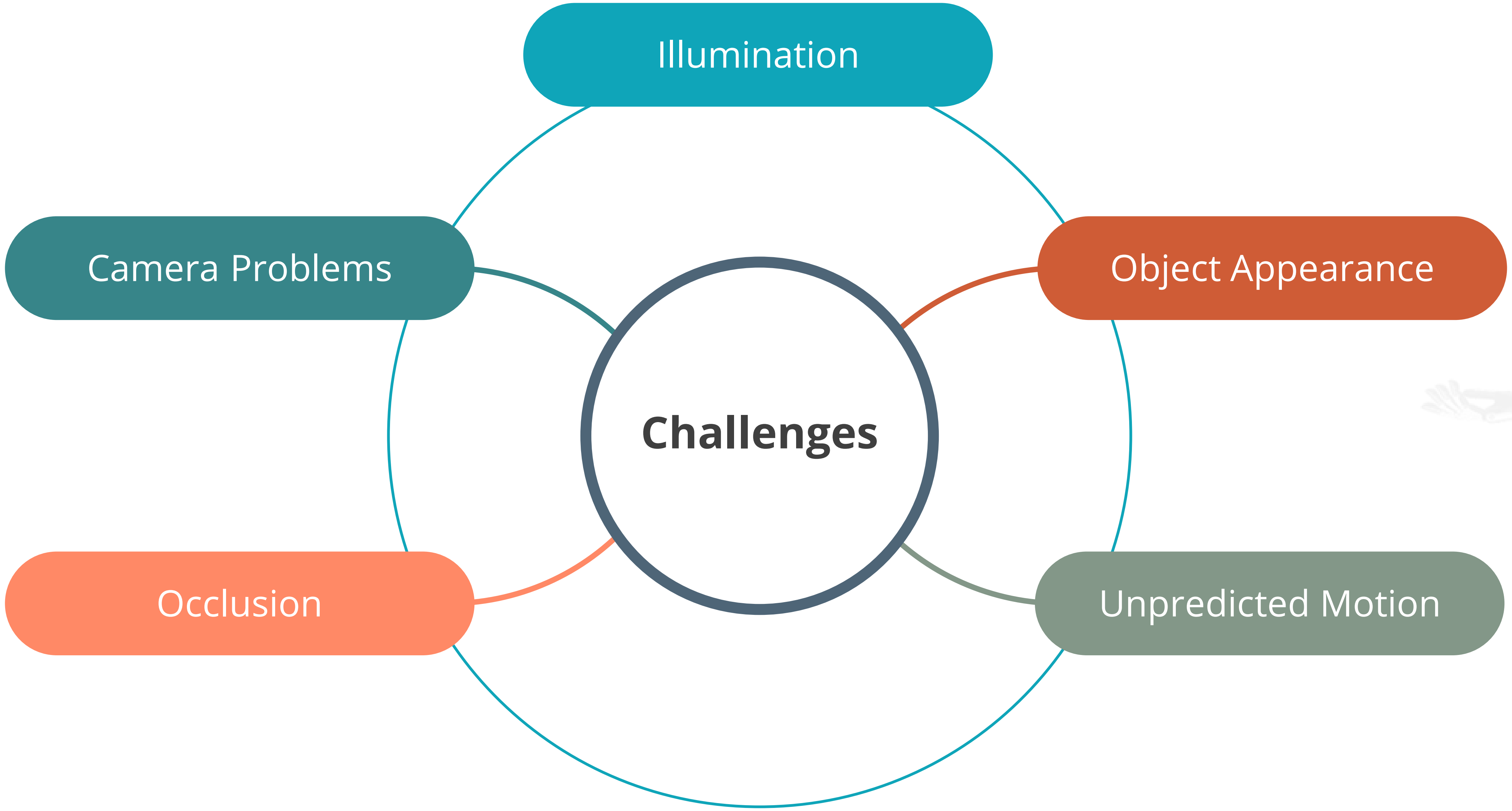
- **bx, by** — Center coordinates of the bounding box
- **bw** — Width of the bounding box
- **bh** — Height of the bounding box

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.

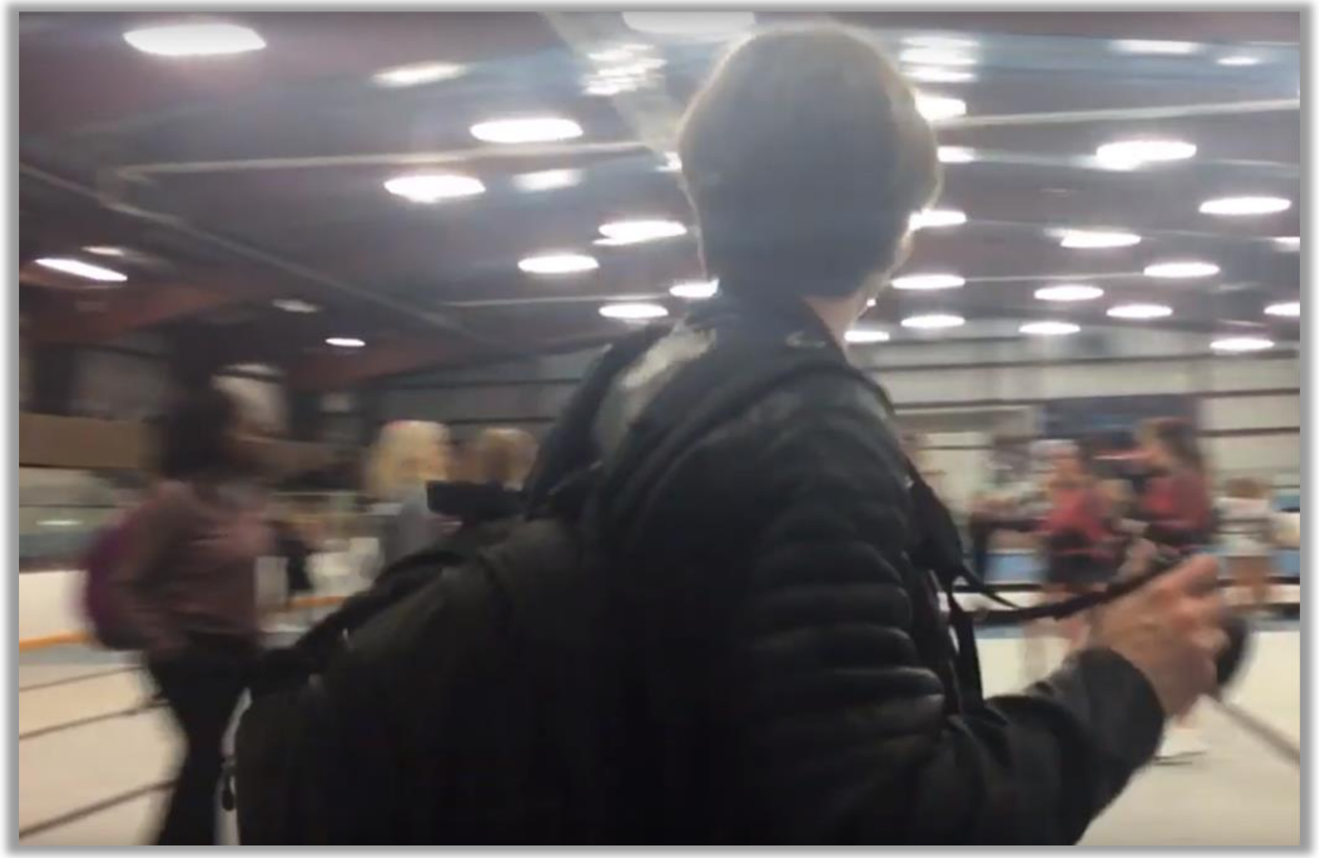


Illumination

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.

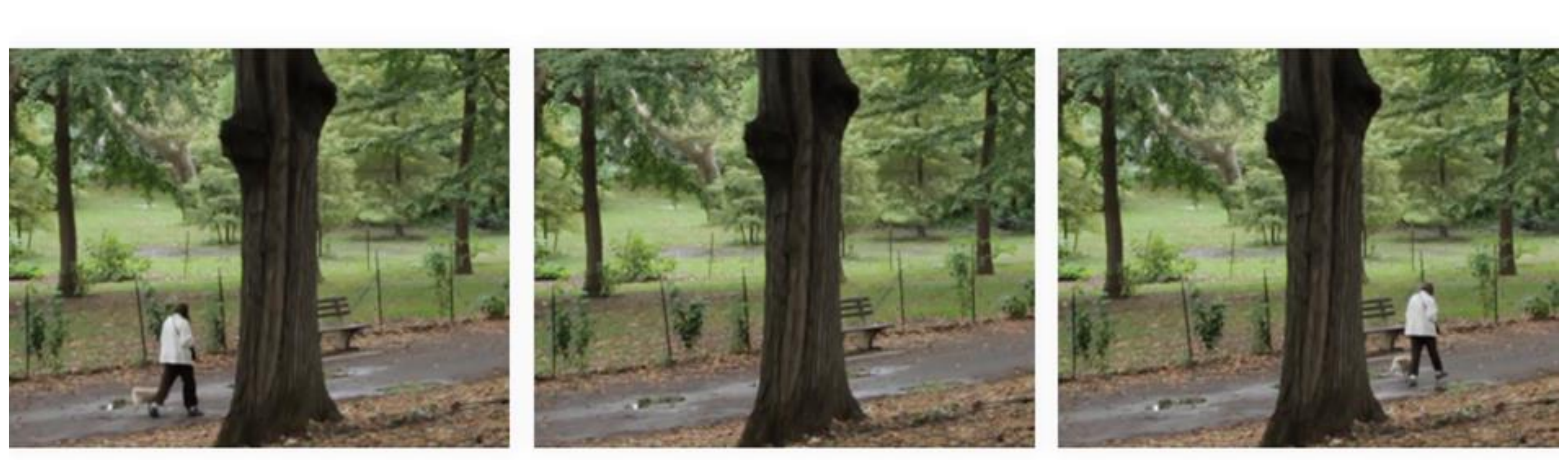


Presence of Unpredicted Motion

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

Occlusion

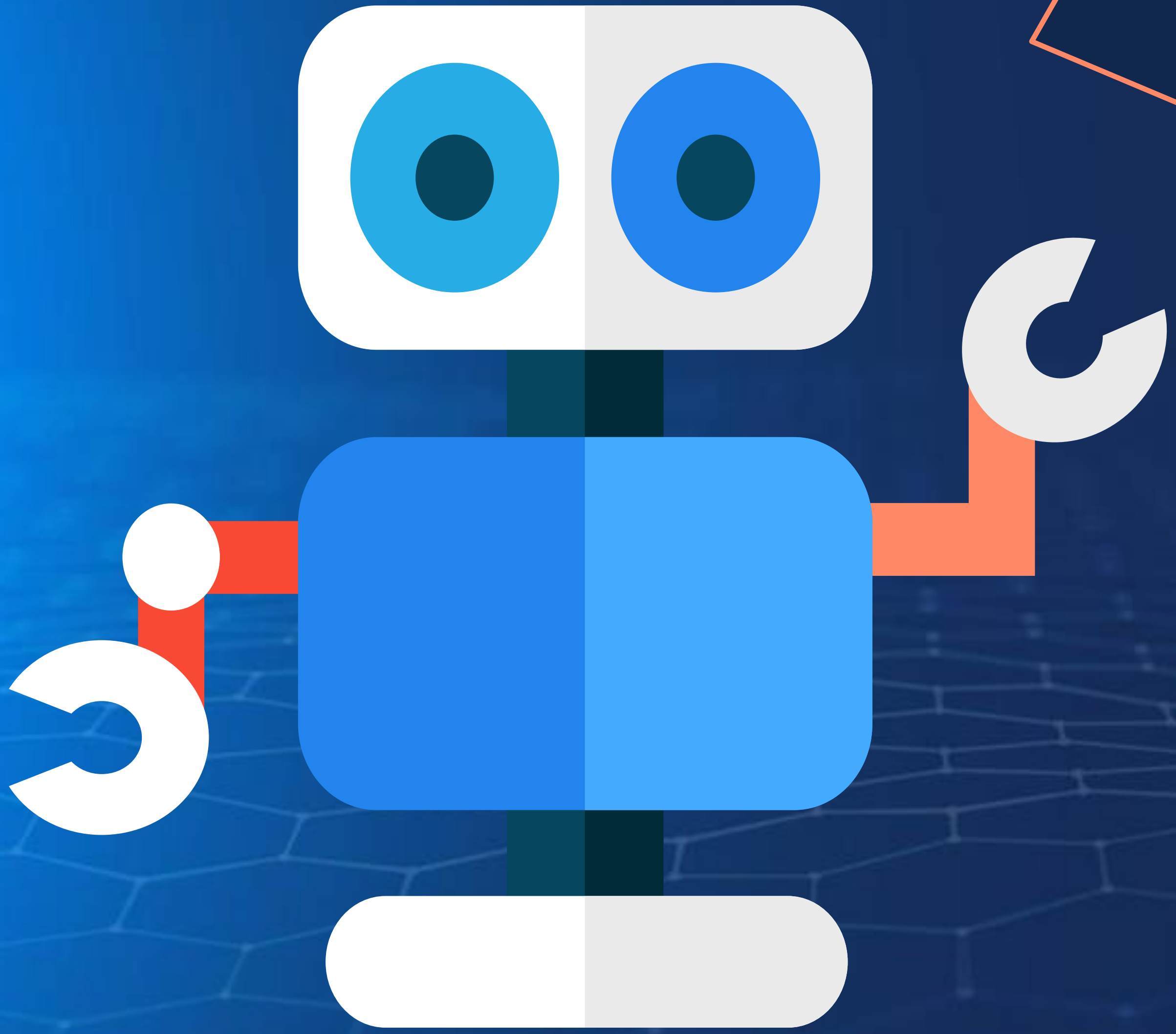
Objects in a video stream may be hidden fully or partially.



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.



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.

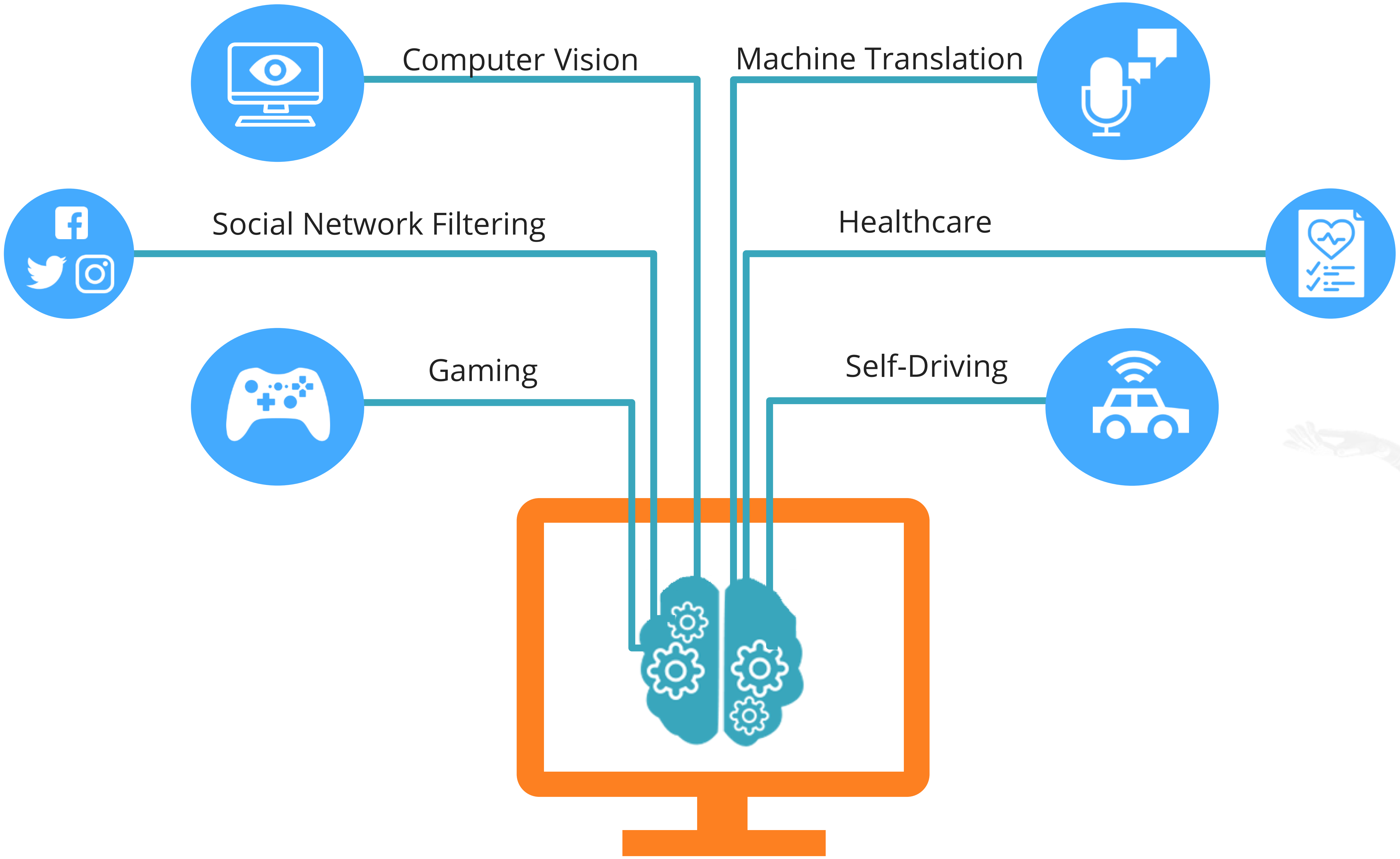
We will look into these concepts in chapter 5.

DATA AND
ARTIFICIAL INTELLIGENCE

Applications of Deep Learning

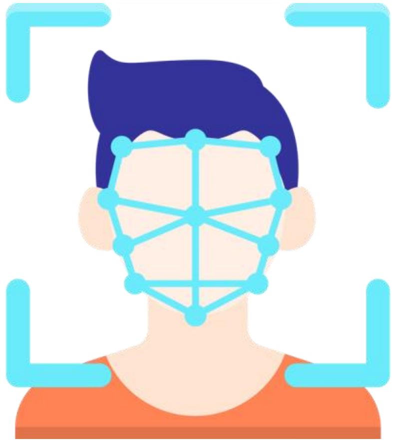
simplilearn

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

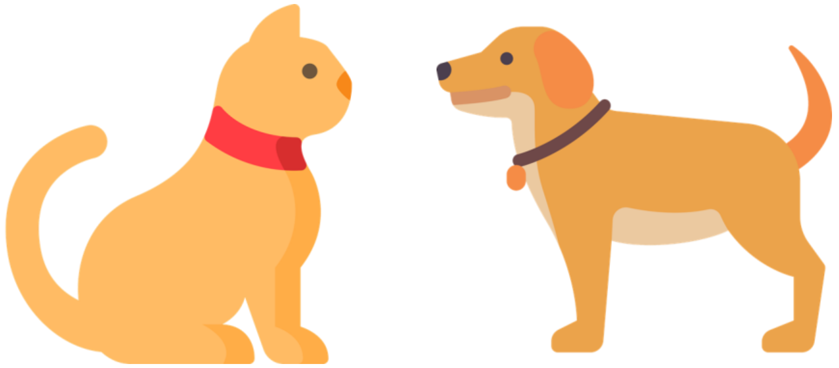
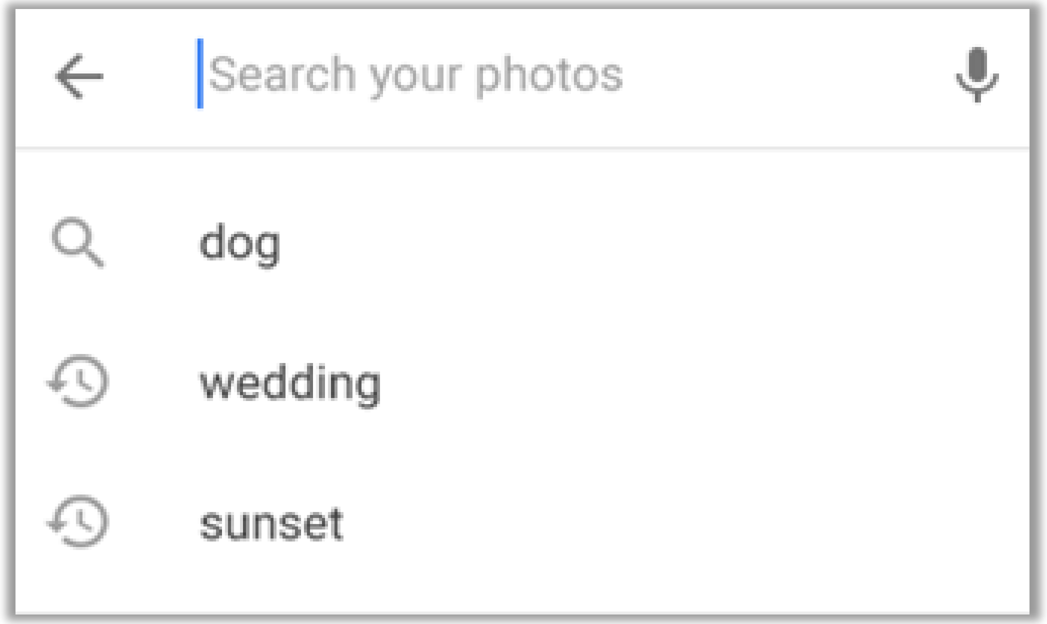


Image Classification

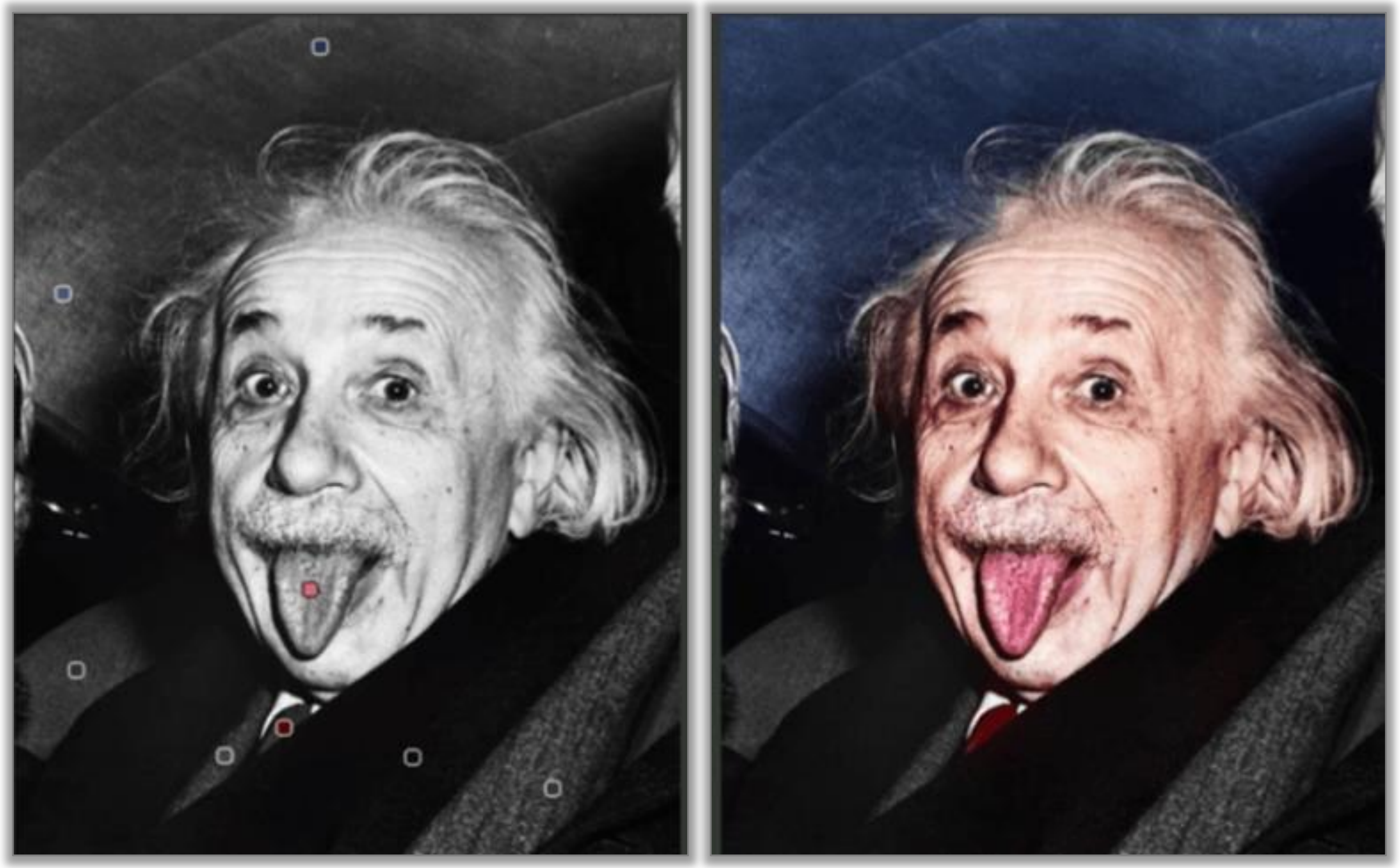
Computer Vision

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.

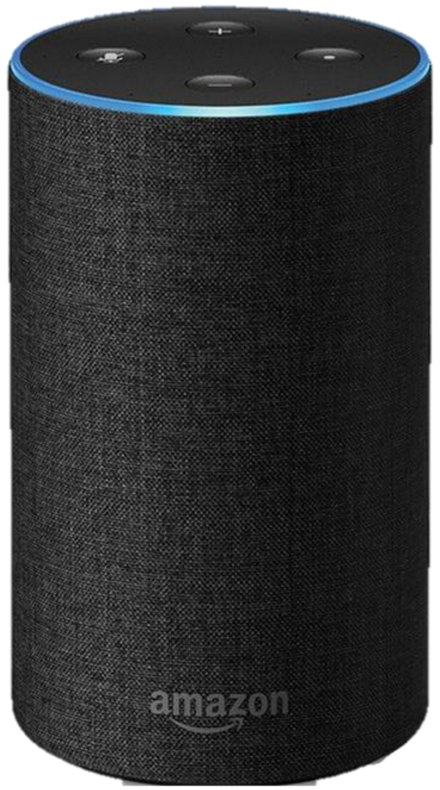


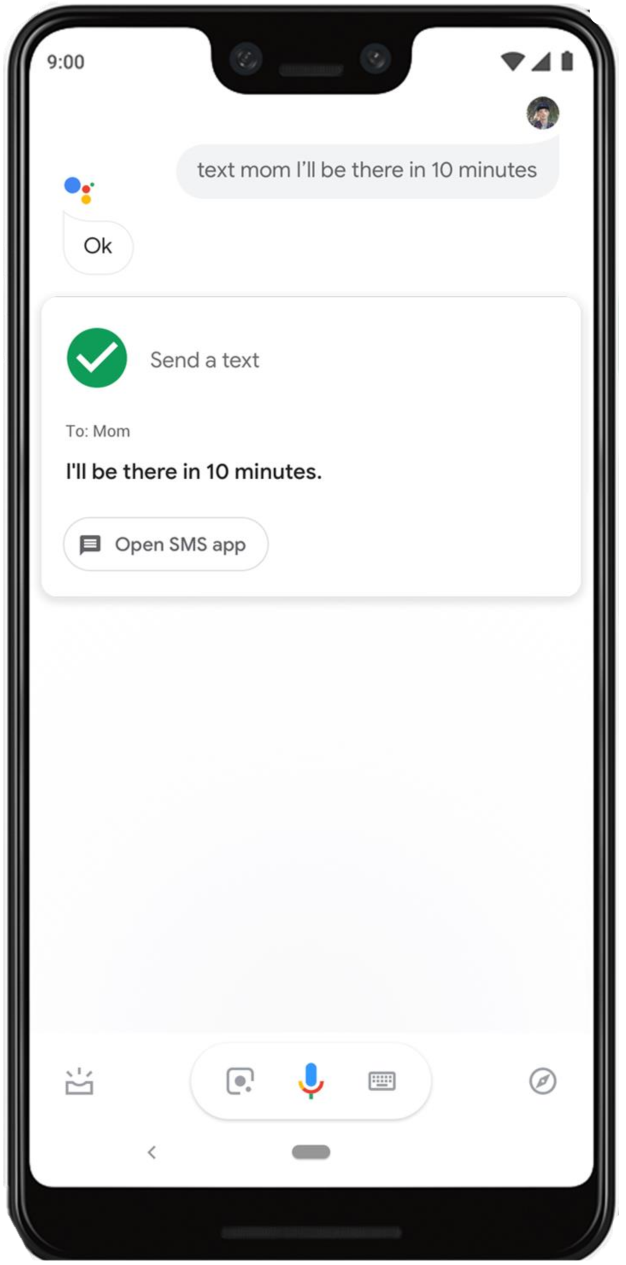
Automatic Colorization

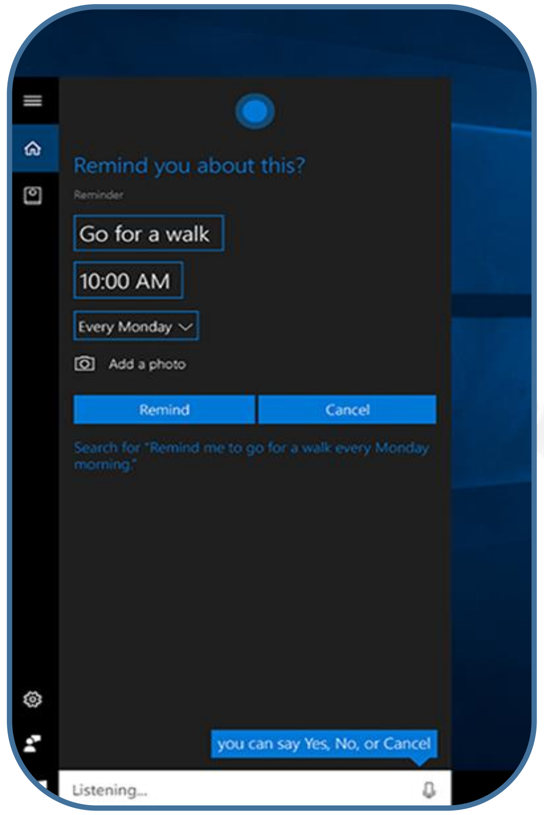
Deep Fakes

Machine Translation

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



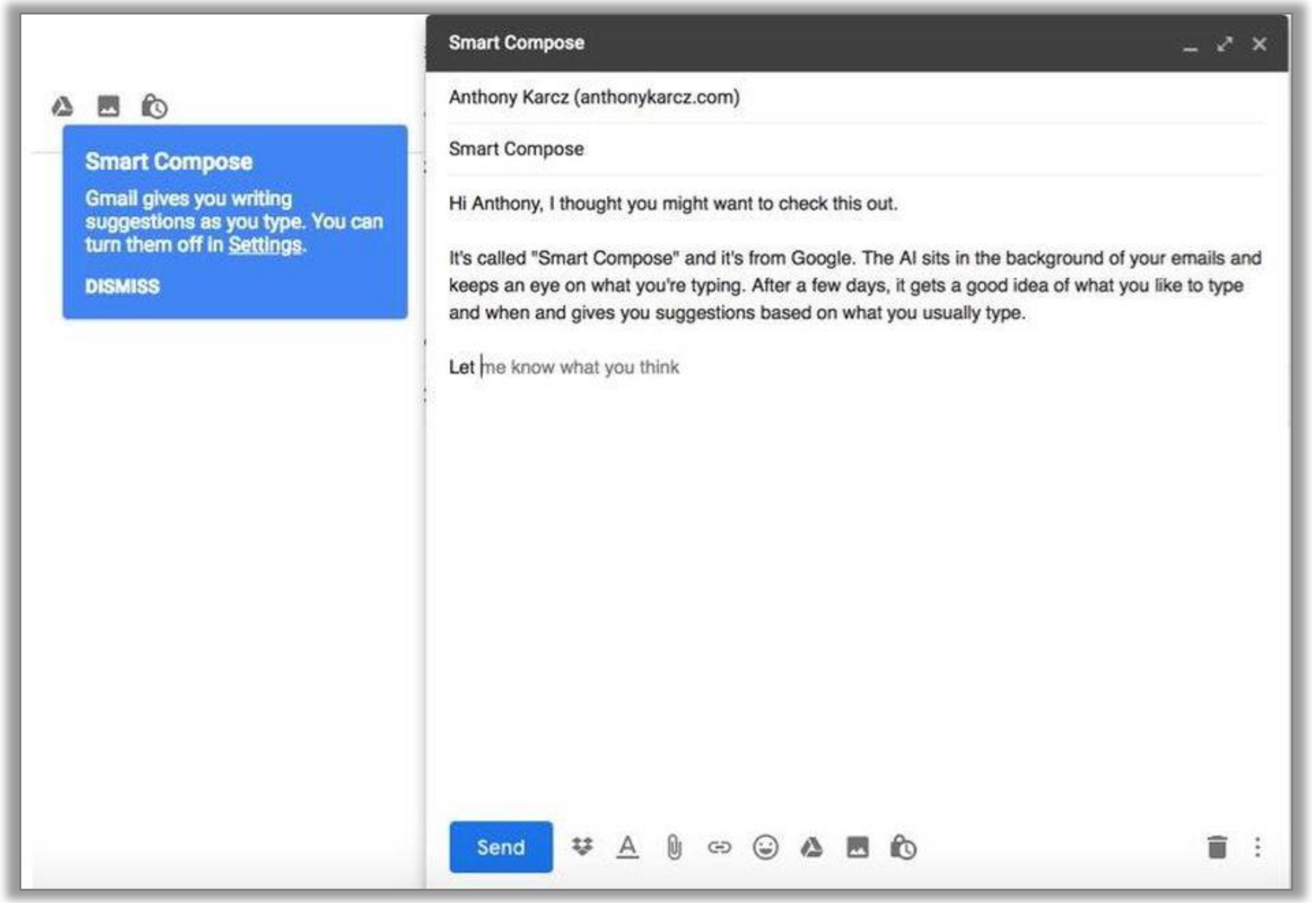




Recent stats shows that speech recognition functions on digital assistants work better than before and customers have almost tripled their use of speech interfaces.

Machine Translation

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



Gmail Auto-complete

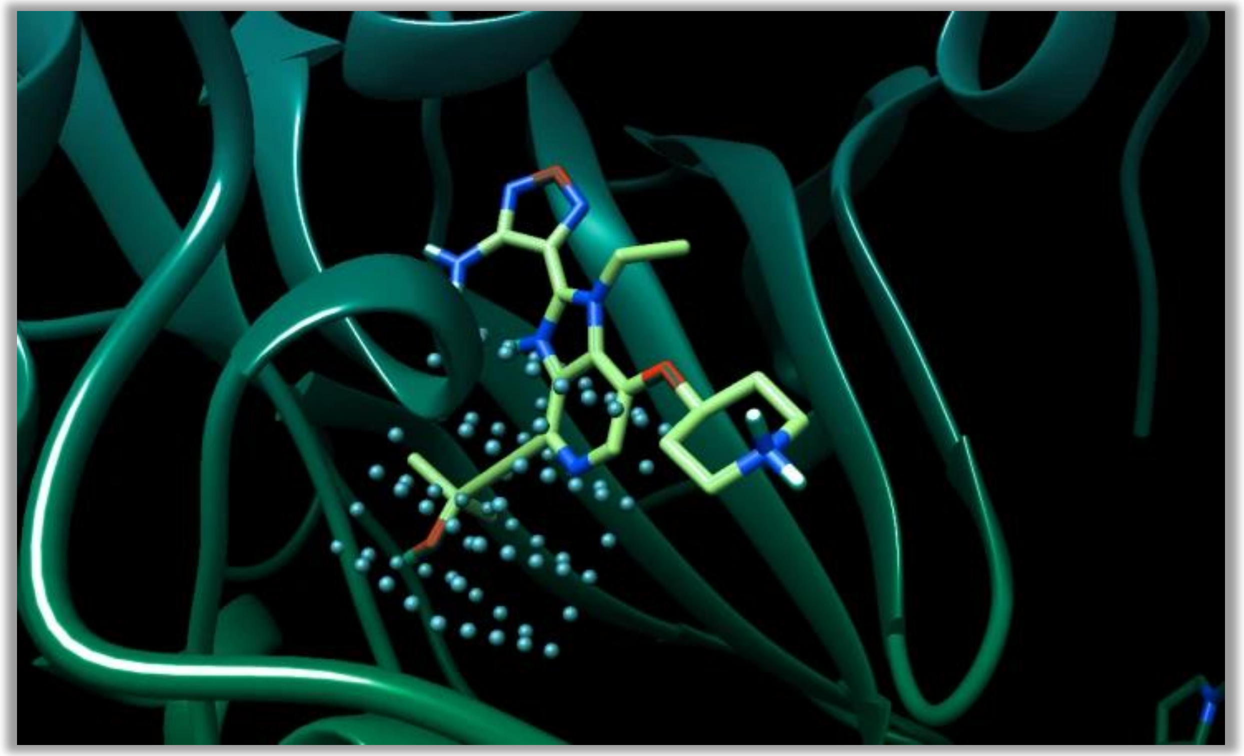
Auto-translate

Healthcare

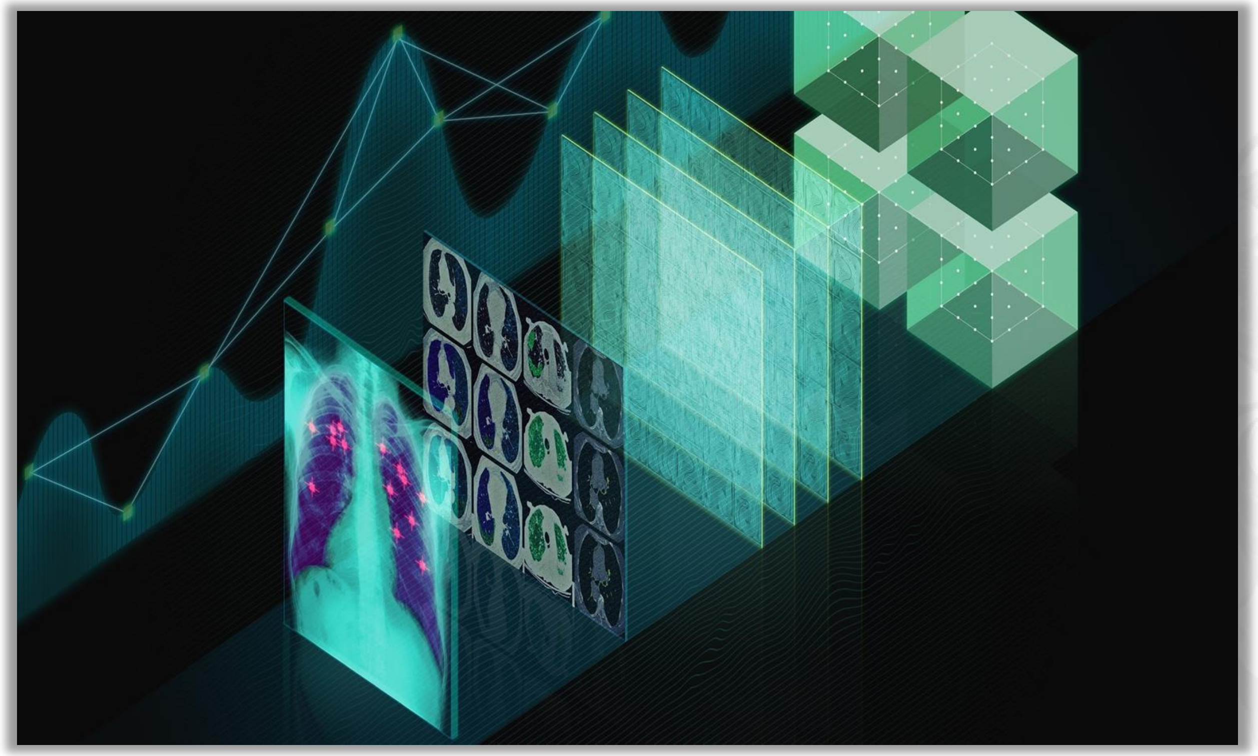
DL methods can draw correlations by analyzing millions of data points and enable clinical physicians to keep pace with current research and treatment protocols.

Healthcare

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



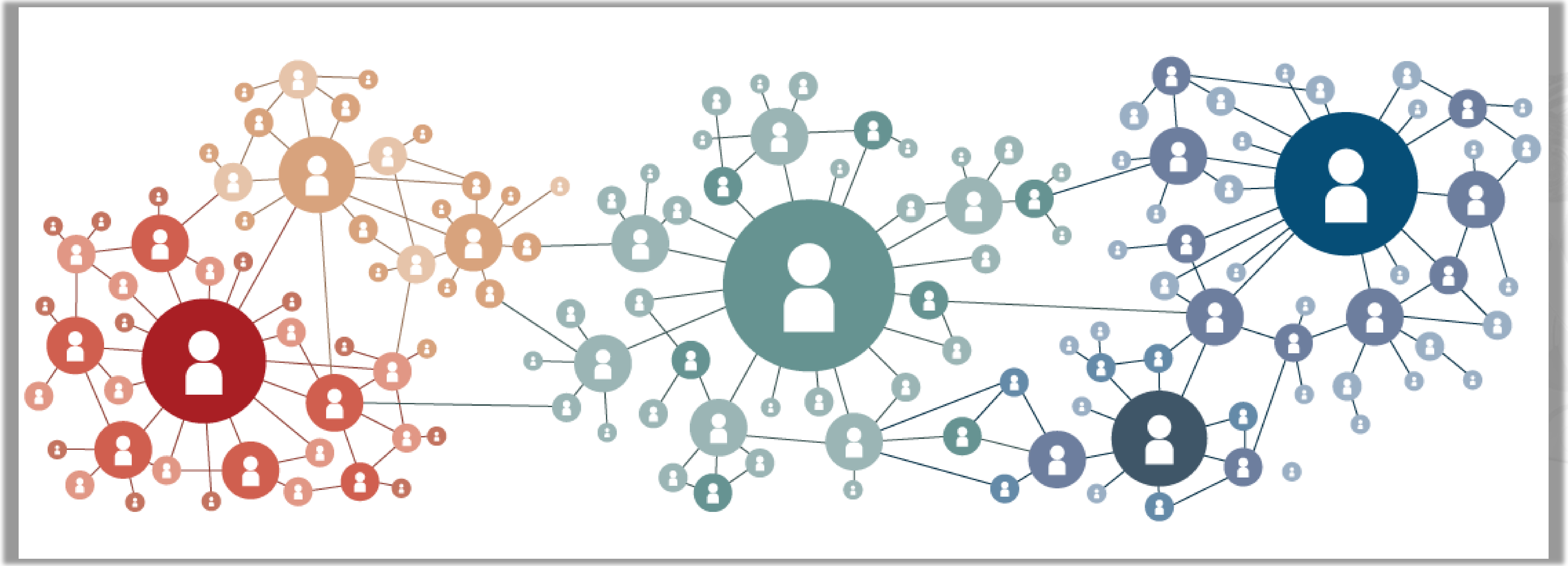
Drug discovery and precision medicine



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

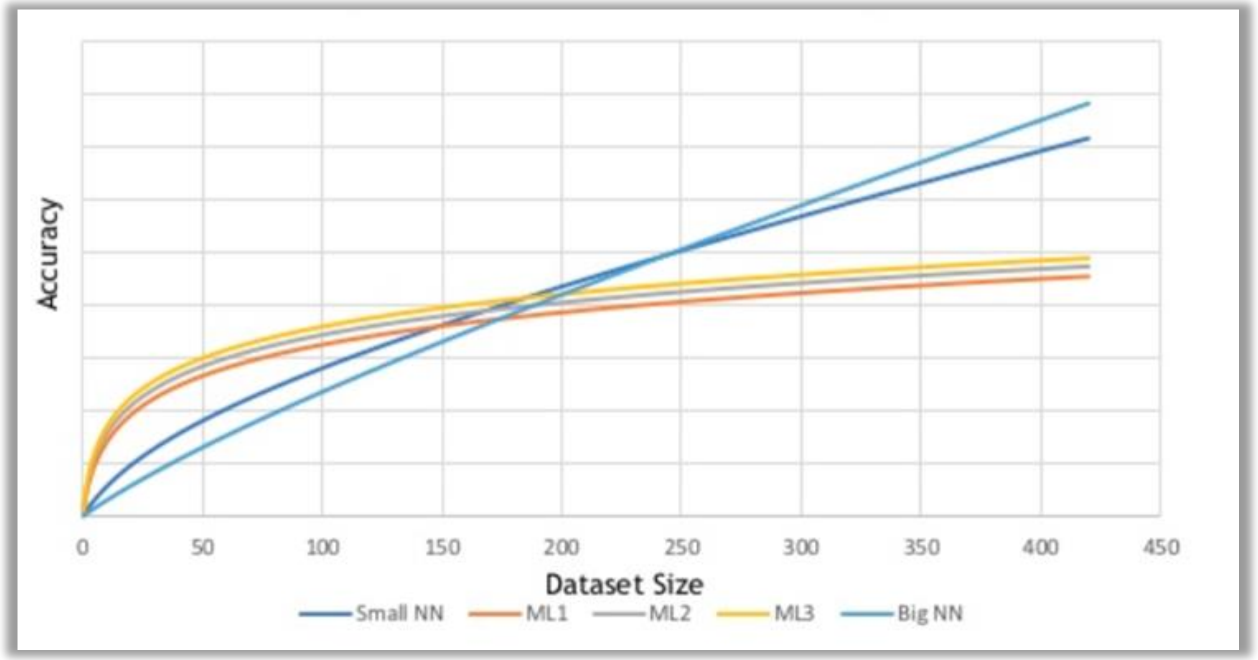
Development of human-like bots is one of the promising DL tools to enrich the gaming experience.

DATA AND
ARTIFICIAL INTELLIGENCE

Challenges in Deep Learning

Training Data

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

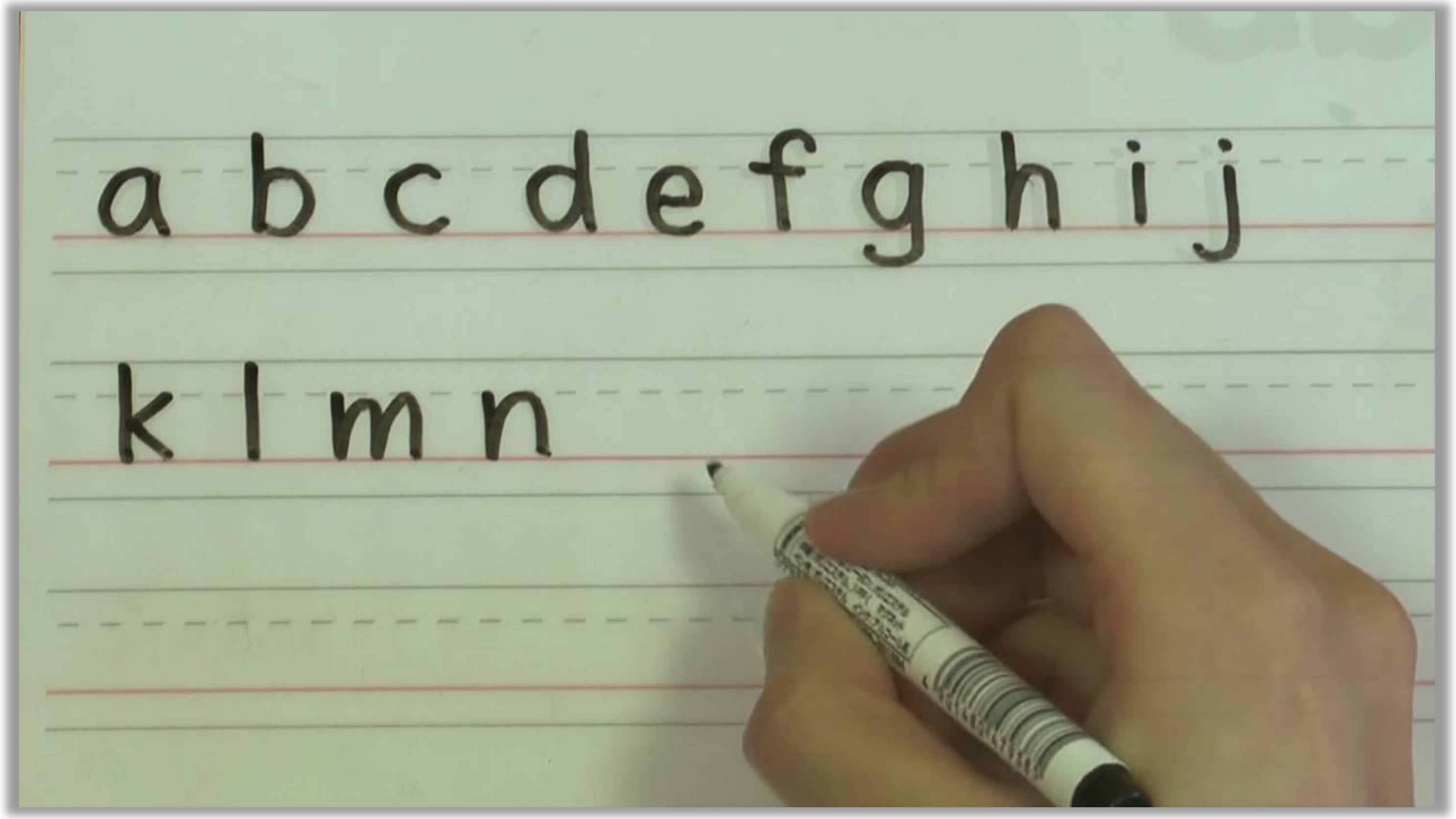


Accuracy increasing with dataset size

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.

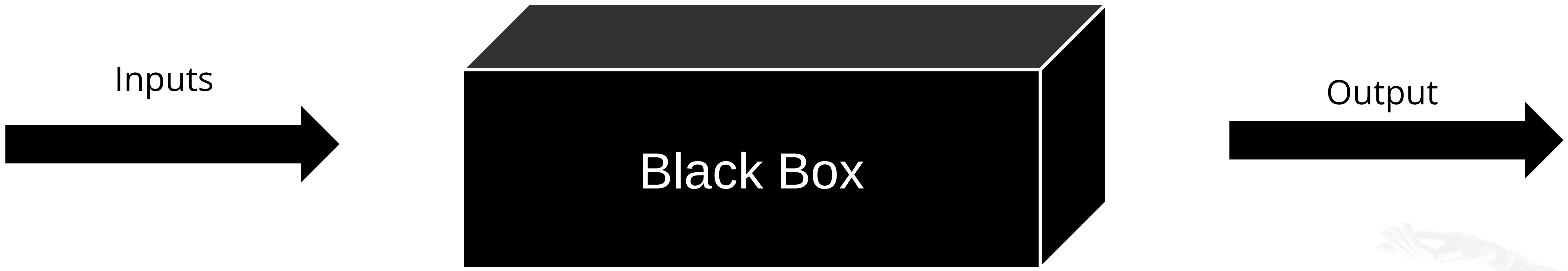
What’s on people’s minds?

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)

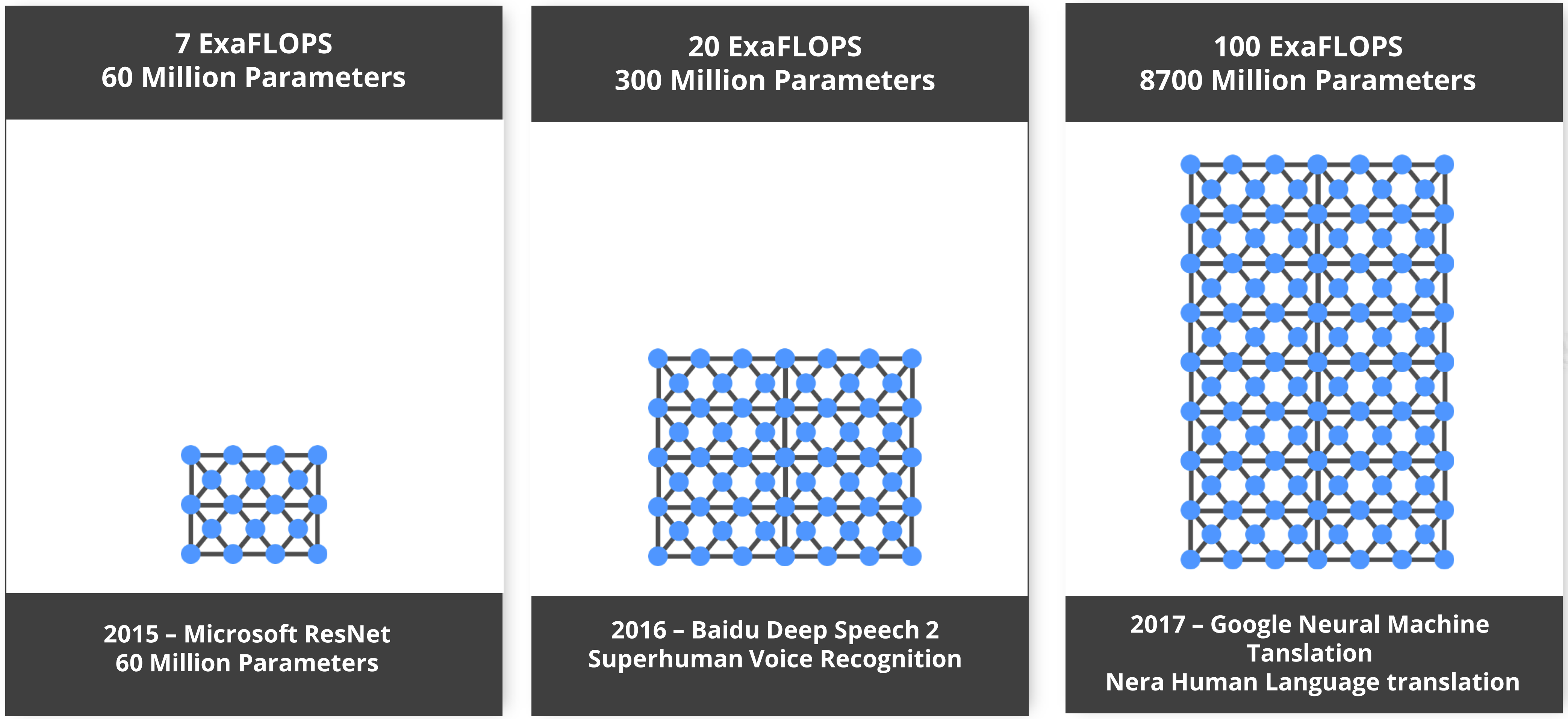
Human users like to understand how a system made a given decision, as decisions are potential liabilities for domains like finance and medicine.

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

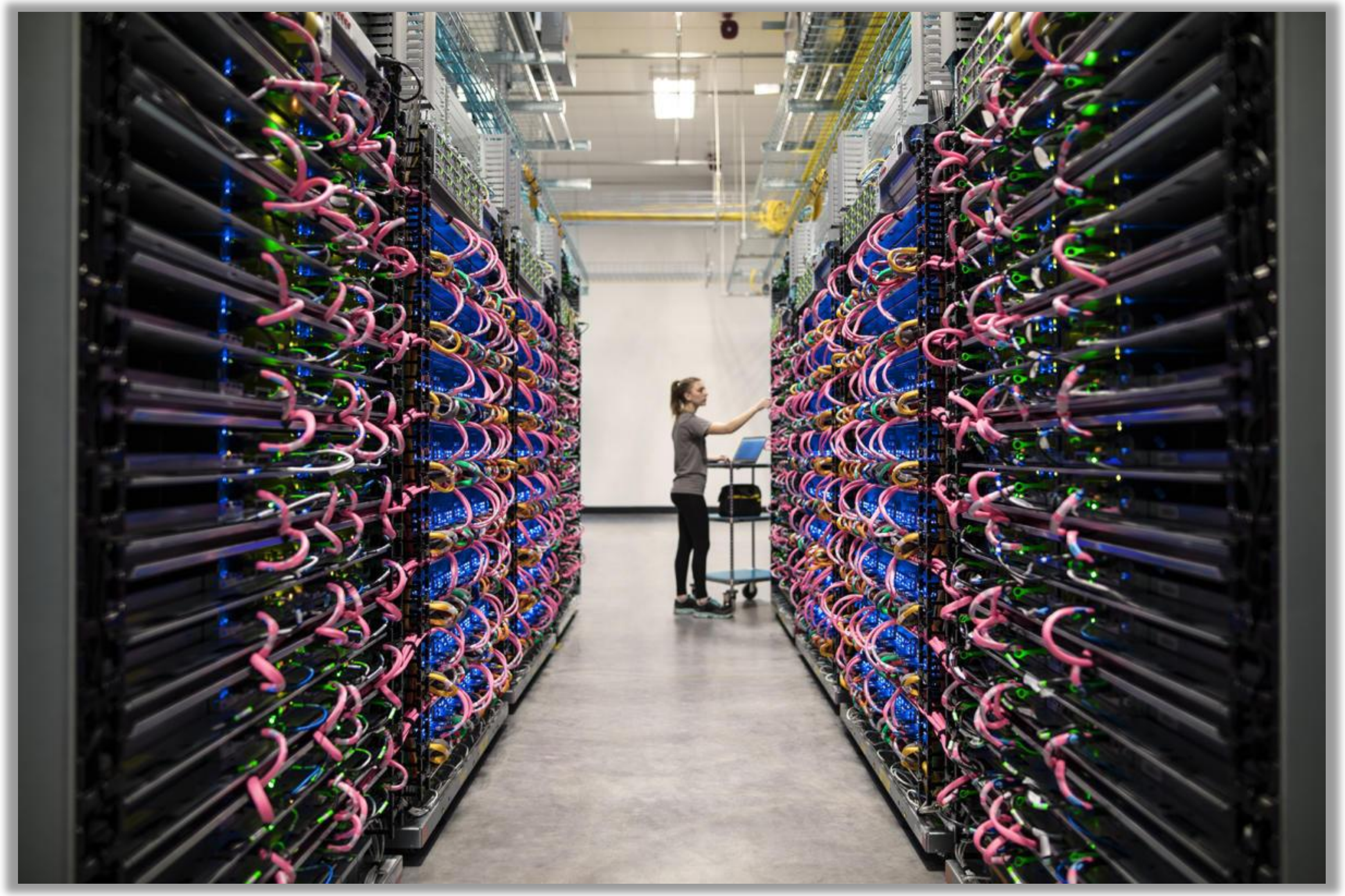
To Tackle Increasingly Complex Challenges



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.