Introduction to Mechatronics

What is Mechatronics in simple words?

The term Mechatronics, originated in Japan in late 1970s, describes a branch of engineering that is firmly established now.

Engineering is the use of Science and Math to design or make things. Engineers usually design and build things

Mechatronics is an interdisciplinary area of engineering that combines mechanical and electrical engineering and computer science.

Mechanical Engineering involves the design, production and operation of machinery.

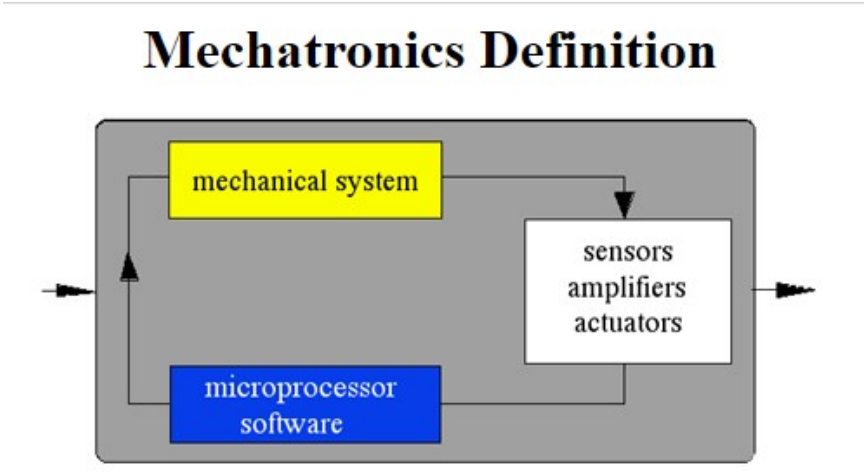
Electrical Engineering is concerned with the study, design and application of equipment, devices and systems which use electricity

Computer Science is the study of computers and computing as well as their theoretical and practical applications.

A Mechatronic system is neither just a marriage of electrical and mechanical systems nor just a control system; it is a complete integration of all of them.

A typical Mechatronic system picks up signals from the environment, processes them to generate output signals, transforming them for example into forces, motions and actions.

The fact that such a system picks up changes in its environment by sensors, and reacts to their signals using the appropriate information processing, makes it different from conventional machines.



What are Mechatronics devices?

Examples of products that have been designed using Mechatronics engineering include printers, robots, DVDs, car anti-lock braking systems and computer hard discs.

Mechatronic control devices are found everywhere; they are built into kitchen appliances, aircraft, cameras, computers, power stations, even in toilet cisterns. They may be built from micro-circuits, mechanical levers, hydraulic or magnetic devices.

A mechatronics system is, indeed, composed of mechanical parts, electric devices, electronics components, sensors, hardware and it is operated and controlled under the supervisions and commands that are programmed through suitable software.

Case Study 1: Hard Disk Drive, an example of Mechatronics

A hard drive is the hardware component that stores all of your digital content. Your documents, pictures, music, videos, programs, application preferences, and operating system represent digital content stored on a hard drive. Hard drives can be external or internal.

Mechatronics and control played a vital role in this path of achieving rapid growth in the capacity of HDD and continuously decreasing cost.

Many Mechatronic systems demand for ultra-high precision in controlling the output of the system.

The HDD is one such system where the tolerance limit for position error is only few nanometers.

The HDD includes several subsystems some of which are Mechatronic systems, and the integration of all these subsystems to realize a practical product is a challenging task. The Mechatronic parts of HDD include the servomechanism that controls the position of the read-write heads of the HDD and the spindle motor system that spins the disks at precisely regulated speed.

What are servos used for?

Servo motors or “servos”, as they are known, are electronic devices and rotary or linear actuators that rotate and push parts of a machine with precision. Servos are mainly used on angular or linear position and for specific velocity, and acceleration.

The Key Components of Hard Disk Drive

The hard drive, which typically provides storage for data and applications within a computer, has four key components inside its casing -- the platter (for storing data), the spindle (for spinning the platters), the read/write arm (for reading and writing data) and the actuator (for controlling the actions of the read/write arm).

How a hard drive works:

- When you save a document, it gets written somewhere "non-volatile" that keeps its state even when the power is off. How does that work for a hard drive?
- The hard drive contains a spinning platter with a thin magnetic coating
- A "head" moves over the platter, writing 0's and 1's as tiny areas of magnetic North or South on the platter
- To read the data back, the head goes to the same spot, notices the North and South spots flying by, and so deduces the stored 0's and 1's
- A Modern hard drive can store well over a trillion 0/1 bits per platter, so the individual North/South spots are quite small
- "Flash" storage is made with chips (no moving parts) and is gradually replacing spinning hard drives like this. Flash chips are what's inside camera SDHC memory cards and USB storage keys.

Fault Detection and Diagnosis in Mechatronics Systems

A mechatronic system typically includes sensors, data acquisition, actuators (that operate in synergy) driven by specific control algorithms to perform a desired function on a controlled device.

One of the most recent and promising application of mechatronics concerns its application to improve the safety of complex systems. With this aim, it can be applied to different sectors: Transportation systems, vehicles, wind turbines, industrial processes, manufacturing, food industry, automation, and many others.

This section presents the diagnostics of mechatronic systems on the basis of AI-based techniques

A. Diagnostics of mechatronic systems on the basis of neural networks with high-performance data collection

What is the artificial intelligence?

Artificial intelligence (AI) is the ability of a computer or a robot controlled by a computer to do tasks that are usually done by humans because they require human intelligence and discernment.

What is difference between machine learning and artificial intelligence?

Artificial intelligence is a technology that enables a machine to simulate human behavior. Machine learning is a subset of AI which allows a machine to automatically learn from past data without programming explicitly. The goal of AI is to make a smart computer system like humans to solve complex problems.

Mechatronics makes use of Machine Learning and hence it is in some way or the other related to ML.

What is machine learning?

Machine learning is a branch of artificial intelligence (AI) and computer science which focuses on the use of data and algorithms to imitate the way that humans learn, gradually improving its accuracy.

INTRODUCING ARTIFICIAL INTELLIGENCE, MACHINE LANGUAGE

LET'S FIRST OF ALL UNDERSTAND WHAT A COMPUTER IS

A COMPUTER IS AN ELECTRONIC MACHINE THAT CAN BE USED TO PROCESS DATA

AND WE CAN USE IT TO DO LITERALLY ANYTHING WE WANT

THE WAY TO DO THIS IS BY A PROCESS CALLED PROGRAMMING or CODING

BASICALLY, PROGRAMMING IS A SET OF INSTRUCTIONS THAT WE GIVE TO A COMPUTER TO DO SOME TASK

THAT TASK CAN BE CREATING A GAME LIKE SUPER MARIO OR PLAYING A LIST OF SONGS OR EVEN CREATING A WEBSITE

THERE ARE OVER 250 COMPUTER PROGRAMMING LANGUAGES.

SOME OF THE POPULAR PROGRAMMING LANGUAGEAS ARE C++, JAVA & PYTHON

HOW DOES COMPUTER WORK WITH PROGRAMS WRITTEN USING PROGRAMMING LANGUAGES

COMPUTER READS INSTRUCTIONS IN THE FORM OF ONES AND ZEROS AND THIS IS REGARDED AS BINARY CODE OR BINARY DIGITS

BINARY CODE LOOKS LIKE 11110000 OR 10101111

FOR EXAMPLE, 255 in decimal is 11111111 in binary, 240 in decimal is 11110000 in binary

BINARY CODES ARE INSTRUCTIONS THAT ARE EASY FOR THE COMPUTER TO READ

BUT THEY ARE KIND OF HARD FOR US TO READ

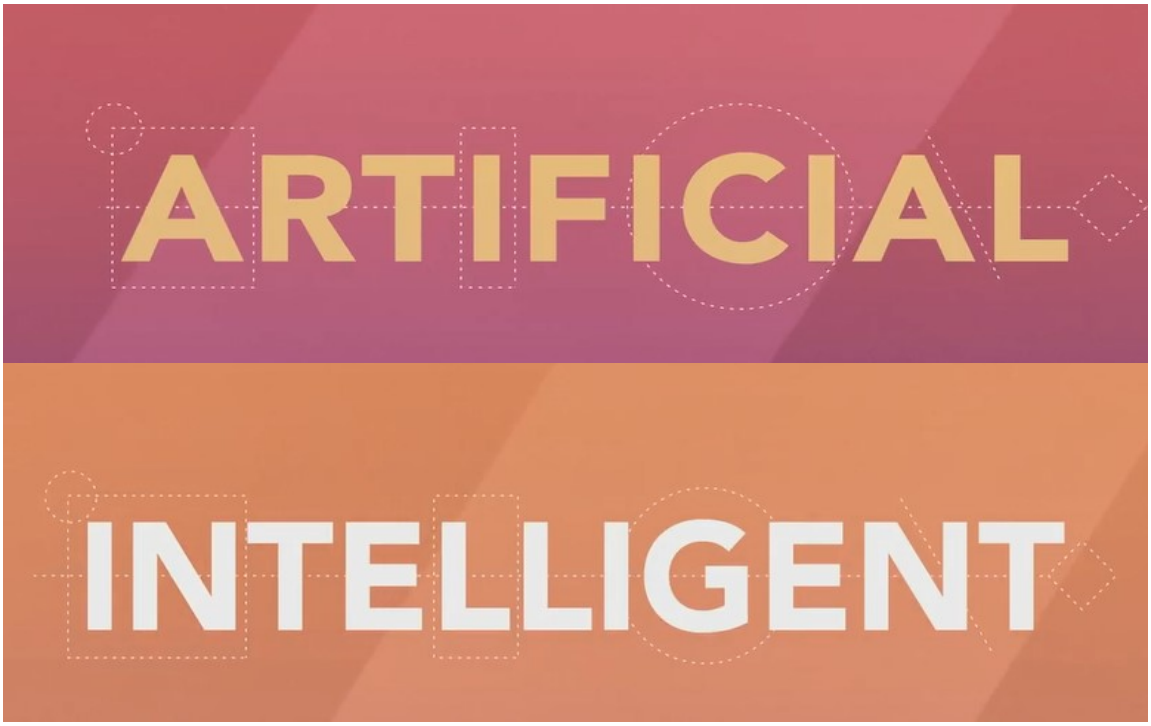
THAT IS WHY WE USE PROGRAMMING LANGUAGES LIKE C, JAVA, PYTHON, THAT ARE MADE UP OF WORDS INSTEAD OF NUMBERS TO PROGRAM A COMPUTER. THAT WAY WE CAN READ THEM AND UNDERSTAND HOW THEY WORK

IF WE TAKE A SIMPLE PROGRAM LIKE PYTHON, WE CAN WRITE A PROGRAM TO PRINT HELLO WORLD AS SHOWN BELOW

THE OUTPUT OF THE PROGRAM PRINTS HELLO WORLD.

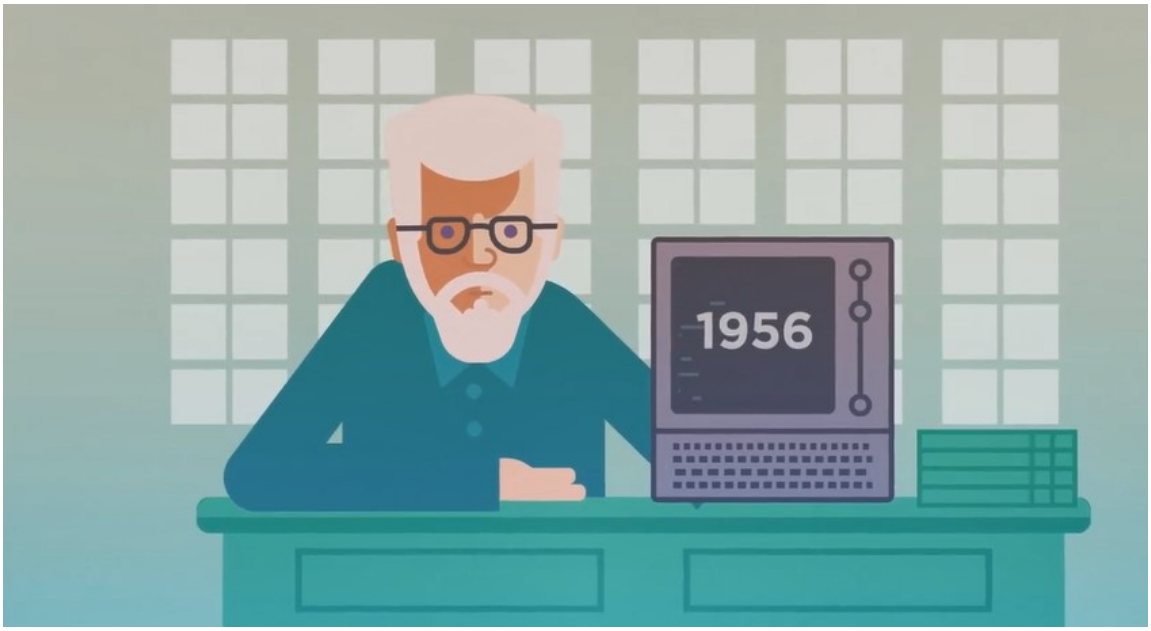
NOTICE THAT THE COMMAND LINE INTERFACE HELPS US TO IDENTIFY WRONG CODES TYPED AS SHOWN IN LINE 1 & 2

EVEN THOUGH WE WROTE ON THE PROGRAM–print(‘Hello world!’), THE COMPUTER BREAKS DOWN THE TEXT TO ONES AND ZEROS, SO IT CAN READ IT AND PROCESS IT TO GIVE US AN OUTPUT

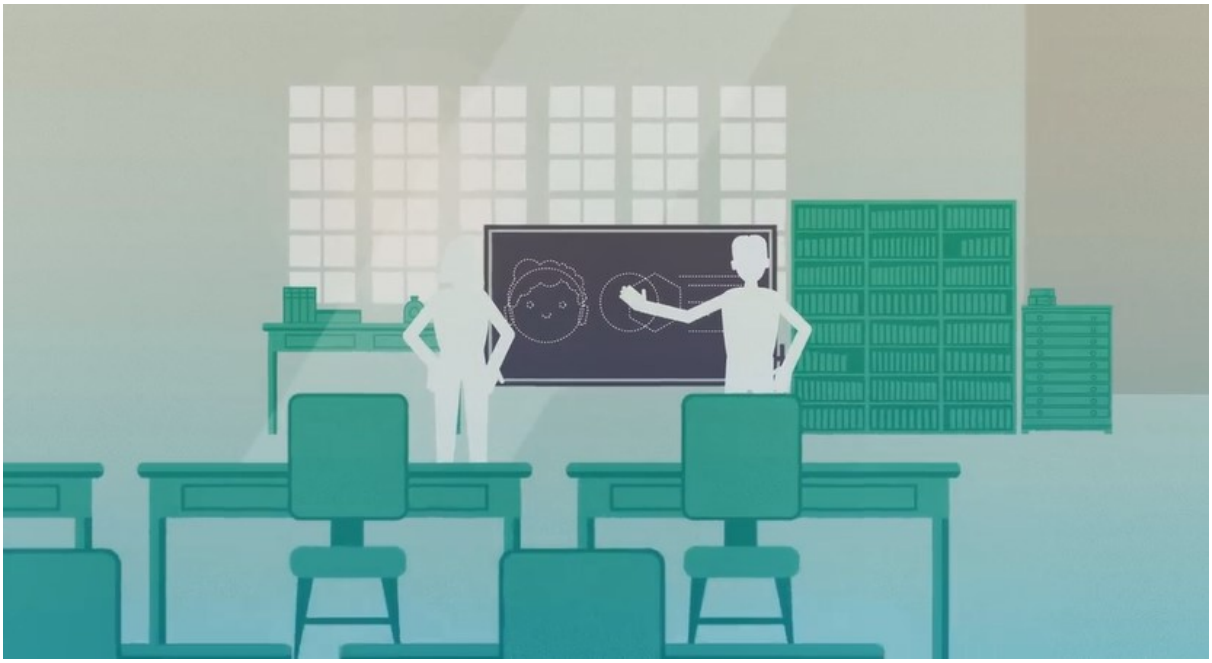


AI is a broad area of computer science

It is a concept that makes machine seems like they have human intelligence



This technology isn't new, It's been an idea ahead of it time. The term artificial intelligence was first coin in 1956 by a Dutch Professor John McCarthy

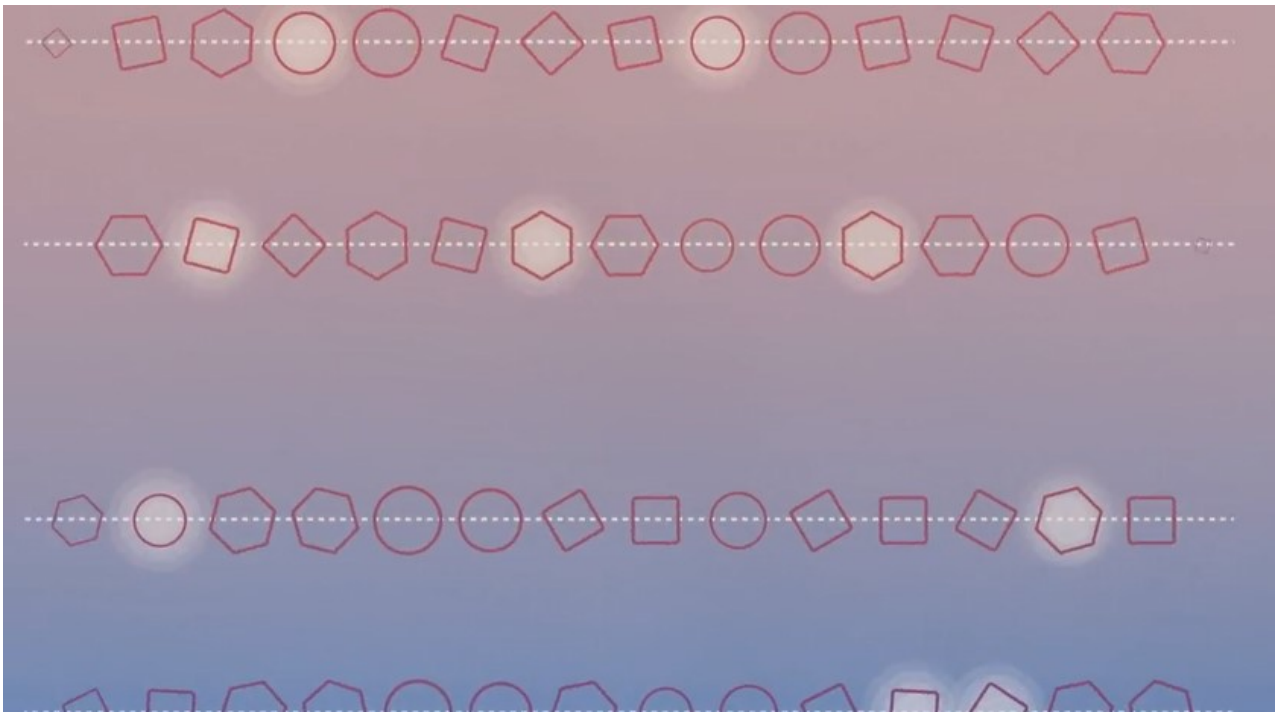


He called together young Mathematicians and Scientist to see if a machine can learn like a young child does using “Trial and Error” to they can develop a formal reasoning.

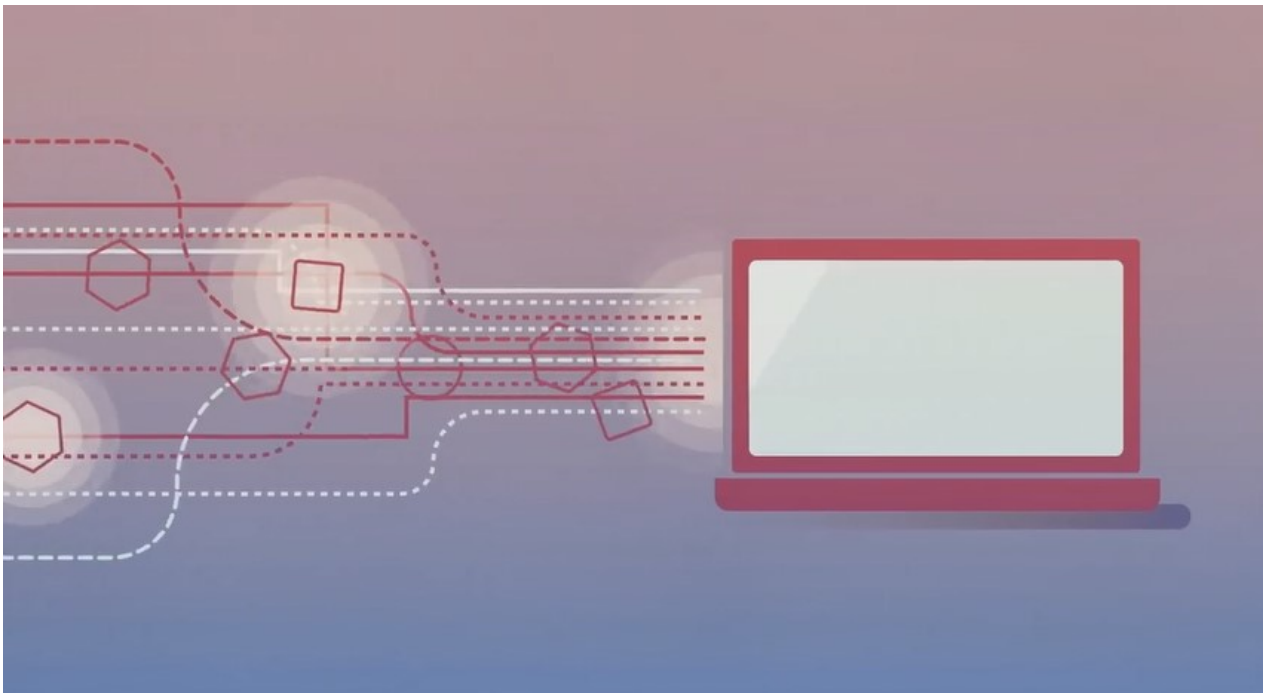
The project proposal was to figure out how to make machine use language, abstraction, concept to solve all kind of problems reserved for humans and to improve on their learning experience. That was more than 60 years ago

However, the study of AI has since remained in the University classrooms

But that changing, because for the past few years, a couple of factors has lead to AI becoming the next big thing in the world

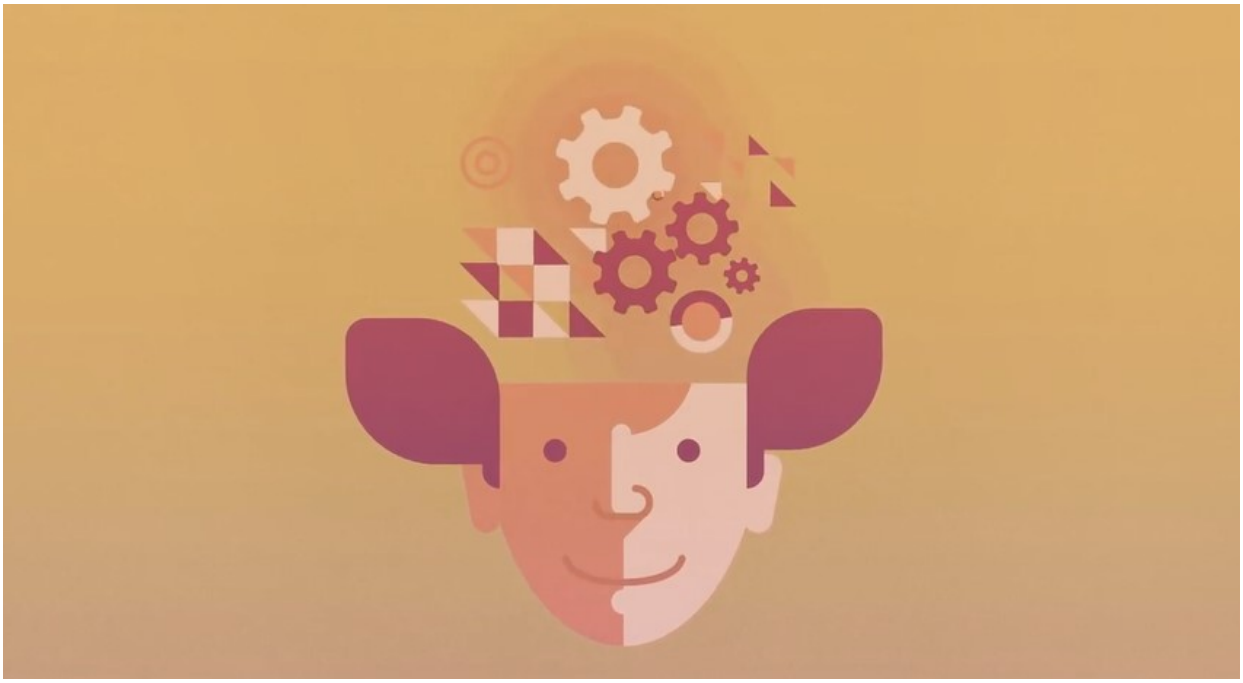


First is the huge amount of data are being created every minute. Infact 90% of the world data has been generated in the last 2 years mostly dues to Smart Phones and High Computing Power.



Thanks to advances in processing speed, computer can actually make sense of all this information we generate more quickly

Very soon AI will become a little less Artificial and More Intelligent



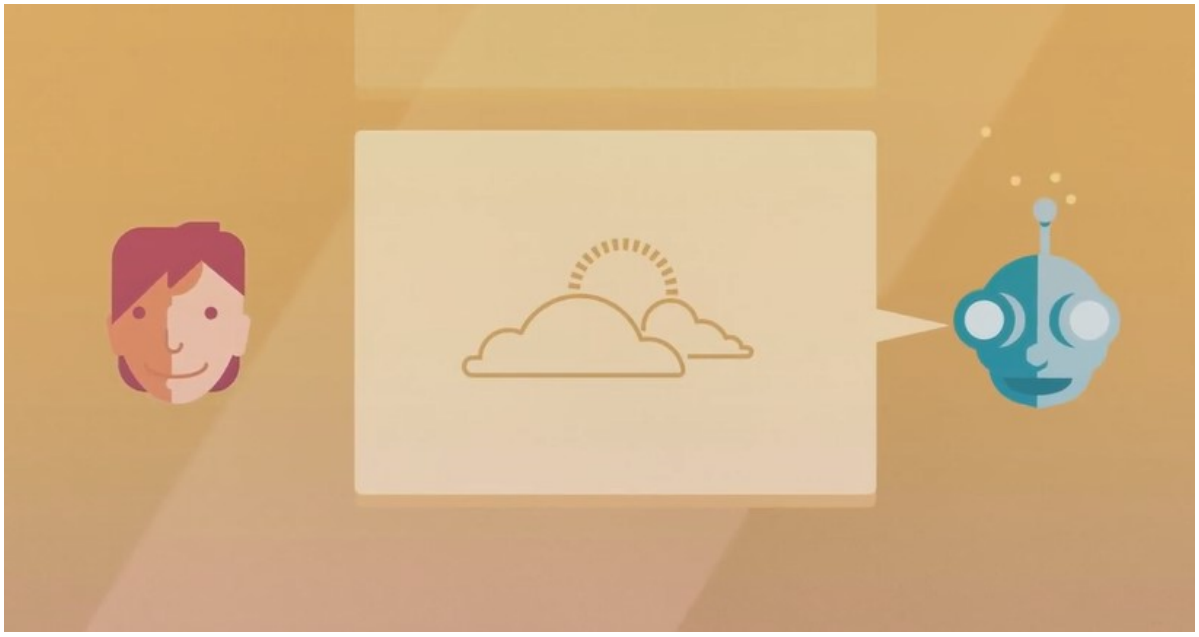
When it comes to AI, A robot is nothing other than a shell concealing what is actually used to power the Technology

That means AI can manifest itself in many different ways

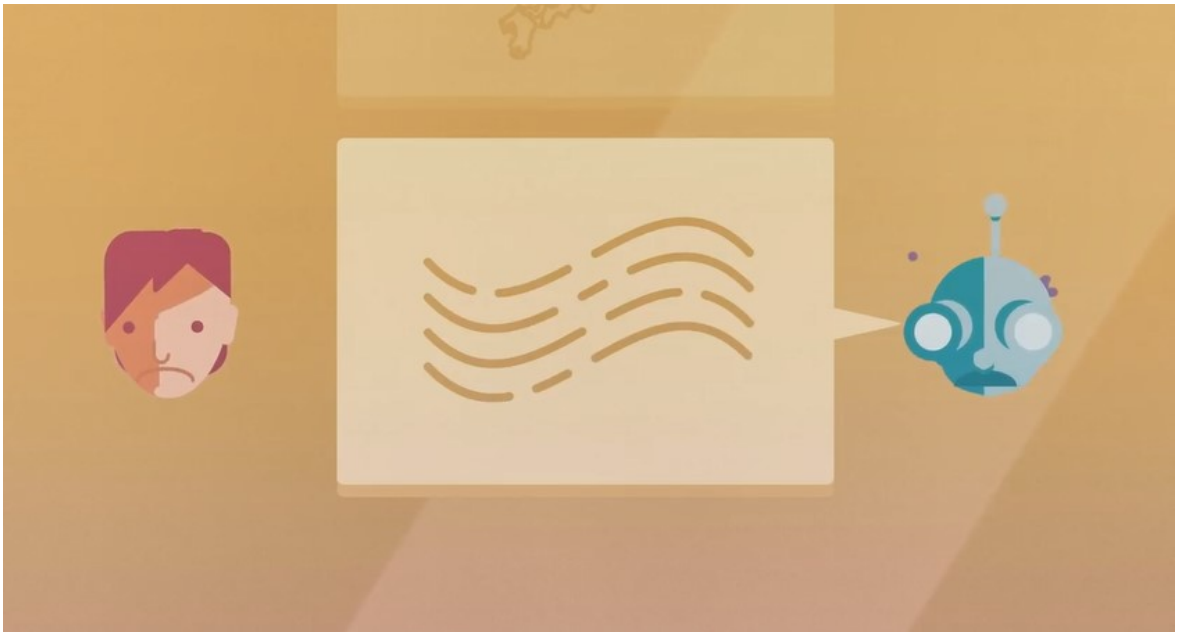
Let's break down the options

FOR EXAMPLE

A. A Simple Input to Output Solution



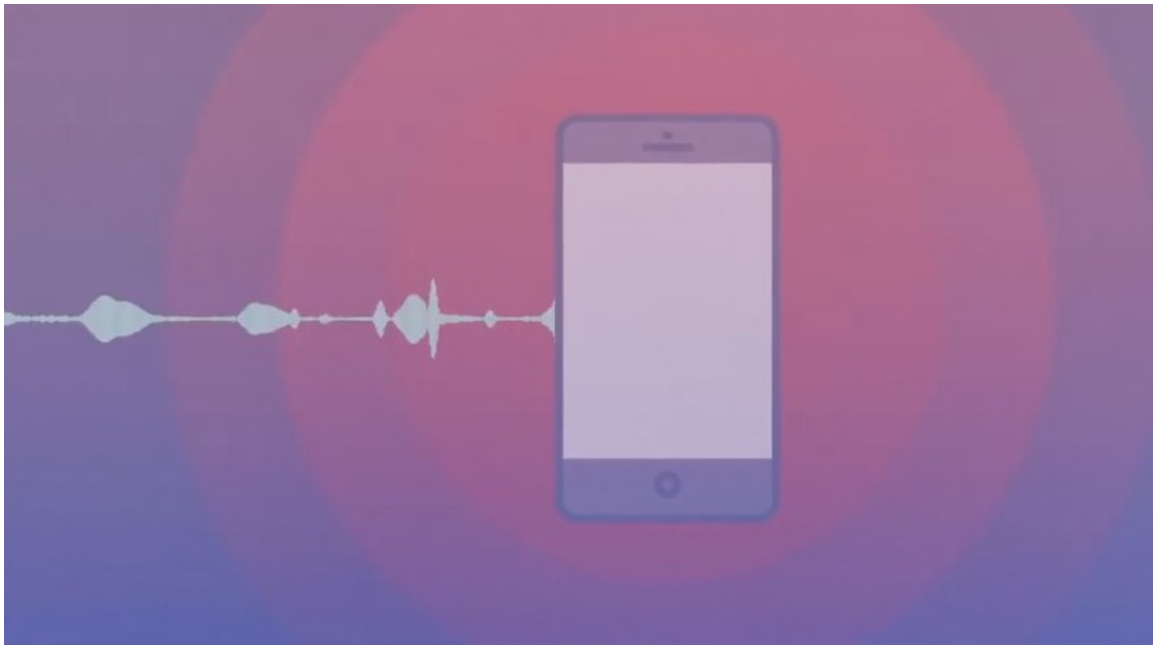
Example: If you asked a weather 'bot' for a forecast, it will tell you the weather condition like partly cloudy with a temperature of 17 degrees for an example



Then ask that same bot what time it is in Tokyo, it will look confused

That is because the bot creator only programmed it to give you the weather condition and it does this by pulling it from a particular weather source

B. Natural Language to Text Processing



Natural Language processing makes the ‘bot’ a bit more sophisticated. When you ask the ‘bot’ where the gas station is, it will translate your voice into text, feeding the query to a search engine and it will read the answer back in human syntax

So in another word, you don’t have to speak in code

C. Machine Intelligence

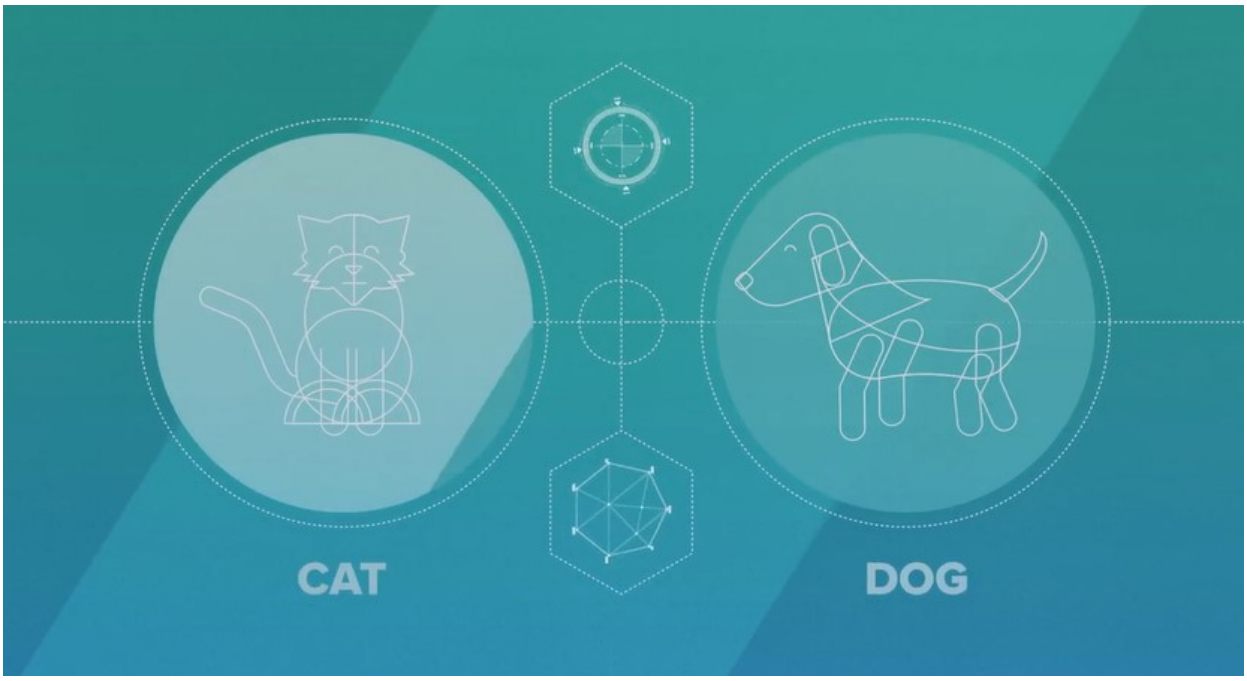
At the far end of the spectrum is the Machine Learning

It is one of the most exciting areas of AI

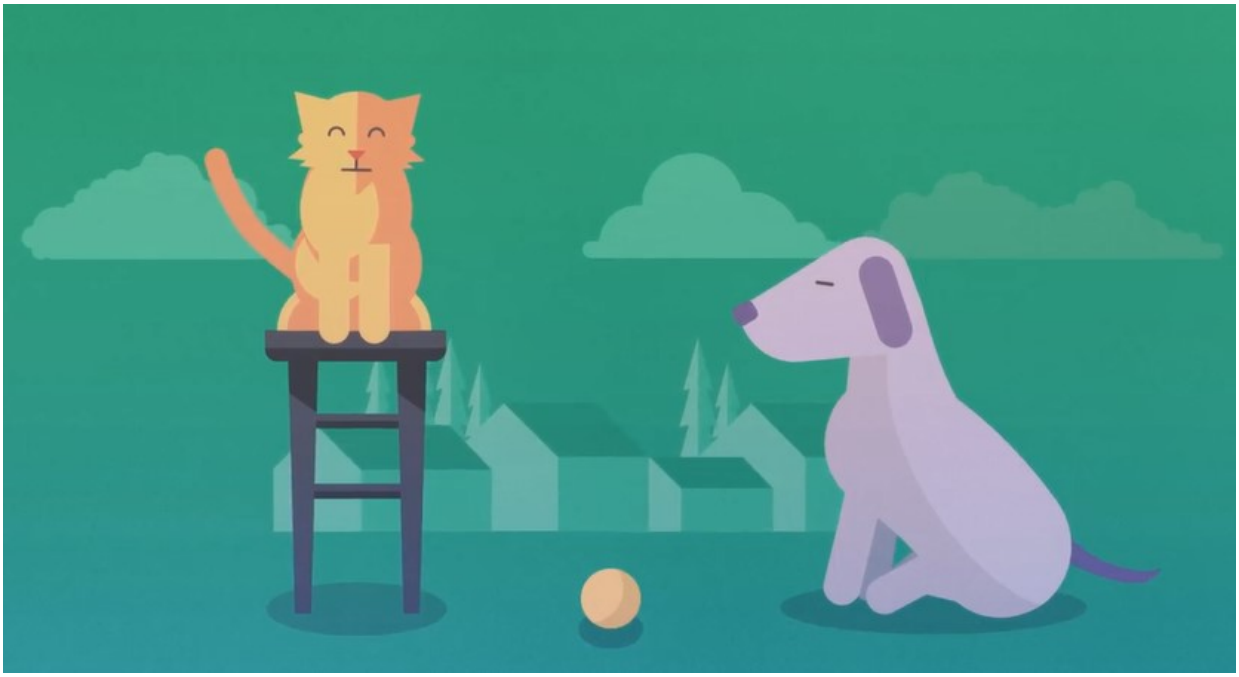
Like human, a machine retains information and becomes smarter over time

But unlike human, it is not susceptible to things like short time memory loss, information overload, sleep deprivation and distractions

But how does this machine learn

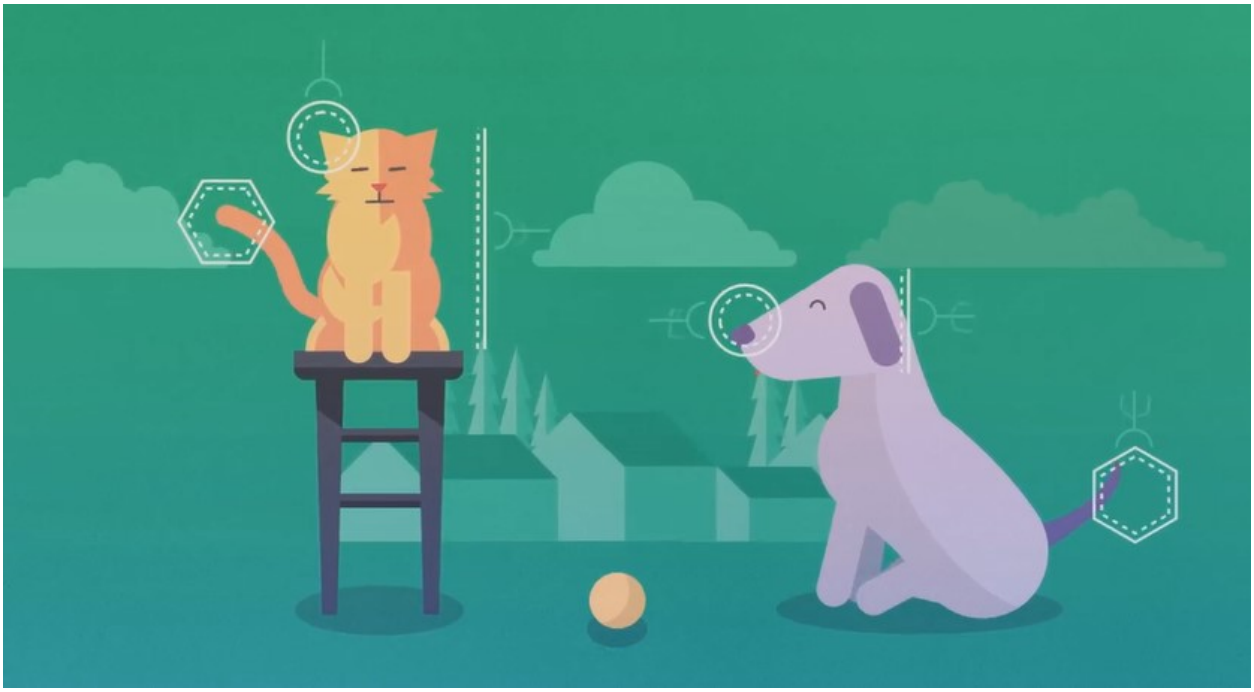


Well, while it may be easy for human to know the difference between a cat and a dog for an example, for a computer, not so easy

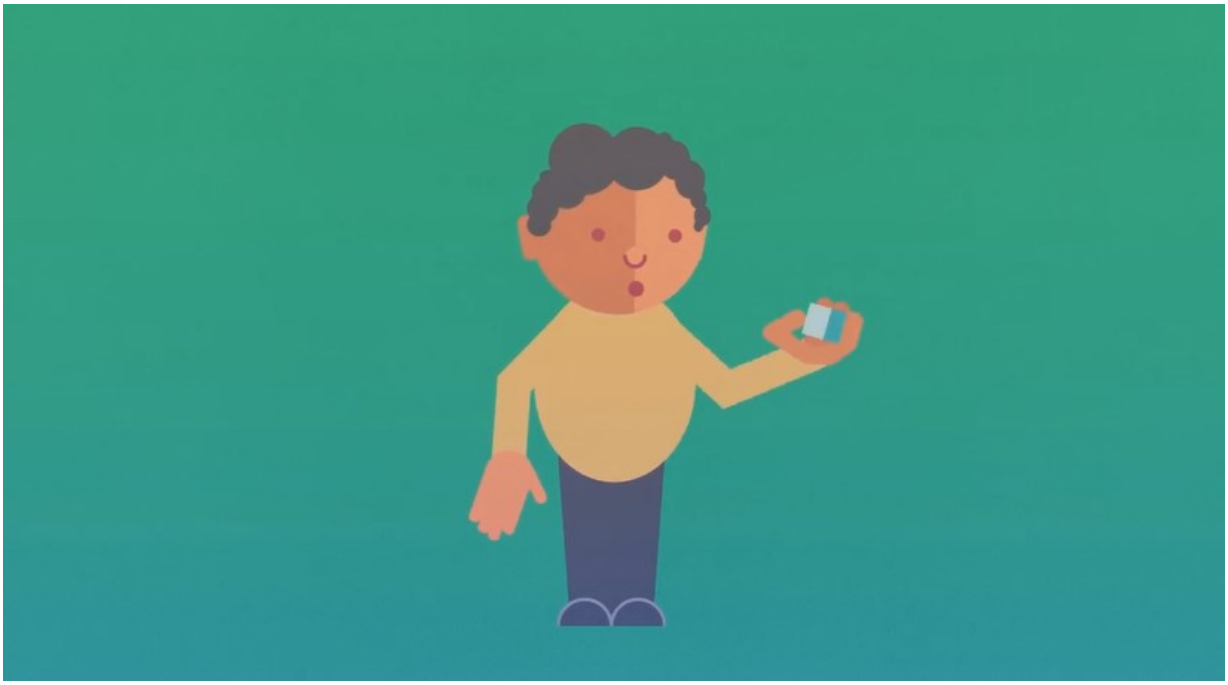


When you are only considering physical appearance, the difference between a cat and dog can be a little grey

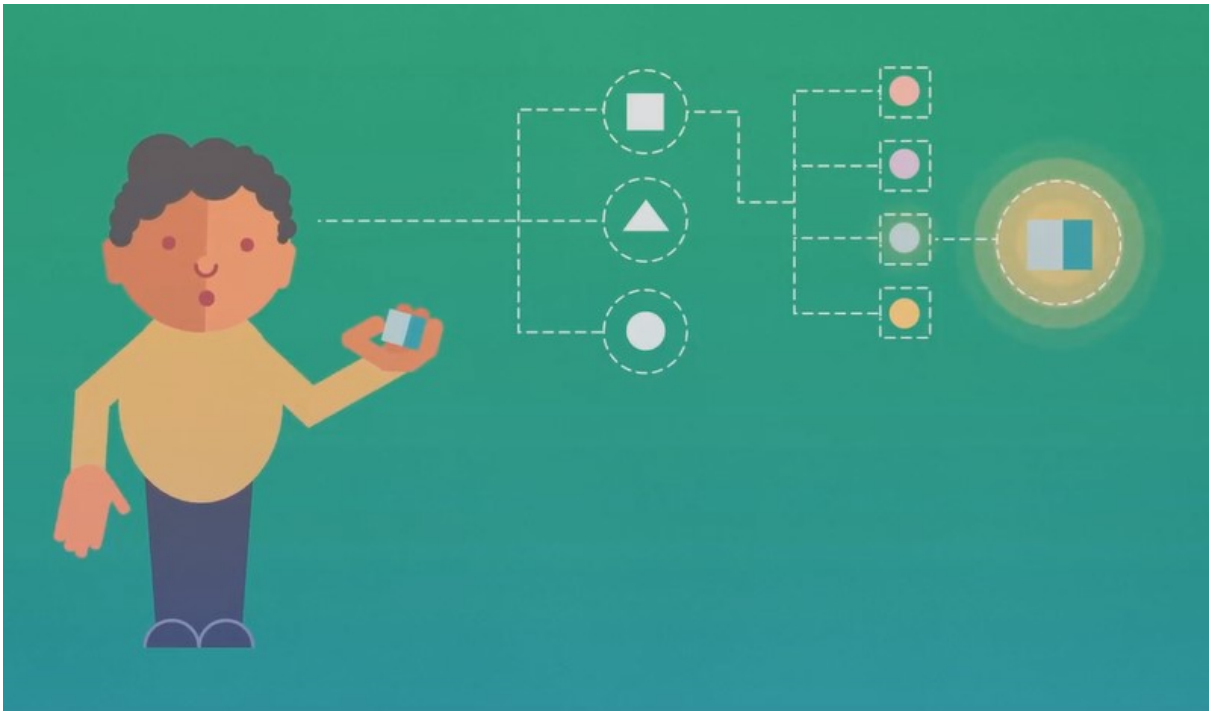
You can say cat has pointed ears and dogs have floppy ears but those roles are universal, other animals have similar ears



Other options could be the tail length, ears, color etc. It means there are lot of options and tedious roles a computer programming will have to identity to manually write a program that will help a computer spot the difference

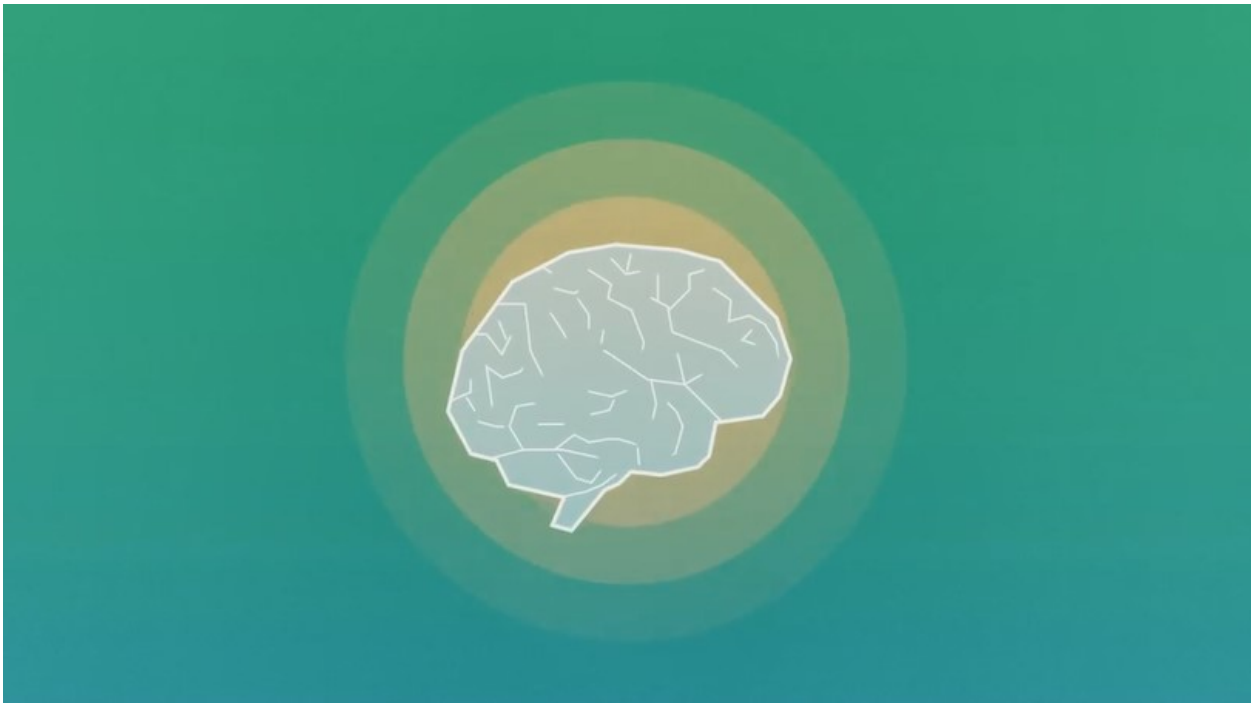


Machine learning is making computer learn like human and like any toddler that means they have to learn by experience



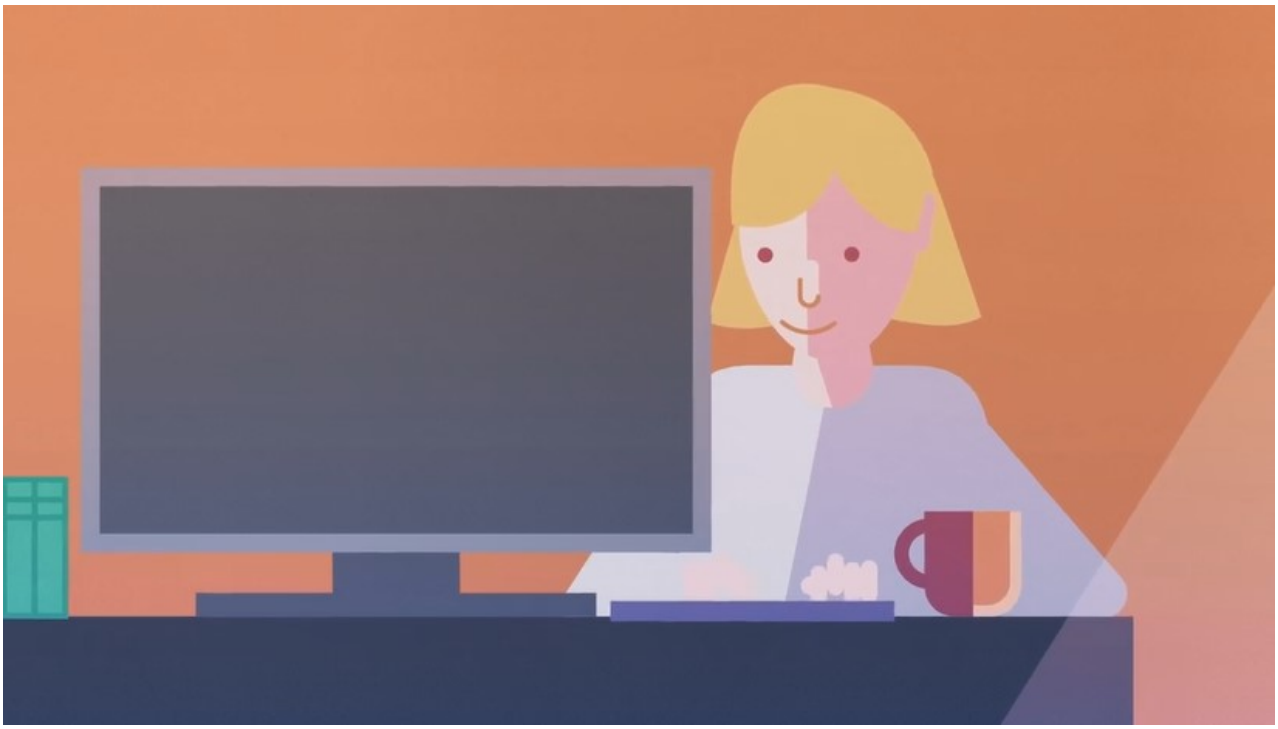
With machine learning, program analyze thousand of examples to build an algorithm, it then tweak the algorithm to help achieve its goal

Overtime the program actually gets smarter

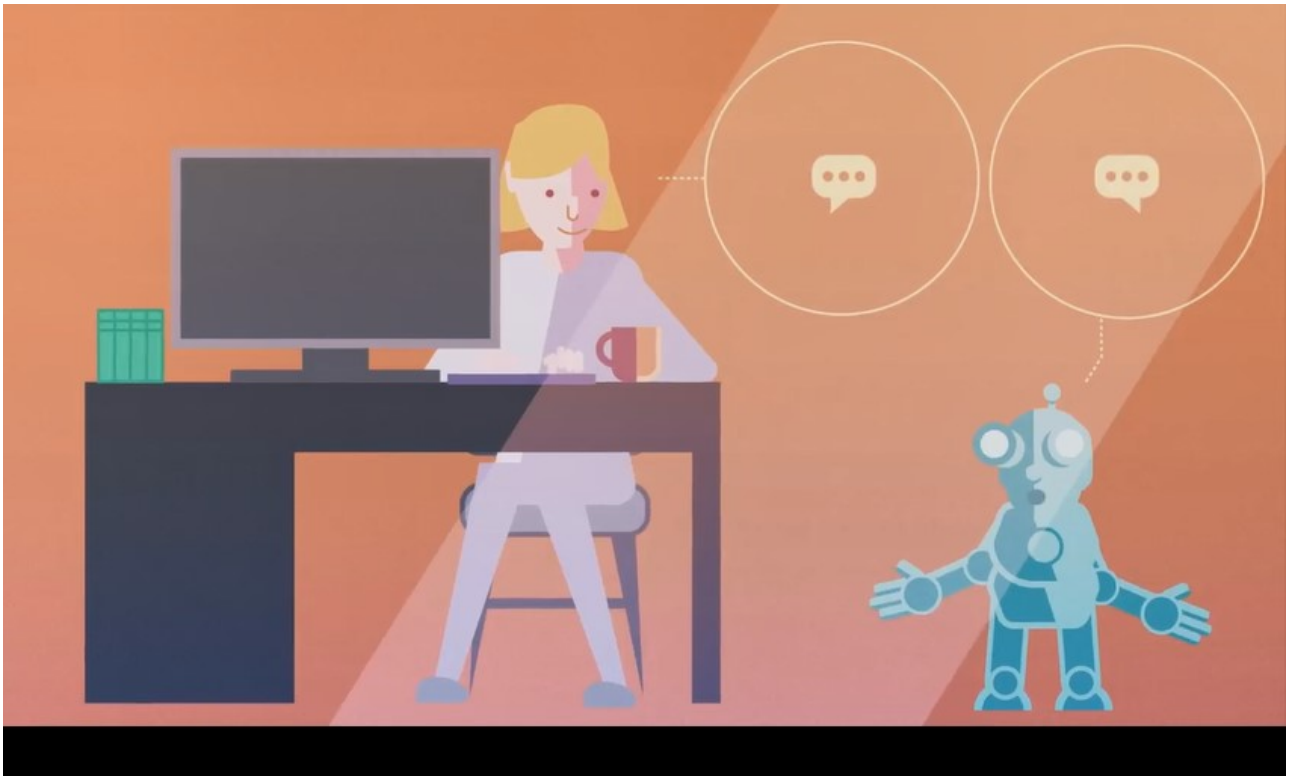


Some programs even mimic the way human brain is structured, like the ‘Neural Network” that helps humans, and now machines solve problems

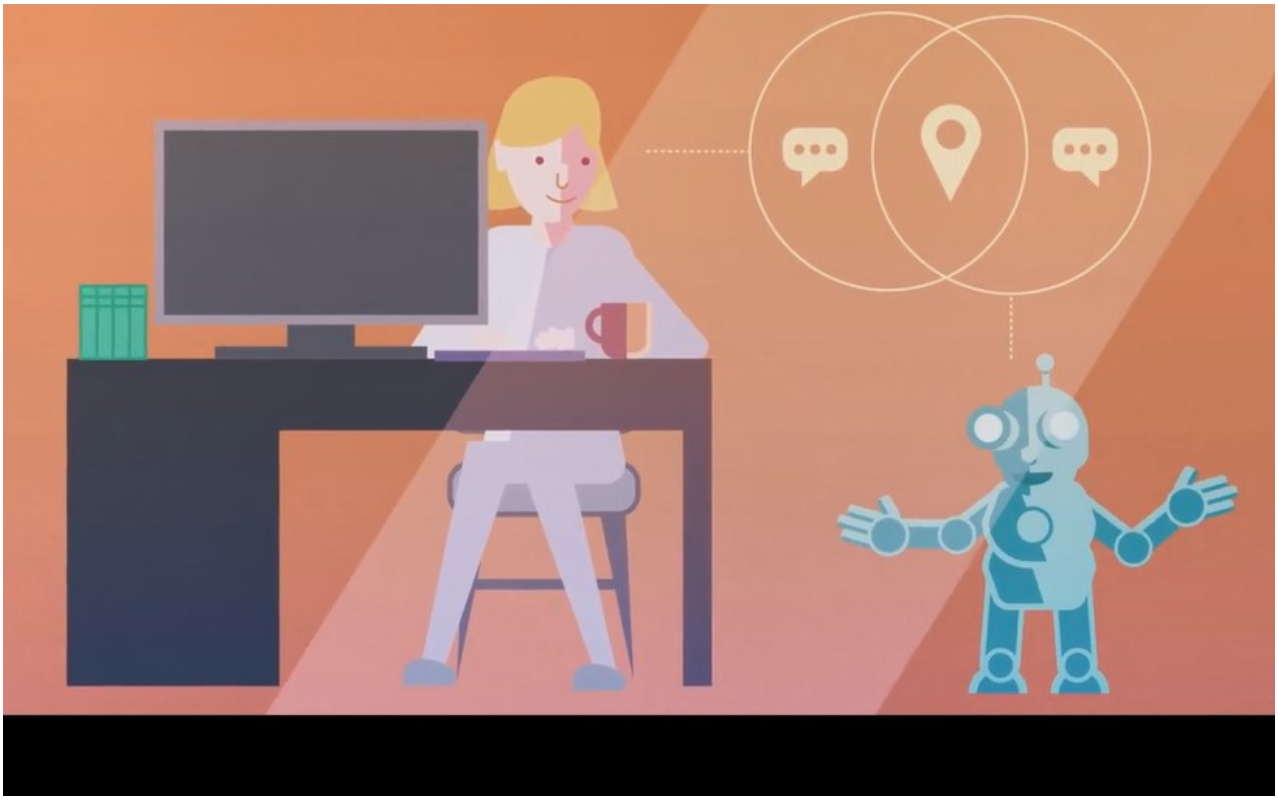
How will AI affect your job



Will it make your job obsolete?



Just like the industrial revolution, it isn't human versus machine



It is human and machine versus problem

The point is that AI helps you accomplish more in less time, taking on the repetitive task of your work, while you master the strategy and relationship that exist from the machine learning experience

That way human can do what they do best, be human

PRACTICALS

Case Study: Demonstrate the Use of machine Learning in Mechatronics

A simple Neural Network

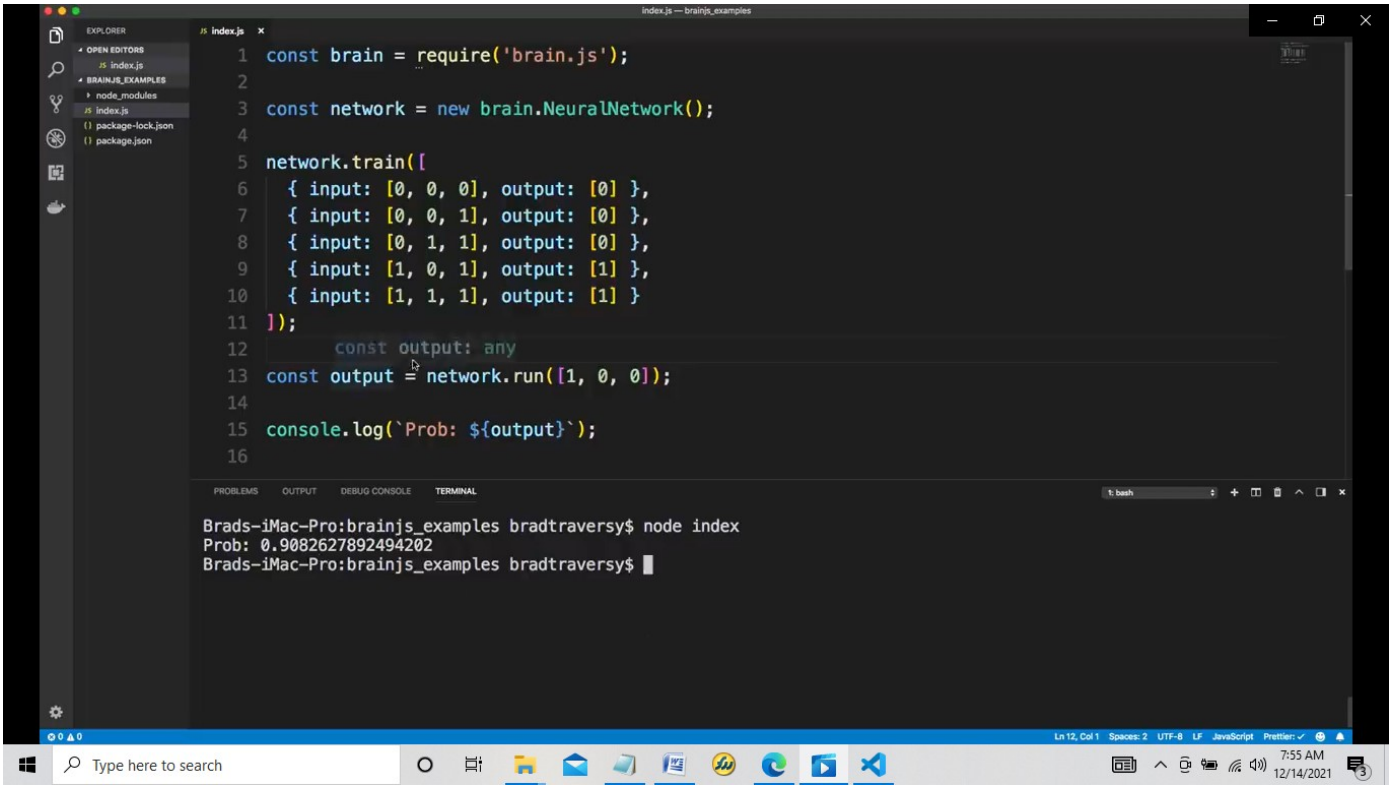
Let's start by defining the problem our network will be trained to solve:

Table 1: Problem Examples

	Input	Output
Example 1	0 0 0	0
Example 2	0 0 1	0
Example 3	0 1 1	0
Example 4	1 0 1	1
Example 5	1 1 1	1
Unknown	1 0 0	?

We are trying to find the value of the last example, know for anyone paying enough attention, the output value will match the value of the input left-most column; let's see if we can make our neural network answer the question correctly.

Based on the examples inputs and outputs our neuron will need to take 3 inputs and return a single output.



B. This section focuses on the application of “Mechatronics on Fault Detection and Diagnosis” in Vehicles

ATTACH THE MANUAL FOR CAR DIAGNOSTIC TOOL