

DATA SCIENCE IN MANUFACTURING

WEEK 7

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BY THE END OF THIS LECTURE YOU SHOULD:



Be introduced to Machine Learning (ML) and Artificial Intelligence (AI)



Get familiar with the uses of ML and AI in manufacturing



Understand the basic principles behind ML and AI

LECTURE: WEEK 7

Artificial Intelligence and Machine Learning



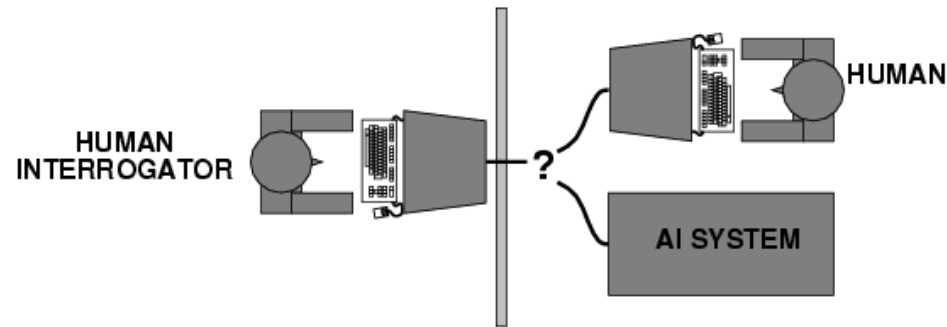
John McCarthy in his paper “What is artificial intelligence” [6] defines AI as “the science and engineering of making intelligent machines, especially intelligent computer programs. It is related to the similar task of using computers to understand human intelligence, but AI does not have to confine itself to methods that are biologically observable.”

ARTIFICIAL INTELLIGENCE



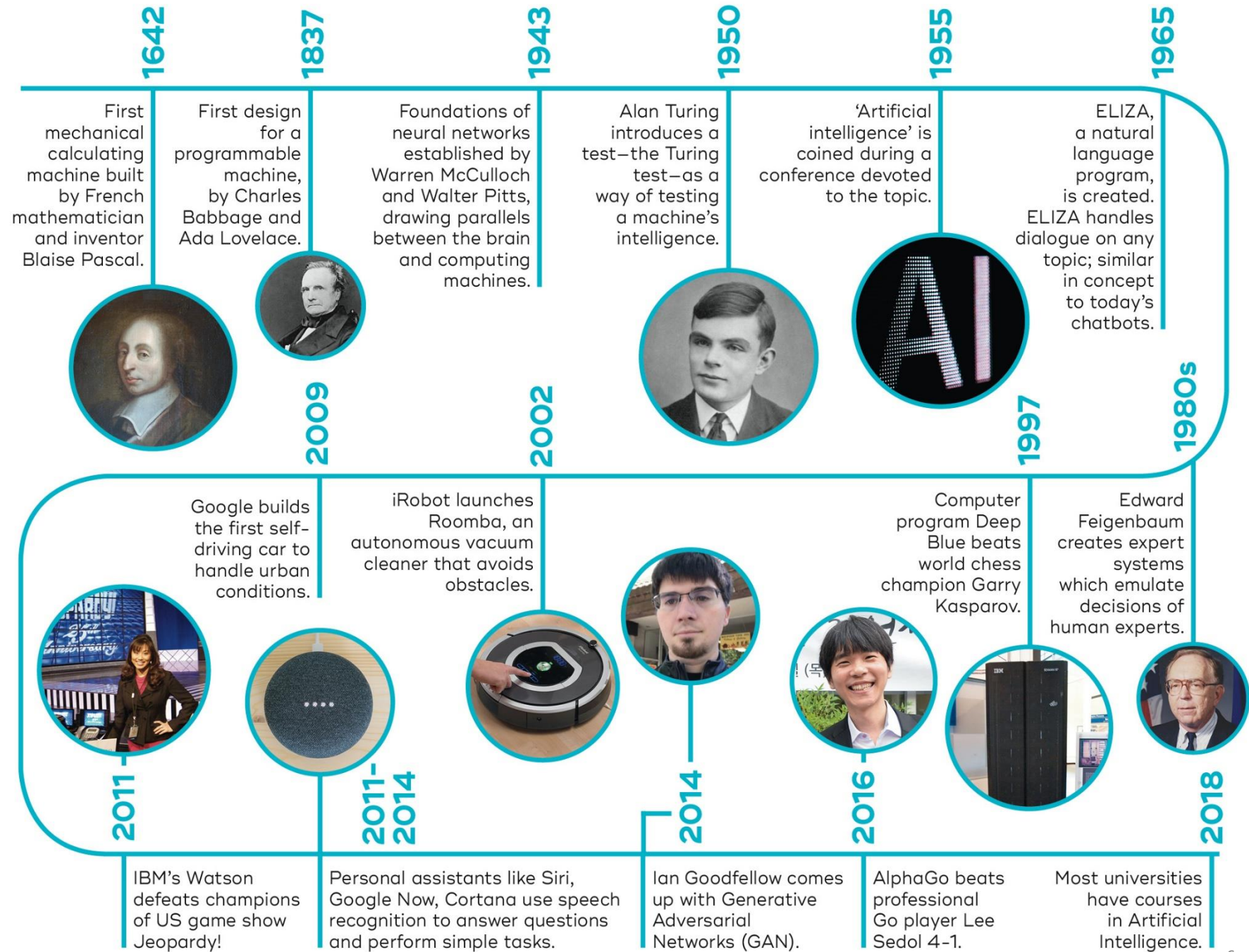
TURING TEST

- Turing (1950) "Computing machinery and intelligence": "Can machines think?" → "Can machines behave intelligently?"
- Operational test for intelligent behaviour: the Imitation Game



- Predicted that by 2000, a machine might have a 30% chance of fooling a lay person for 5 minutes
- Anticipated most major arguments against AI
- Suggested major components of AI: knowledge, reasoning, language understanding, learning

AI TIMELINE



Source: The University of Queensland

SINGULARITY

LAW OF ACCELERATING RETURNS

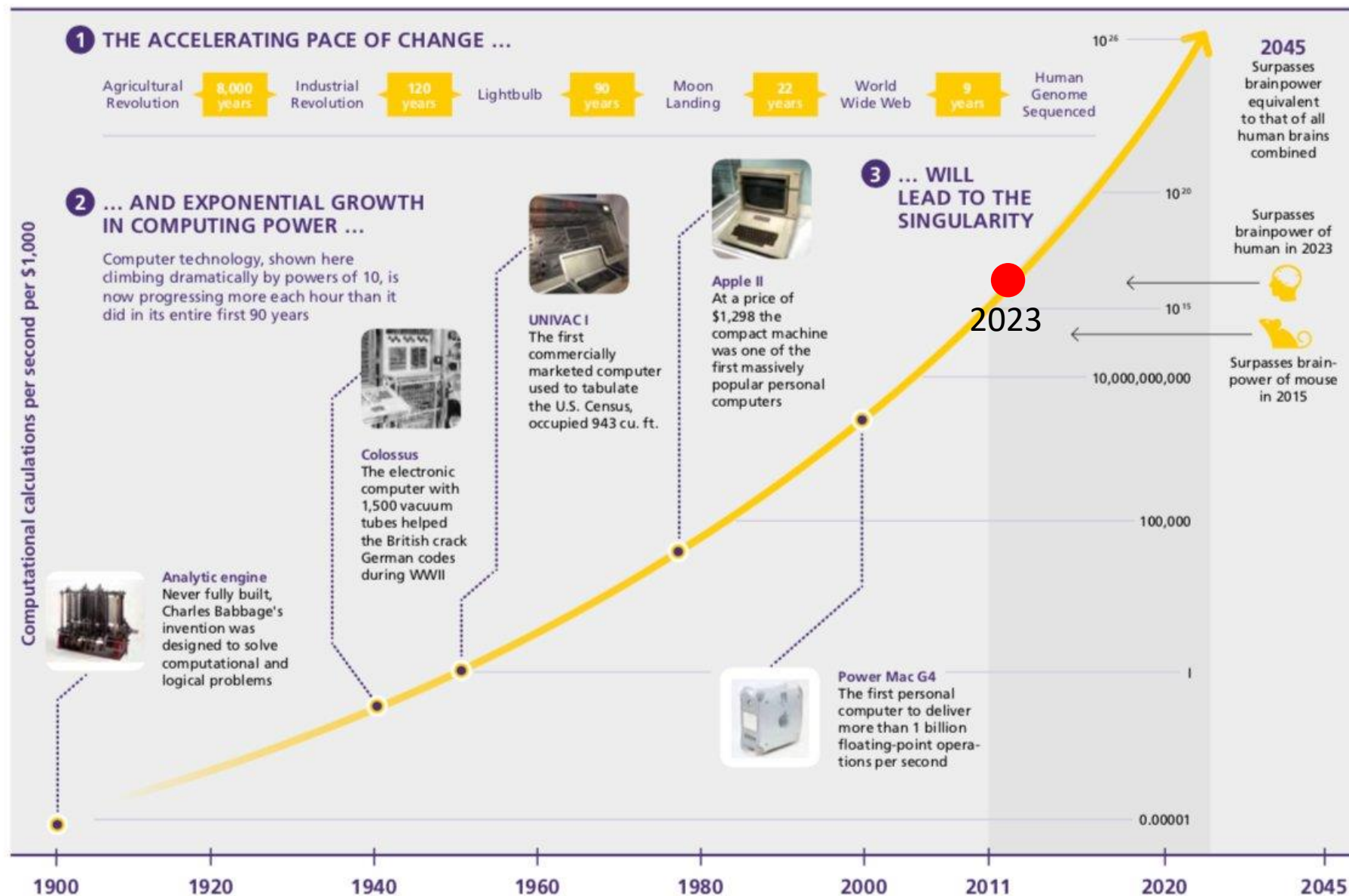


Figure 12: Ray Kurzweil's Law of Accelerating Returns depicts the exponential growth of computer processing power and technology innovations throughout history, and anticipates computers will exceed human intelligence in the future; **Source:** TIME / Wikipedia

SINGULARITY

**“With artificial intelligence we’re summoning the demon”
– Elon Musk**

**“Full artificial intelligence could spell the end of the human race”
– Steven Hawking**

LAW OF ACCELERATING RETURNS

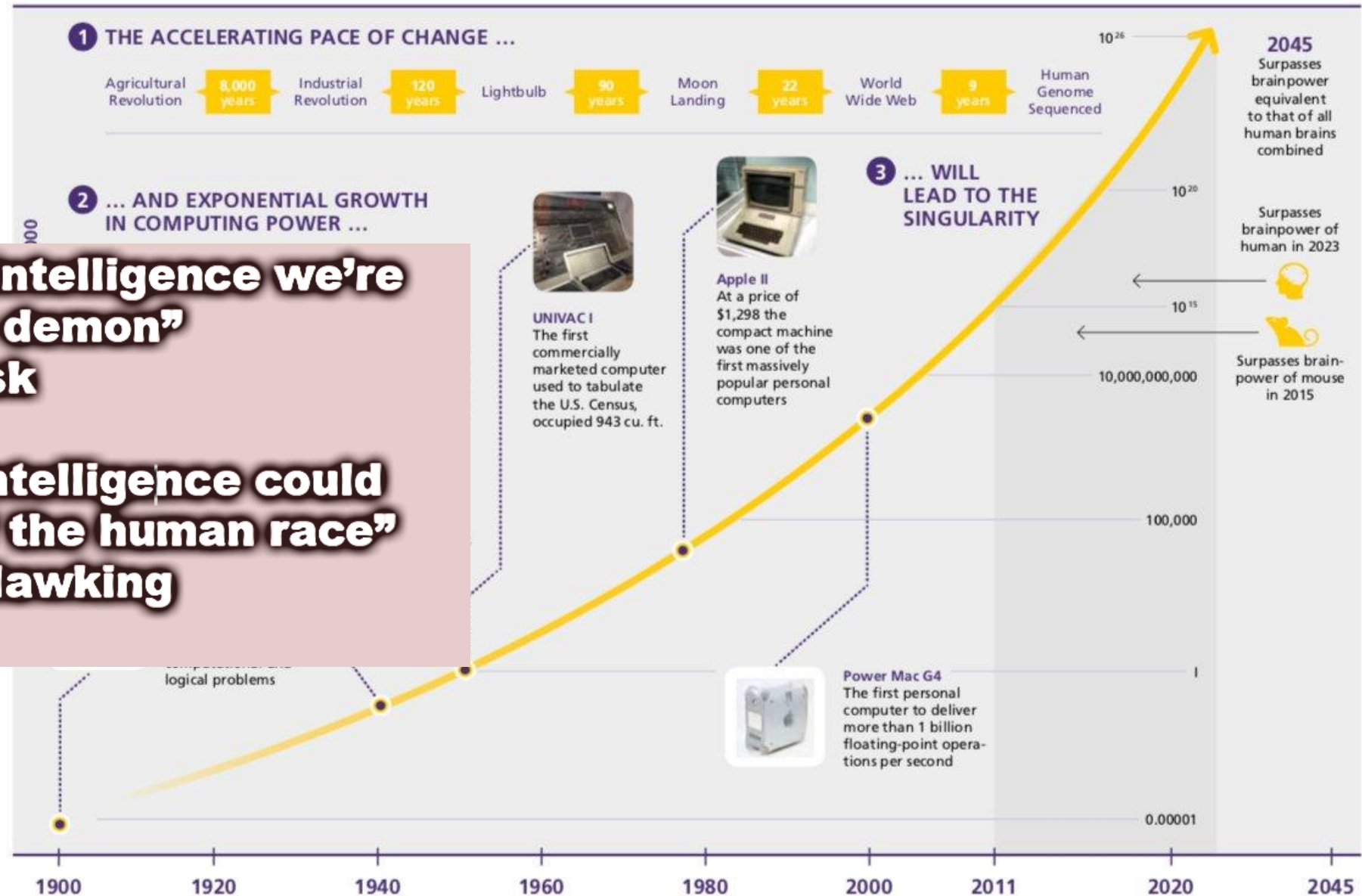
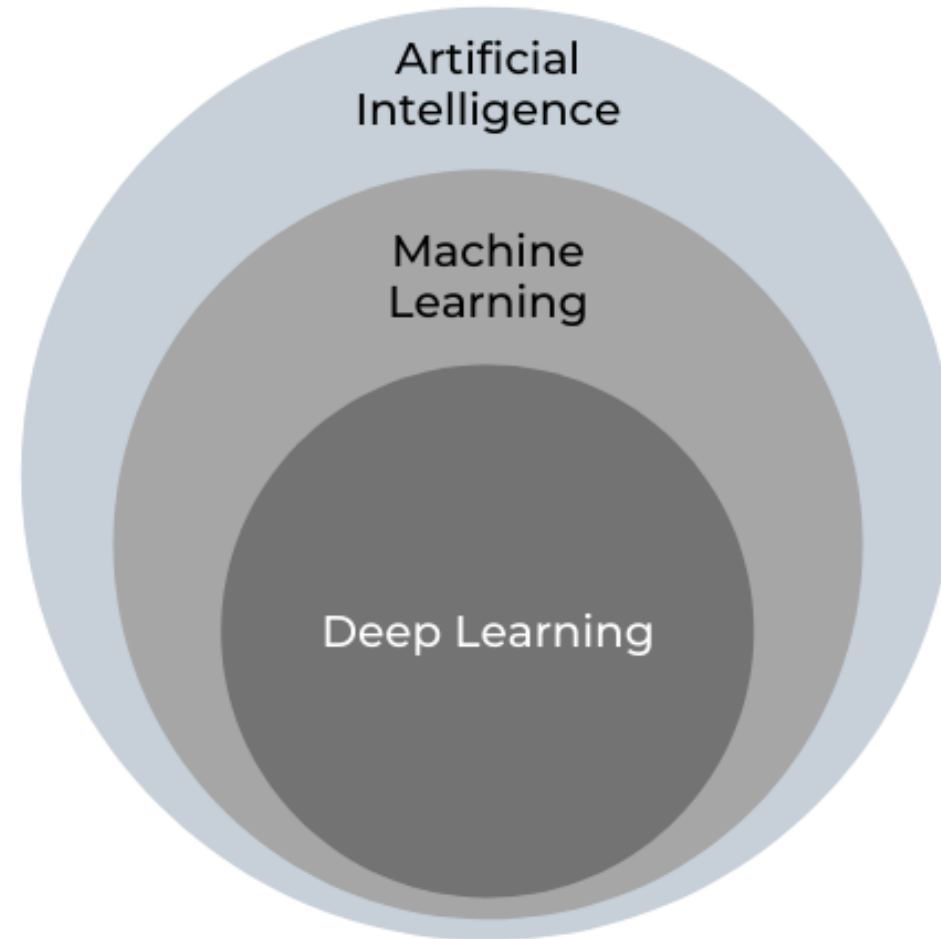
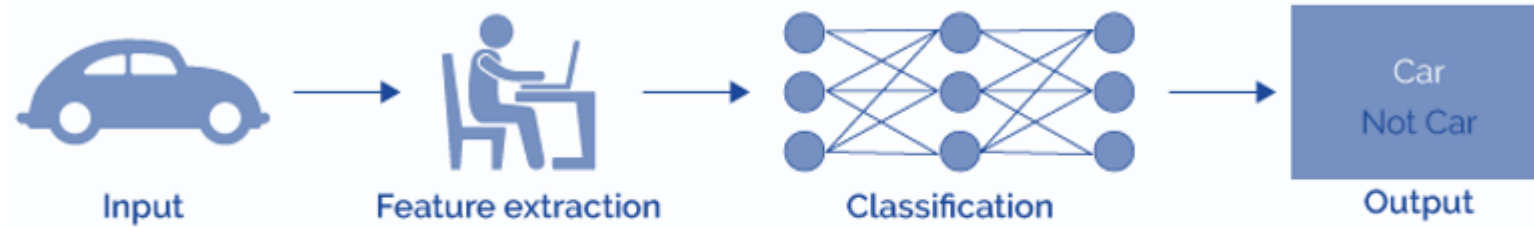


Figure 12: Ray Kurzweil's Law of Accelerating Returns depicts the exponential growth of computer processing power and technology innovations throughout history, and anticipates computers will exceed human intelligence in the future; **Source:** TIME / Wikipedia

DEEP LEARNING VS. MACHINE LEARNING



Machine Learning



Deep Learning



Machine Learning (ML)



MACHINE LEARNING (ML)

- What is machine learning?
- What is supervised, unsupervised and reinforcement learning?
- What is dimensionality reduction and PCA?
- Top prediction algorithms

WHAT IS MACHINE LEARNING?

- ML is one of the most booming areas of AI due to Big Data and advances that allowed significant improvement in ML algorithms.
- Term ML dates back to 1959 when computer scientist Arthur Samuel wondered if computers can learn how to respond instead of being programmed to.
- ML can be divided into three subtopics: supervised learning, unsupervised learning and reinforcement learning.

WHAT IS MACHINE LEARNING?

According to Doug Rose [5], “**Machine Learning** is giving the computer the data and tools it needs to study a problem and solve it without being told what to do. Also, giving the computer the ability to remember what it did so it can adapt, evolve, and learn.”

WHY MACHINE LEARNING?

No human experts

- industrial/manufacturing control
- mass spectrometer analysis, drug design, astronomic discovery

Black-box human expertise

- face/handwriting/speech recognition
- driving a car, flying a plane

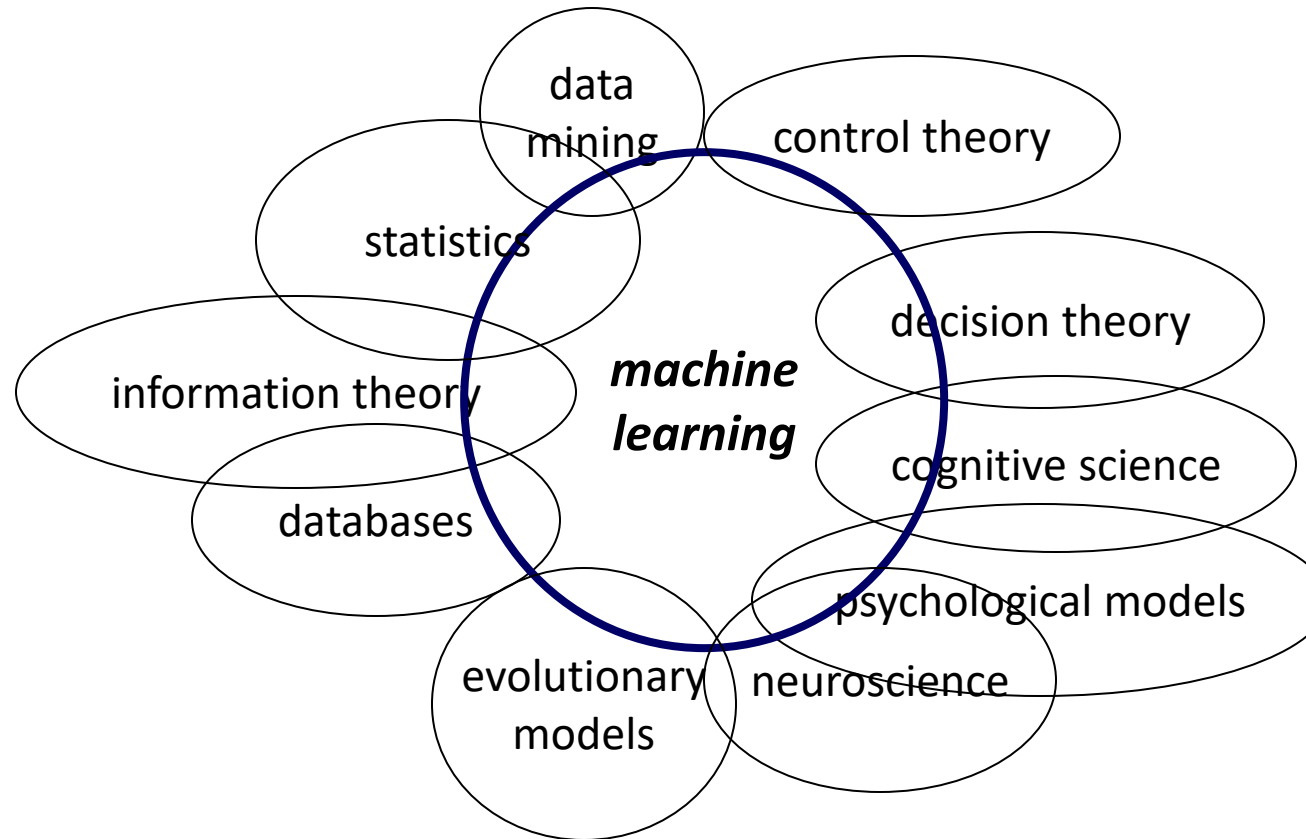
Rapidly changing phenomena

- credit scoring, financial modeling
- diagnosis, fraud detection

Need for customization/personalization

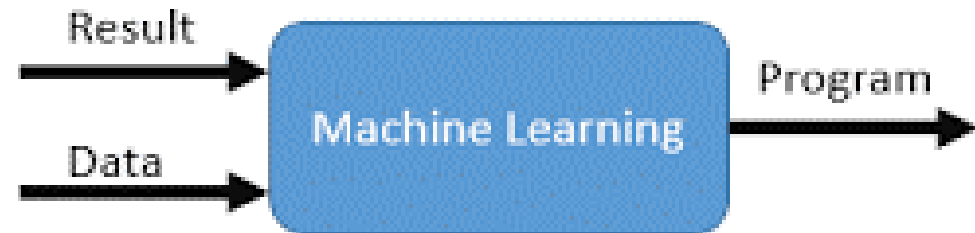
- personalized news reader
- movie/book recommendation

RELATED FIELDS



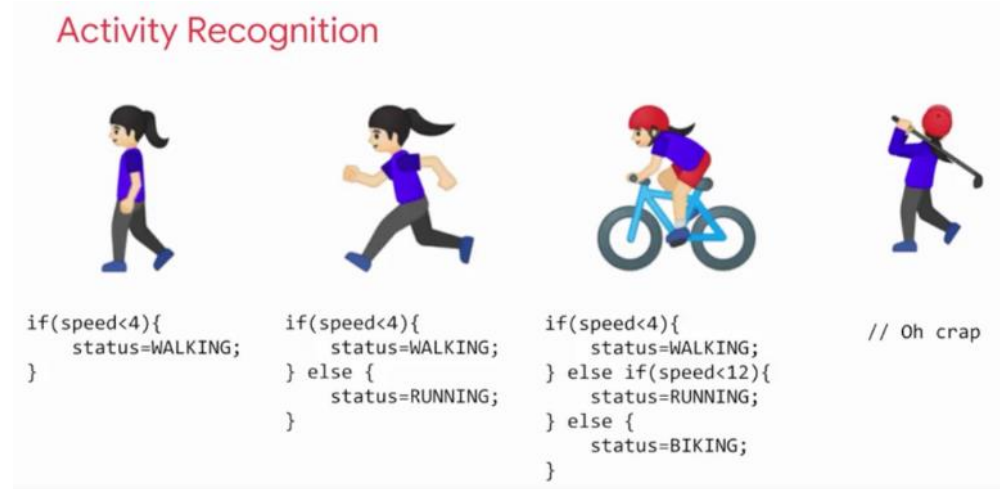
Machine learning is primarily concerned with the accuracy and effectiveness of the *computer system*.

Conventional Programming is writing a program in a traditional procedural language, such as assembly language or a high-level compiler language (C, C++, Java, JavaScript, Python, etc).

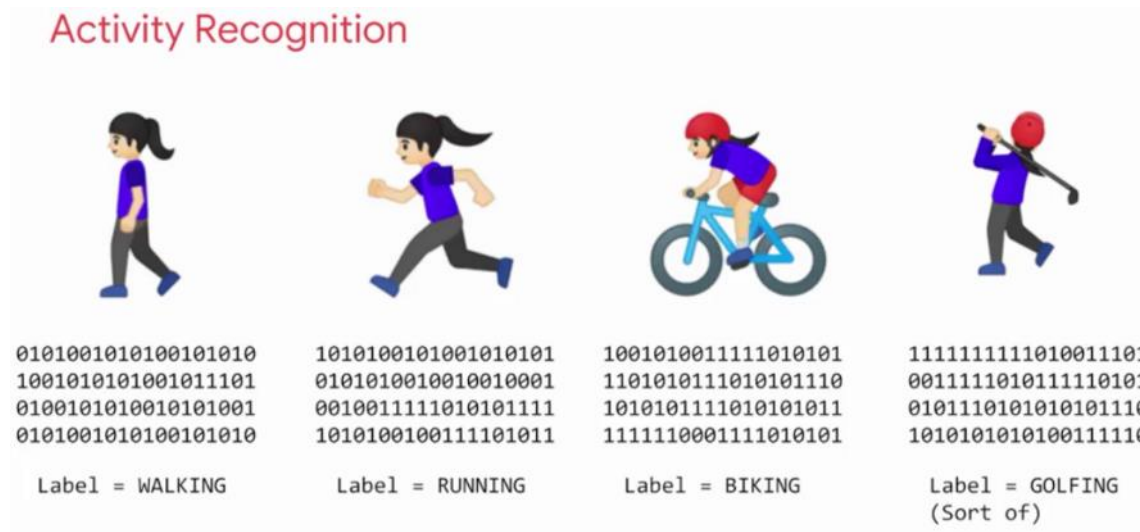


Machine Learning solves this problem by modeling this data with **train data** and **test data** and then ***predict*** the result.

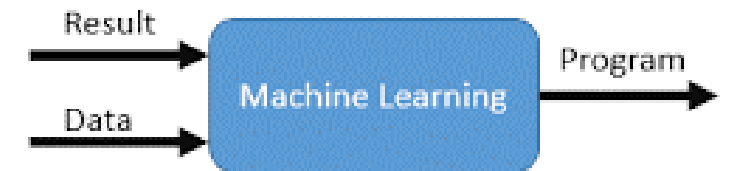
TEACHABLE MACHINES



Conventional Programming



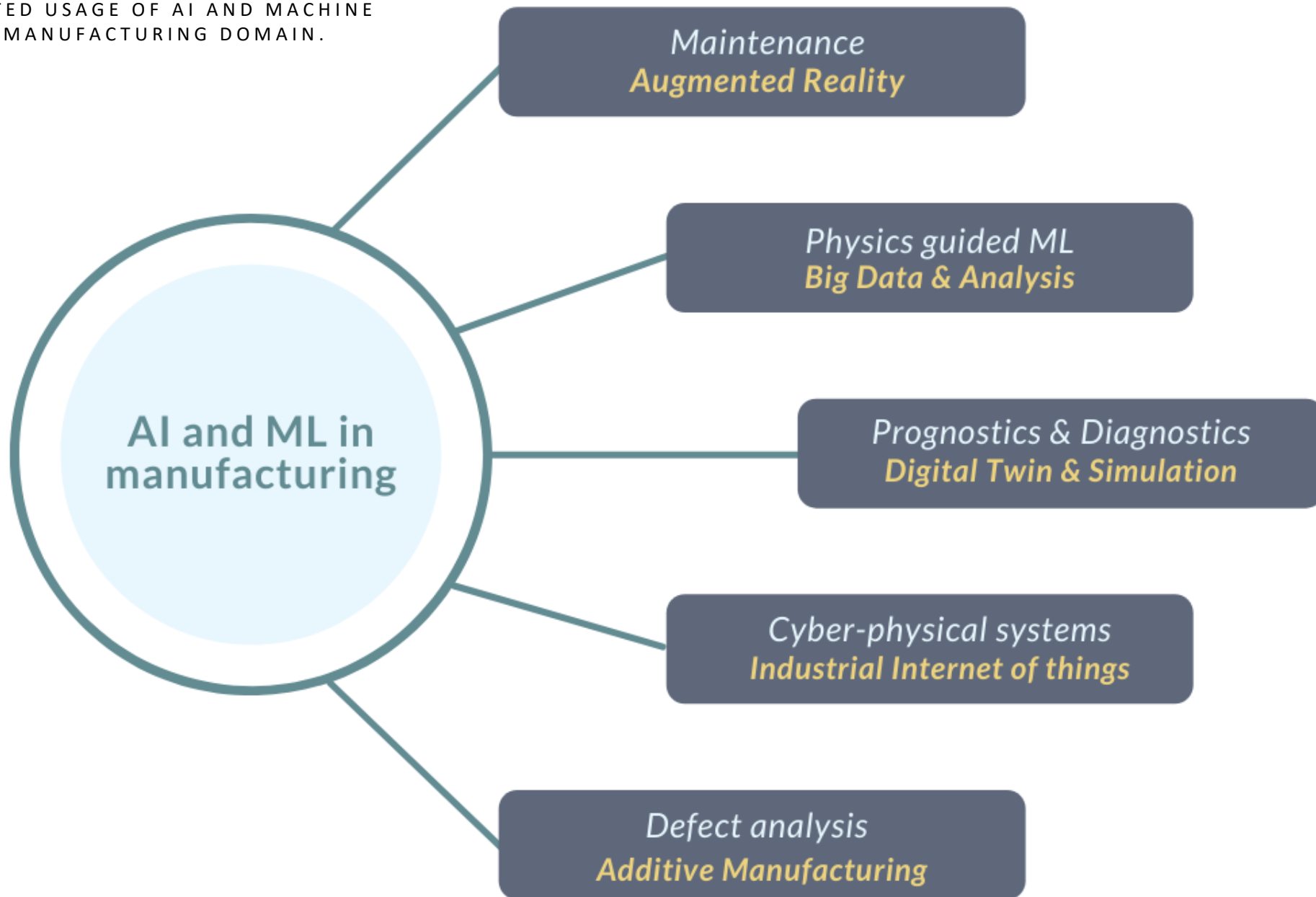
Machine Learning



MACHINE LEARNING APPLICATIONS IN MANUFACTURING

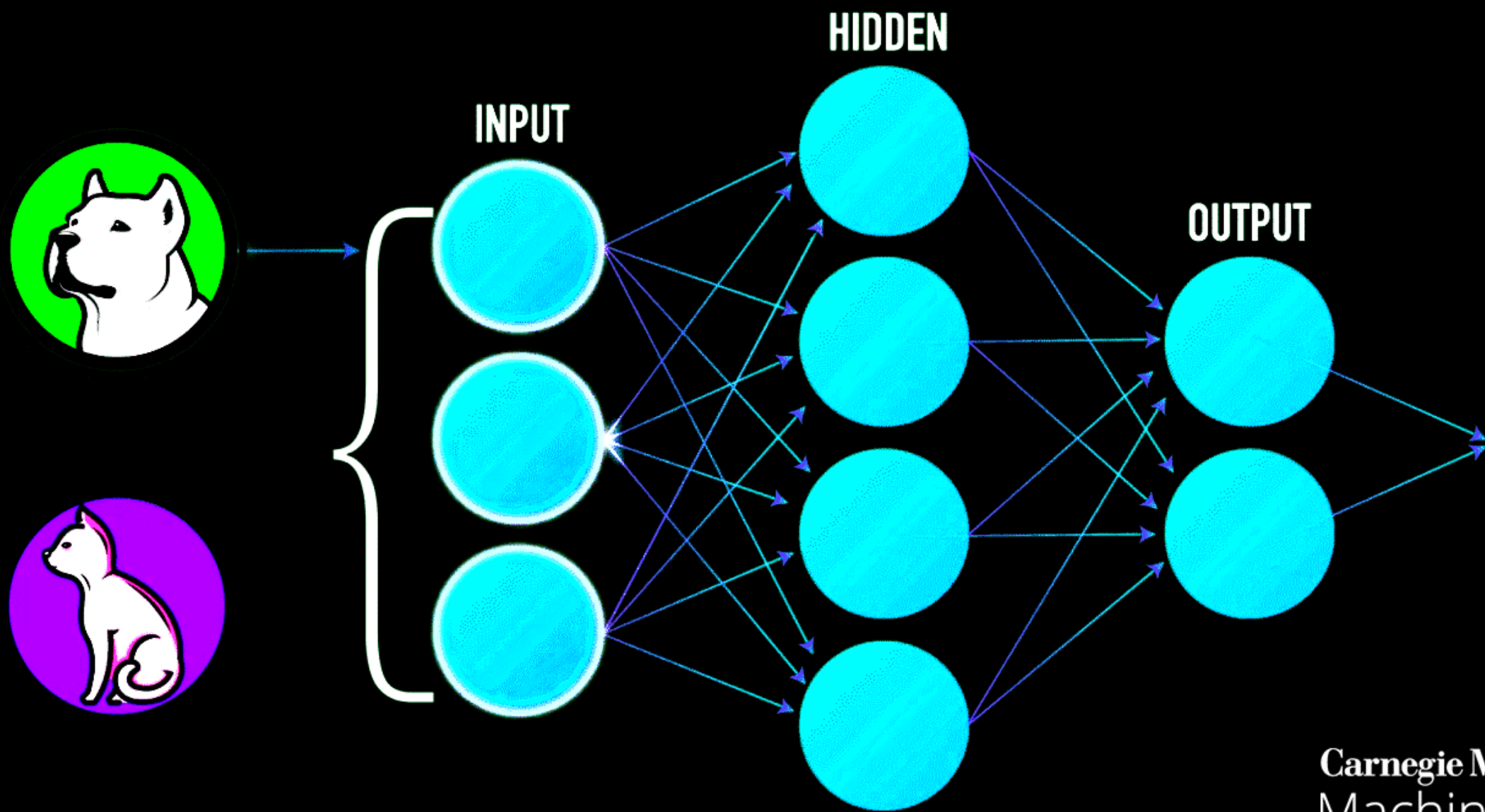
- Predictive maintenance and improving manufacturing operational efficiency
- Predicting quality and improving quality control on the production line
- Reducing maintenance costs and improving reliability
- Digital twins
- Enabling generative design / smart manufacturing
- Optimising logistics and waste
- Energy consumption forecasting
- Cognitive supply chain management
- Improving workplace safety
- Forecasting and responding to consumer demand

[1,2,3]

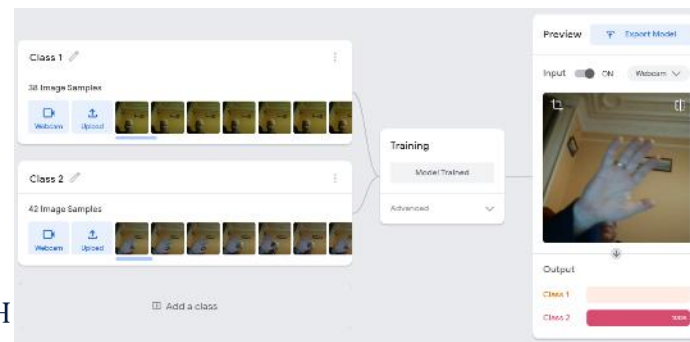
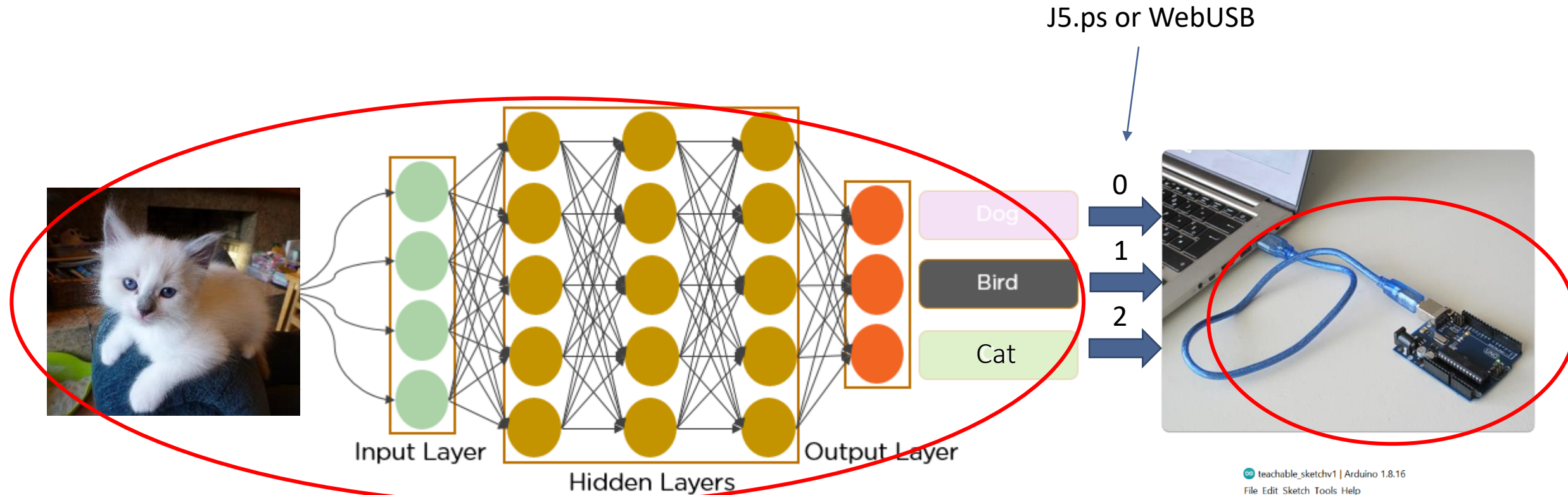


BENEFITS OF MACHINE LEARNING IN MANUFACTURING

- Significant process-driven loss reductions.
- Cost reductions driven by predictive maintenance.
- Consumer-driven product creation thanks to smart manufacturing.
- Boost in capacity through process optimisation.
- Ability to scale product lines by streamlining and optimising processes.
- Extended life of machinery and equipment via Predicting Remaining Useful Life (RUL).
- Better supply chain management.
- Enhanced quality control.
- Improved safety conditions on the manufacturing floor.



TEACHABLE MACHINE SCHEMATIC



```
teachable_sketchv1 | Arduino 1.8.16
File Edit Sketch Tools Help

teachable_sketchv1
#include <Servo.h>

Servo myservo;
char result;

void setup() {
  Serial.begin(9600);
  myservo.attach(9);
  myservo.write(90);
}

void loop() {
  while (Serial.available() > 0) {
    result = Serial.read();
    switch (result) {
      case '0':
        myservo.write(0);
        break;
      case '1':
        myservo.write(90);
        break;
      case '2':
        myservo.write(180);
        break;
    }
  }
}
```

SUPERVISED VS. UNSUPERVISED LEARNING

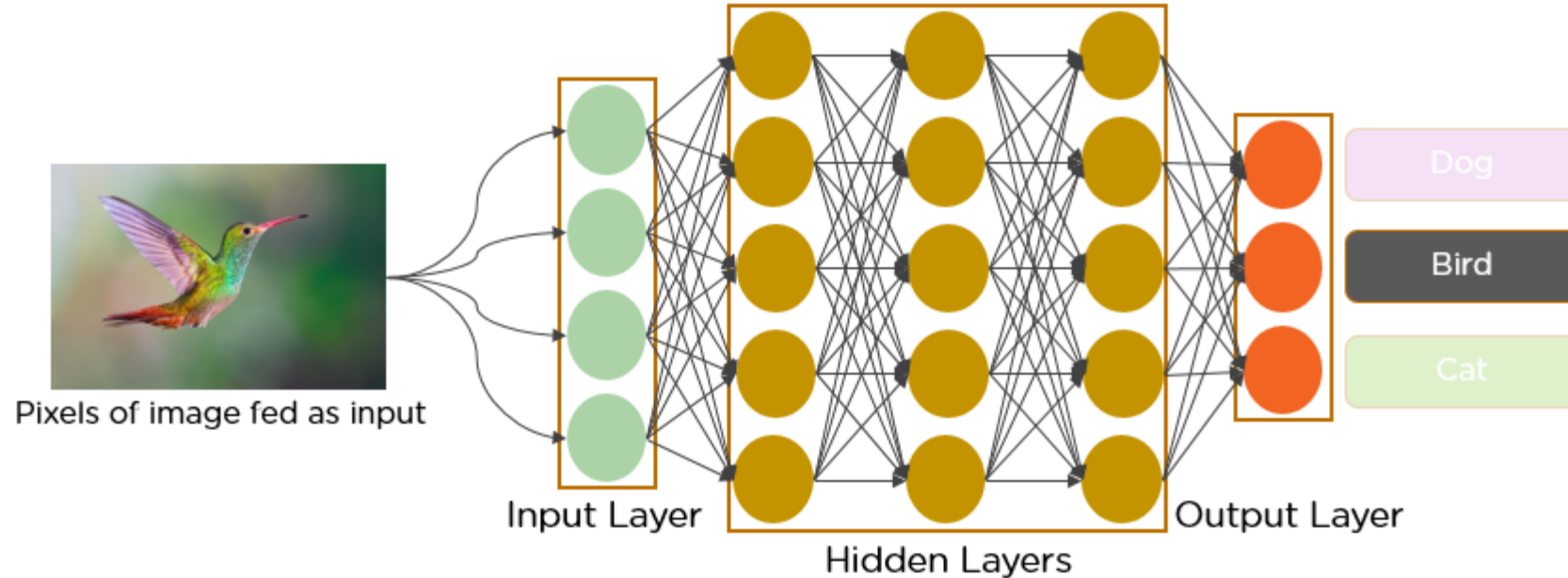
Supervised learning:
classification is
supervised learning
from examples.

- Supervision: The data (observations, measurements, etc.) are labeled with pre-defined classes, which is
- like a “teacher” gives us the classes (supervision).

Unsupervised
learning (clustering)

- Class labels of the data are not given or unknown
- **Goal:** Given a set of data, the task is to establish the existence of classes or clusters in the data

MACHINE LEARNING CLASSIFICATION NETWORK



The training process assigns weights to the arcs of the network so it output the right classifications

RESOURCES

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Dietterich, T. (2003). Machine Learning. *Nature Encyclopedia of Cognitive Science*.

Doyle, P. Machine Learning. <http://www.cs.dartmouth.edu/~brd/Teaching/AI/Lectures/Summaries/learning.html>

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Mitchell, T. (1997). *Machine Learning*.

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Russell, S. (1997). Machine Learning. *Handbook of Perception and Cognition*, Vol. 14, Chap. 4.

Russell, S. (2002). *Artificial Intelligence: A Modern Approach*, Chap. 18-20. <http://aima.cs.berkeley.edu>