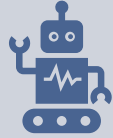# DATA SCIENCE IN MANUFACTURING

WEEK 6

ANDREW SHERLOCK, JONATHAN CORNEY, DANAI KORRE

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 6

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
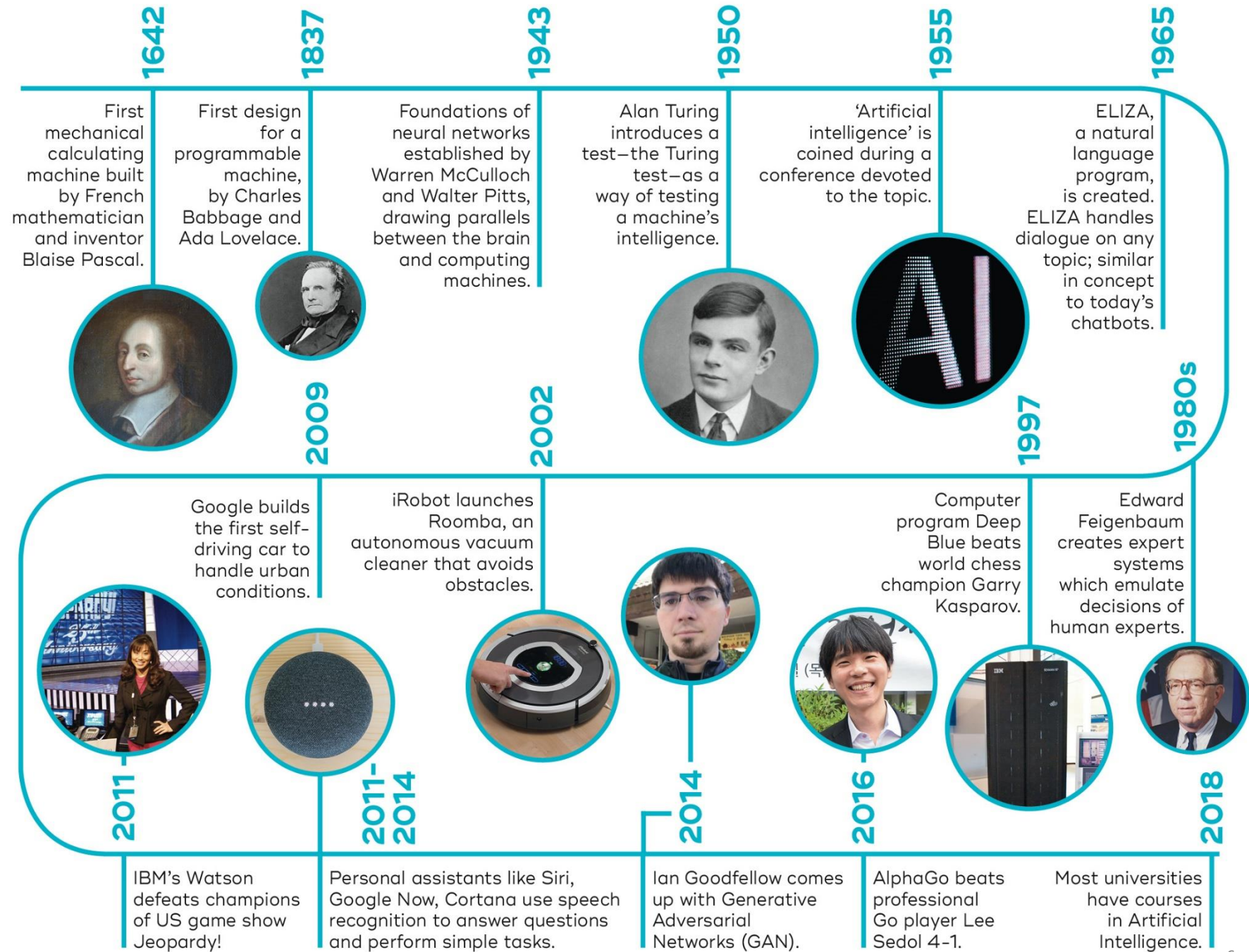
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TURING TEST

- Turing (1950) "Computing machinery and intelligence": "Can machines think?" →"Can machines behave intelligently?"

- Operational test for intelligent behaviour: the Imitation Game
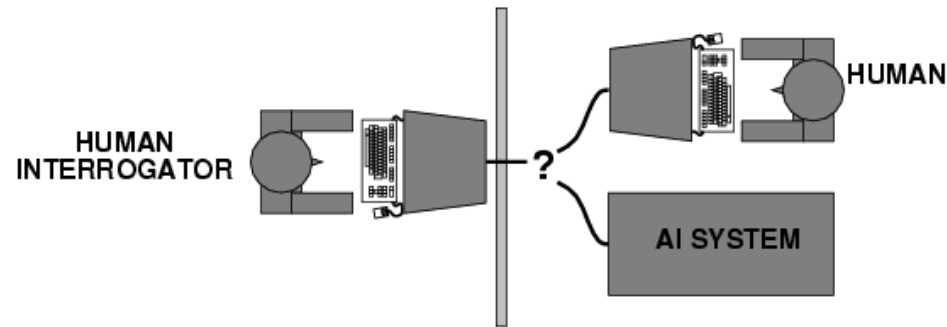
- Predicted that by 2000, a machine might have a 30% chance of fooling a lay person for 5 minutes

- Anticipated most major arguments against AI

- Suggested major components of AI: knowledge, reasoning, language understanding, learning

Source: Mitch Marcus, Penn State

AI TIMELINE

1642 — First mechanical calculating machine built by French mathematician and inventor Blaise Pascal.

1837 — First design for a programmable machine, by Charles Babbage and Ada Lovelace.

1943 — Foundations of neural networks established by Warren McCulloch and Walter Pitts, drawing parallels between the brain and computing machines.

1950 — Alan Turing introduces a test—the Turing test—as a way of testing a machine's intelligence.

1955 — 'Artificial intelligence' is coined during a conference devoted to the topic.

1965 — ELIZA, a natural language program, is created. ELIZA handles dialogue on any topic; similar in concept to today's chatbots.

1980s — Edward Feigenbaum creates expert systems which emulate decisions of human experts.

1997 — Computer program Deep Blue beats world chess champion Garry Kasparov.

2002 — iRobot launches Roomba, an autonomous vacuum cleaner that avoids obstacles.

2009 — Google builds the first self-driving car to handle urban conditions.

2011 — IBM's Watson defeats champions of US game show Jeopardy!

2011–2014 — Personal assistants like Siri, Google Now, Cortana use speech recognition to answer questions and perform simple tasks.

2014 — Ian Goodfellow comes up with Generative Adversarial Networks (GAN).

2016 — AlphaGo beats professional Go player Lee Sedol 4–1.

2018 — Most universities have courses in Artificial Intelligence.

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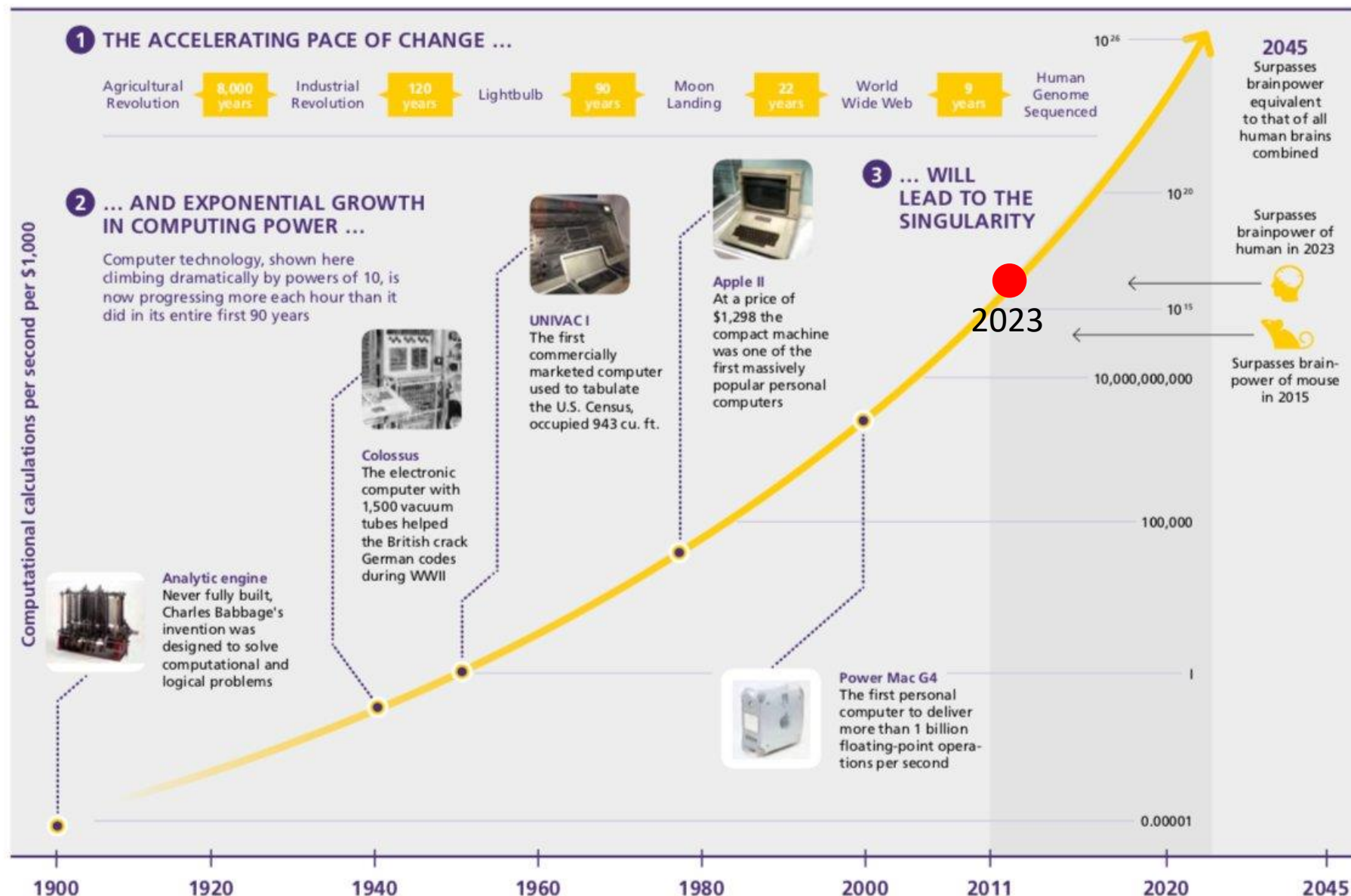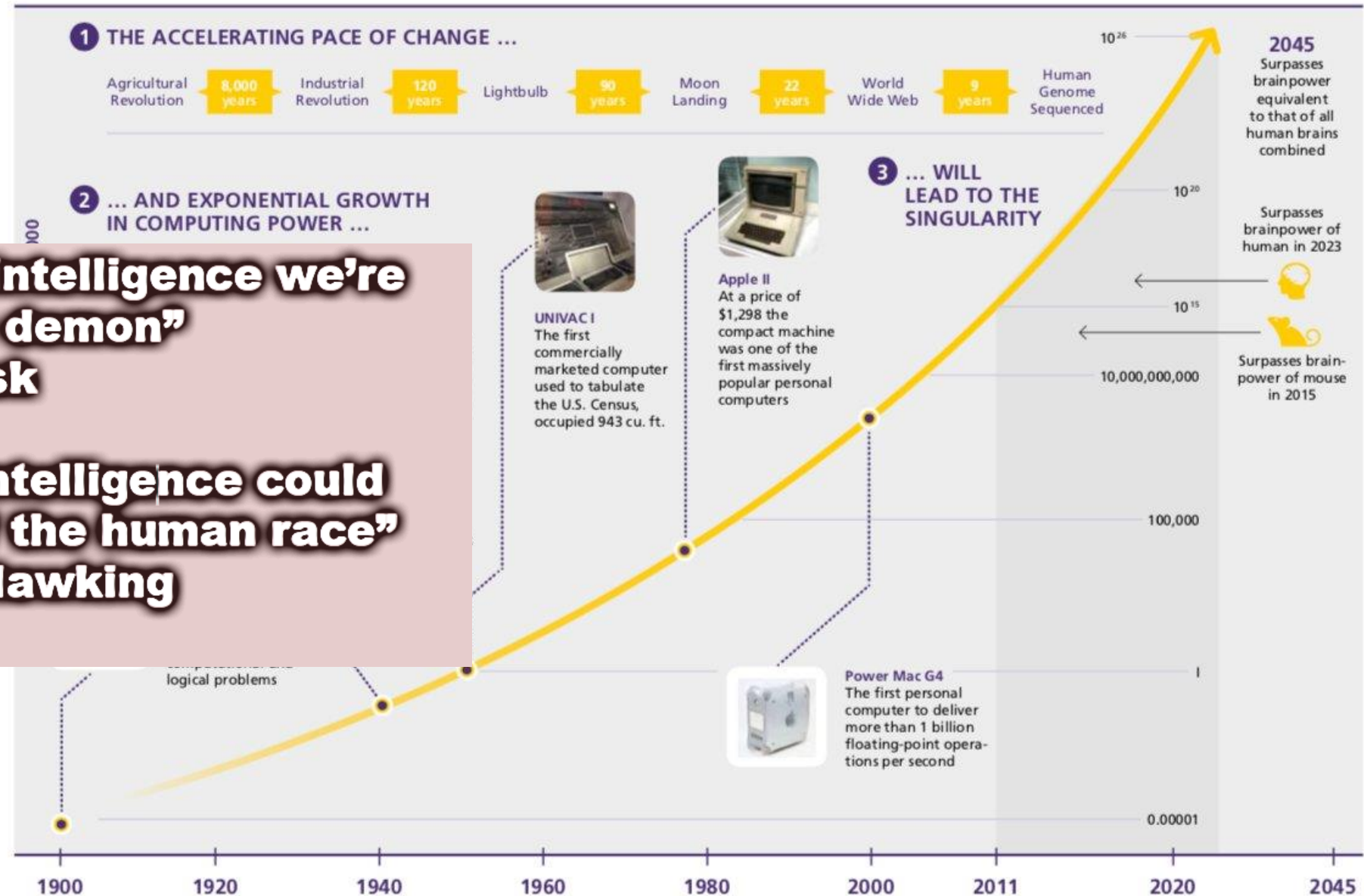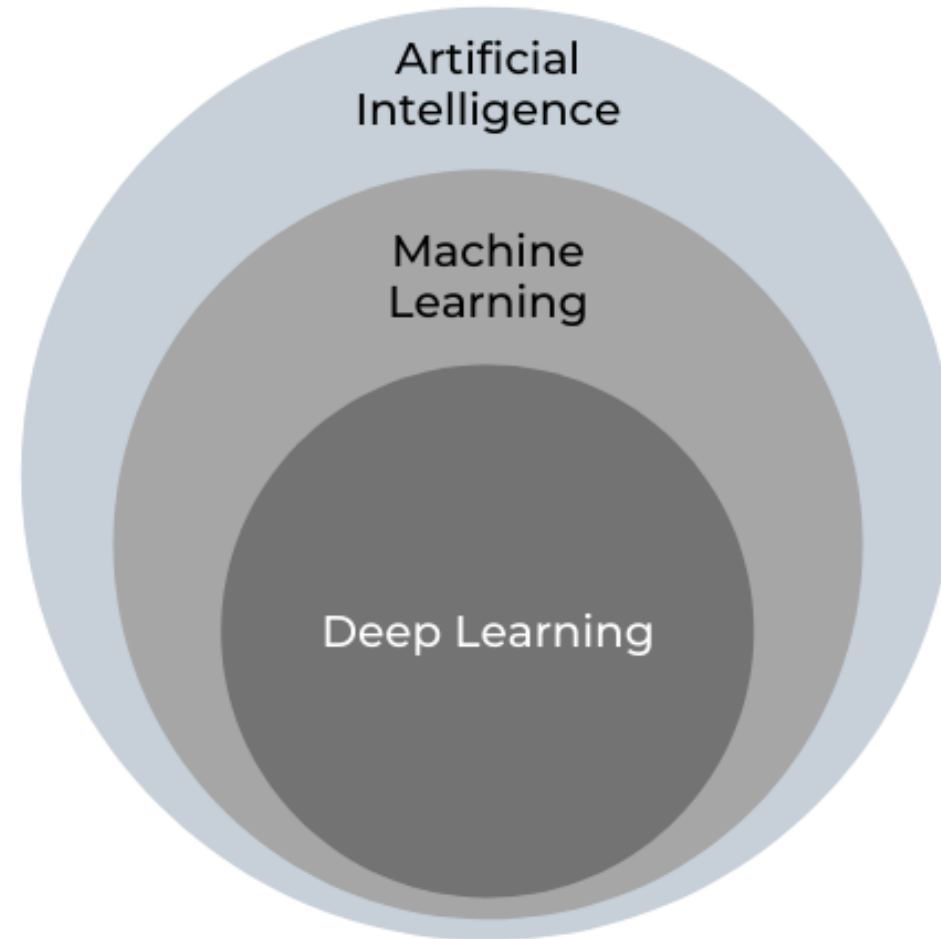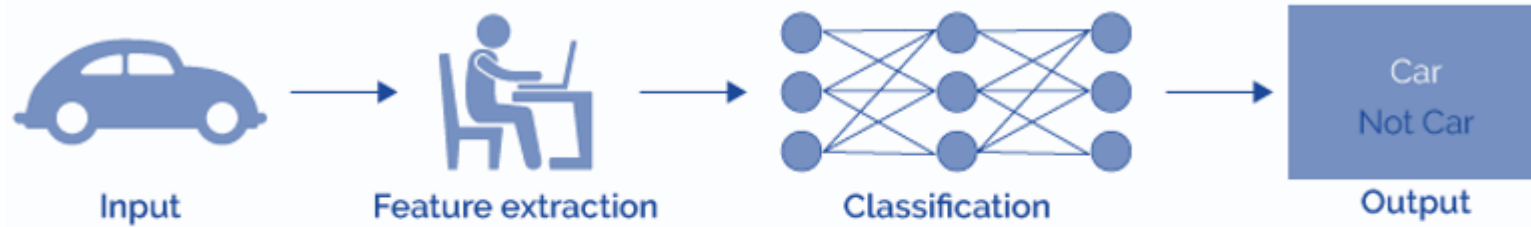School of Engineering

SINGULARITY

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

LAW OF ACCELERATING RETURNS

1 THE ACCELERATING PACE OF CHANGE …

Agricultural Revolution — 8,000 years — Industrial Revolution — 120 years — Lightbulb — 90 years — Moon Landing — 22 years — World Wide Web — 9 years — Human Genome Sequenced

2 … AND EXPONENTIAL GROWTH IN COMPUTING POWER …

3 … WILL LEAD TO THE SINGULARITY

2045 Surpasses brainpower equivalent to that of all human brains combined

Surpasses brainpower of human in 2023

Surpasses brain-power of mouse in 2015

UNIVAC I — The first commercially marketed computer used to tabulate the U.S. Census, occupied 943 cu. ft.

Apple II — At a price of $1,298 the compact machine was one of the first massively popular personal computers

Power Mac G4 — The first personal computer to deliver more than 1 billion floating-point operations per second

"With artificial intelligence we're summoning the demon"
– Elon Musk

"Full artificial intelligence could spell the end of the human race"
– Steven Hawking

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
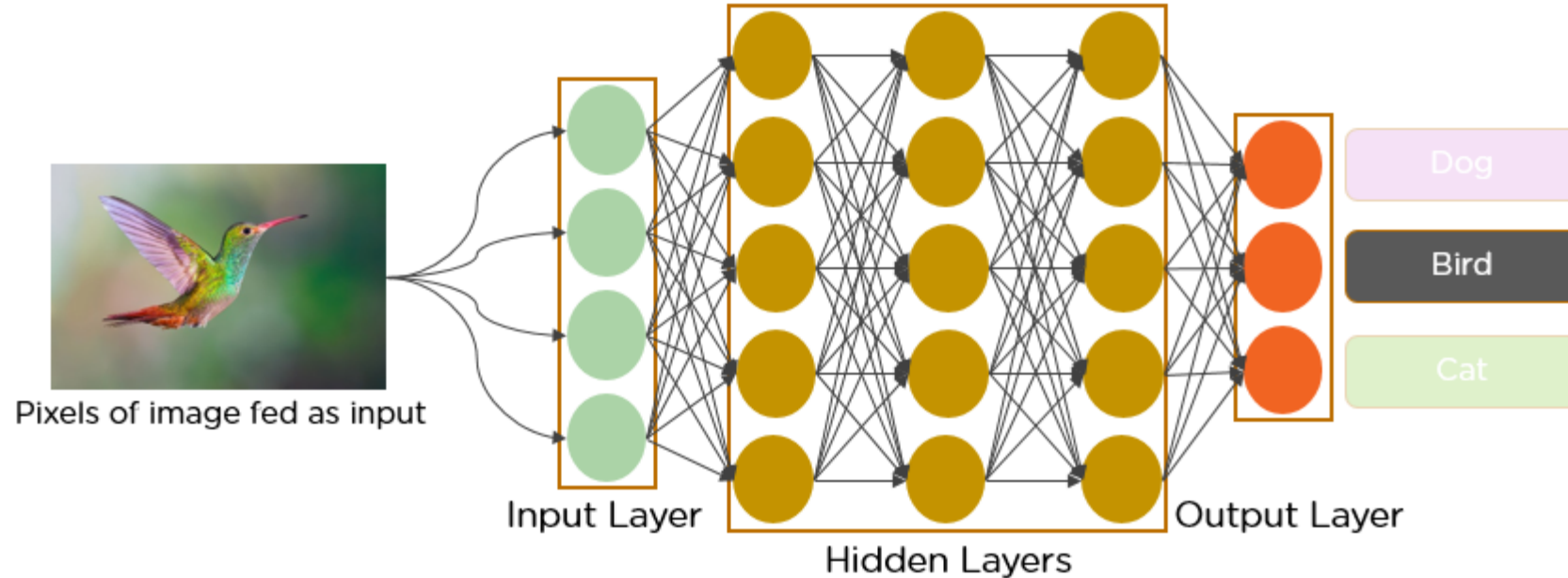
source dhl via @mikequindazzi

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8

DEEP LEARNING VS. MACHINE LEARNING

Artificial Intelligence

Machine Learning

Deep Learning

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Machine Learning

Input → Feature extraction → Classification → Output (Car / Not Car)

Deep Learning

Input → Feature extraction + Classification → Output (Car / Not Car)

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MACHINE LEARNING CLASSIFICATION NETWORK

Pixels of image fed as input

Input Layer

Hidden Layers

Output Layer

Dog

Bird

Cat

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

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

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Source: SRI International

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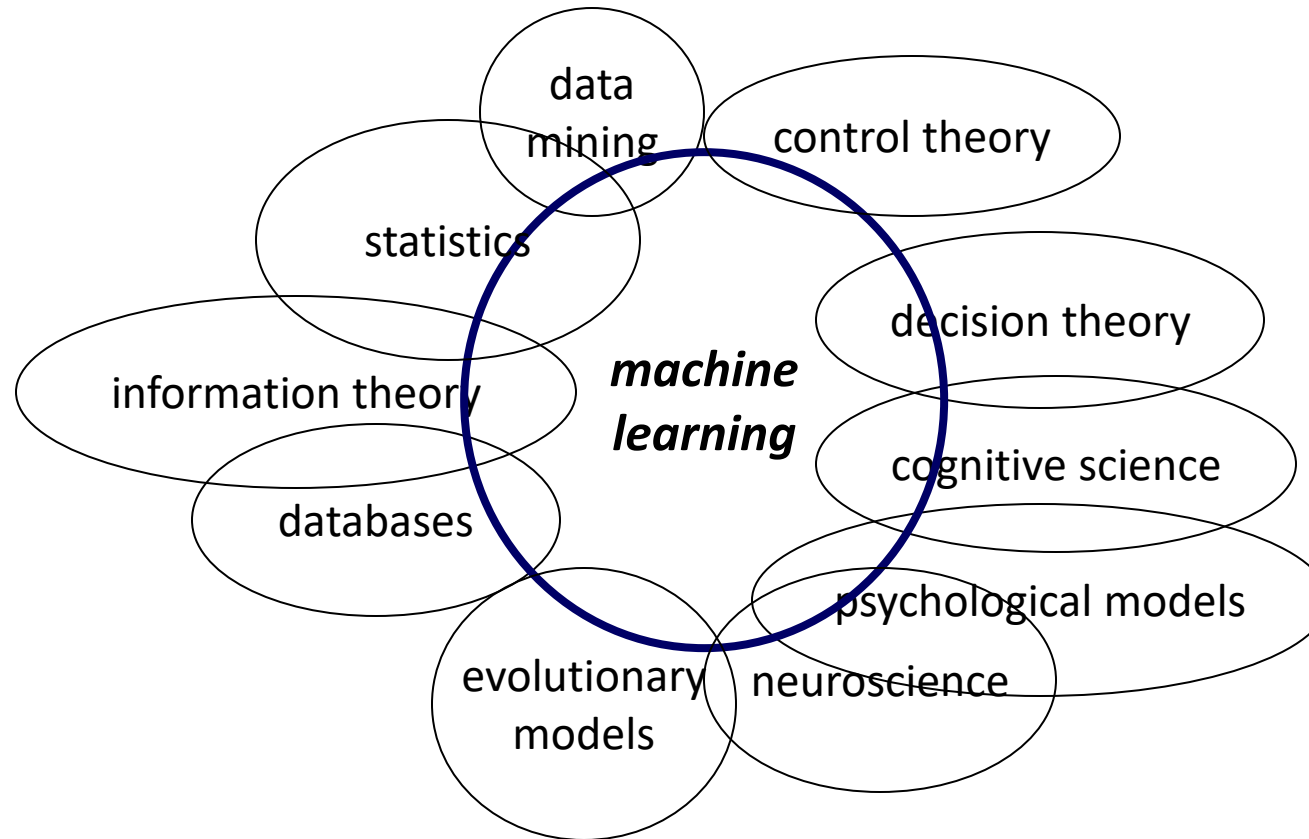
Machine learning is primarily concerned with the accuracy and effectiveness of the computer system.

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).
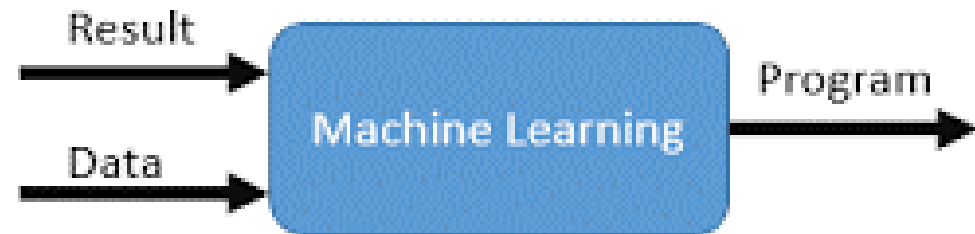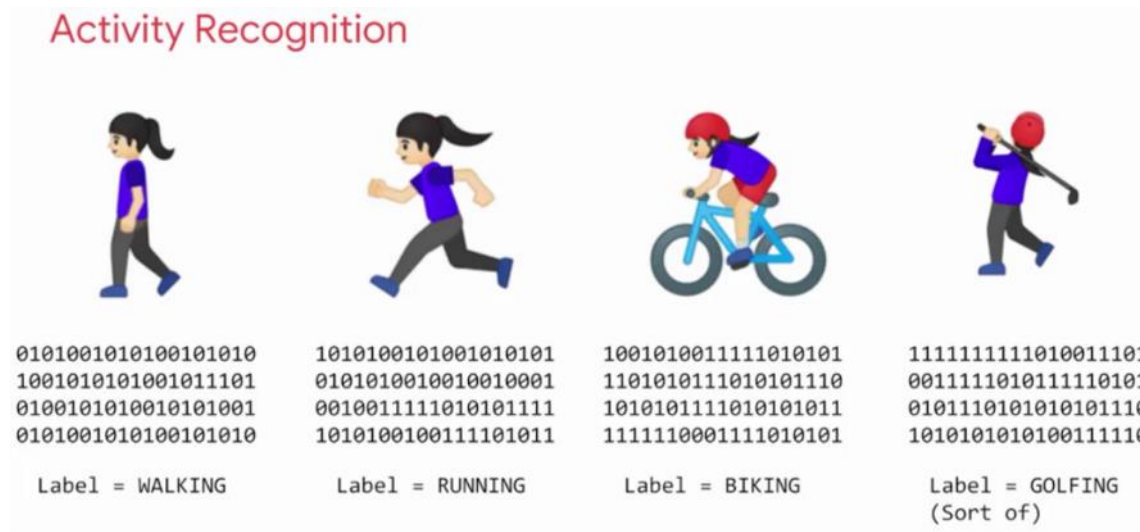

Machine Learning solves this problem by modeling this data with **train data** and **test data** and then *predict* the result.
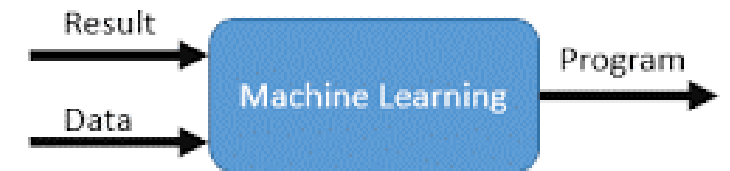
TEACHABLE MACHINES
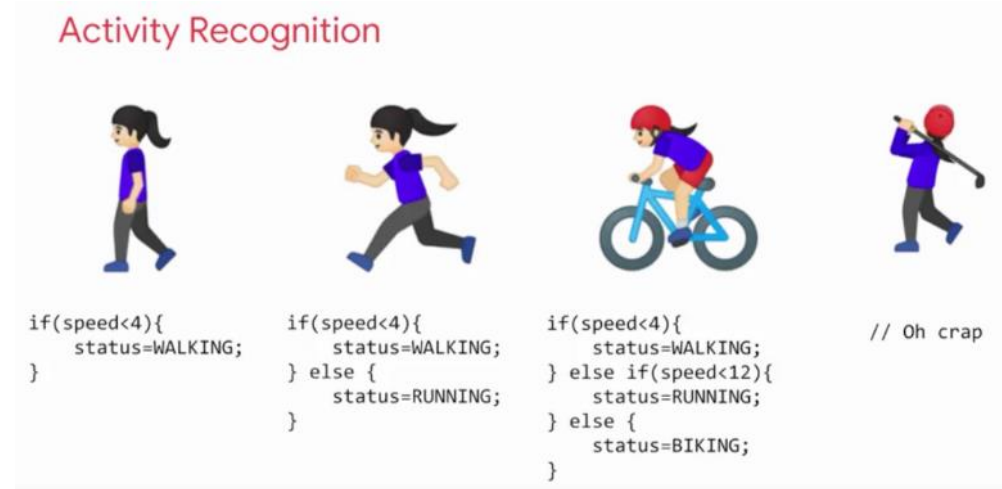
Conventional Programming

Machine Learning

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MACHINE LEARNING APPLICATIONS IN MANUFACTURING

- Predictive maintenance and improving 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

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[1,2,3]
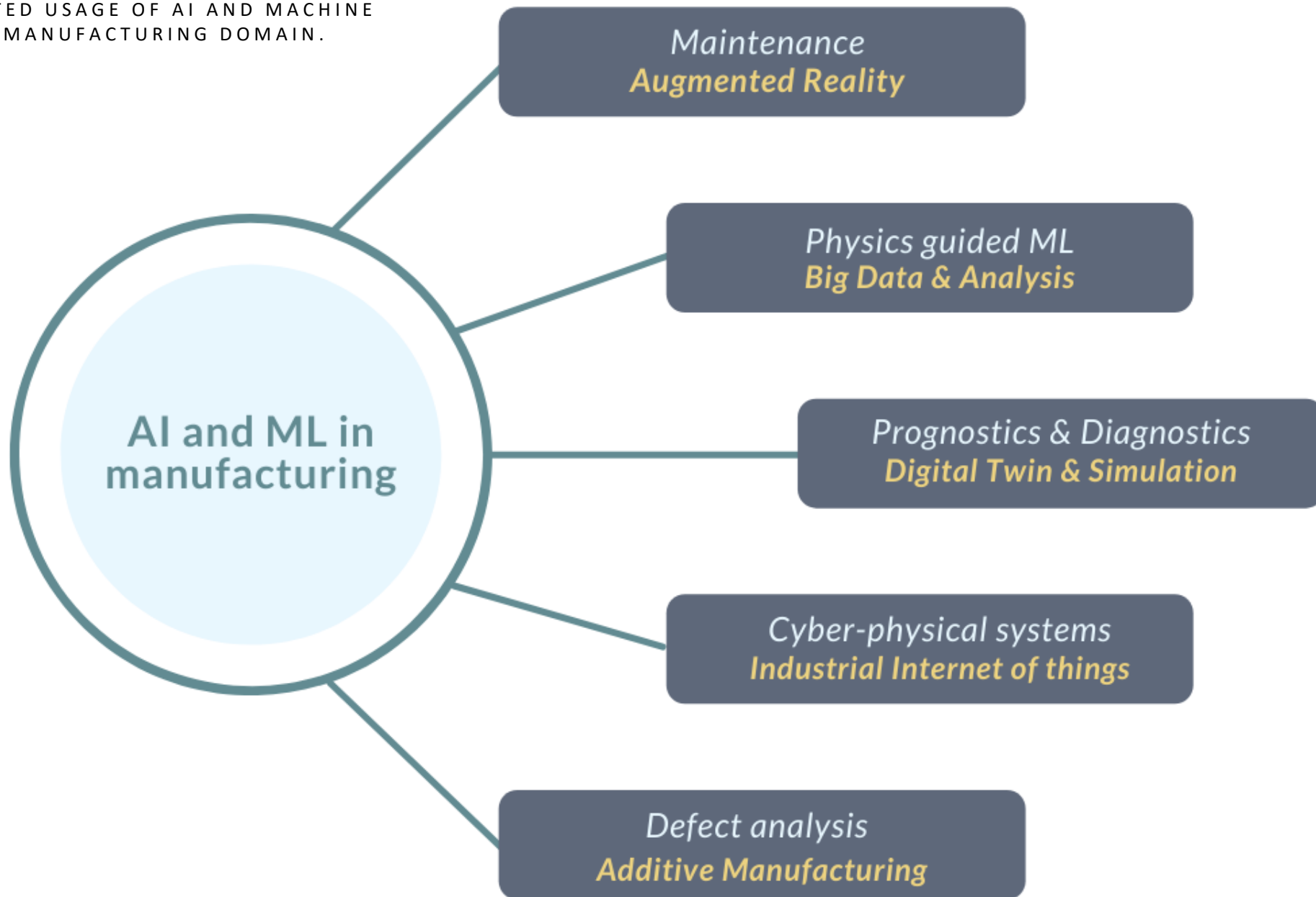
BENEFITS OF MACHINE LEARNING IN MANUFACTURING

- 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.

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[1]

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

Source: Bing Liu, UIC

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