Module 1 Introduction to Automation and Robotics in Industries

Agenda

Module overview

- About me
- About this course
- M1: Overview of Automation and Robotics in Manufacturing
- M1: History and evolution of Automation and Robotics in Manufacturing

Self Introduction

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Education History

2008 – 2012
BE, Mechanical Engineering,
Harbin Institute of Technology

2012-2016
Ph.D, Mechatronics,
Nanyang Technological University

Work Experience

2018 – now
Senior Scientist and Tech Lead, Ph.D Supervisor
Agency for Science, Technology and Research (A*STAR)

2017 – 2018
Medical AI Entrepreneur

2016-2017
Research Associate, ATMRI
Nanyang Technological University

Research Interest

- Unmanned System
- Adaptive Robotic Tool Path Generation
- 3D/2.5D Computer Vision
- Learning-based Robotic Versatile Grasping

Hobbies

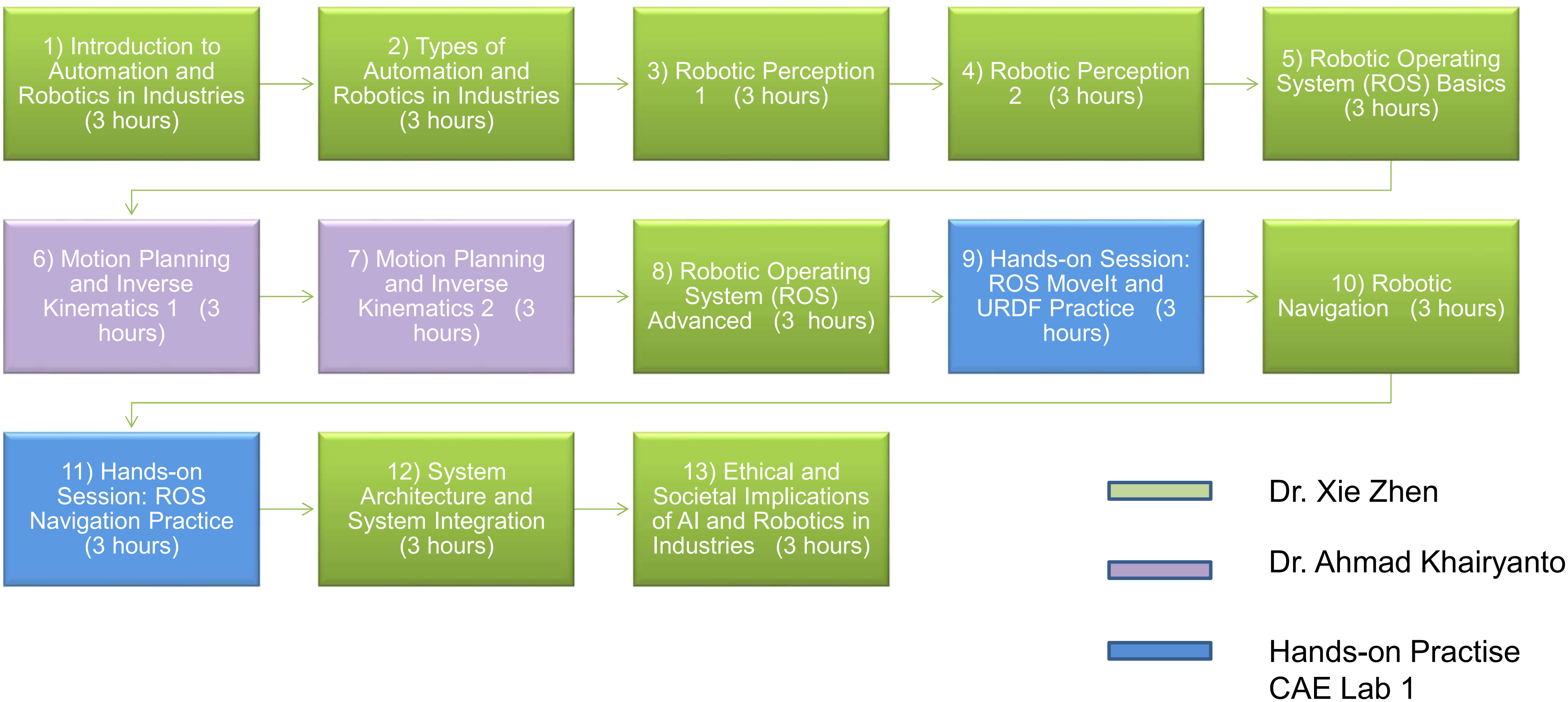
- All kinds of sports
- Travel, photography
- Jazz, vinyl, Frank Sinatra +Ella Fitzgerald, hip-hop, trap,
- Collection

What are you hoping to get out of this course? (1-2 key words)

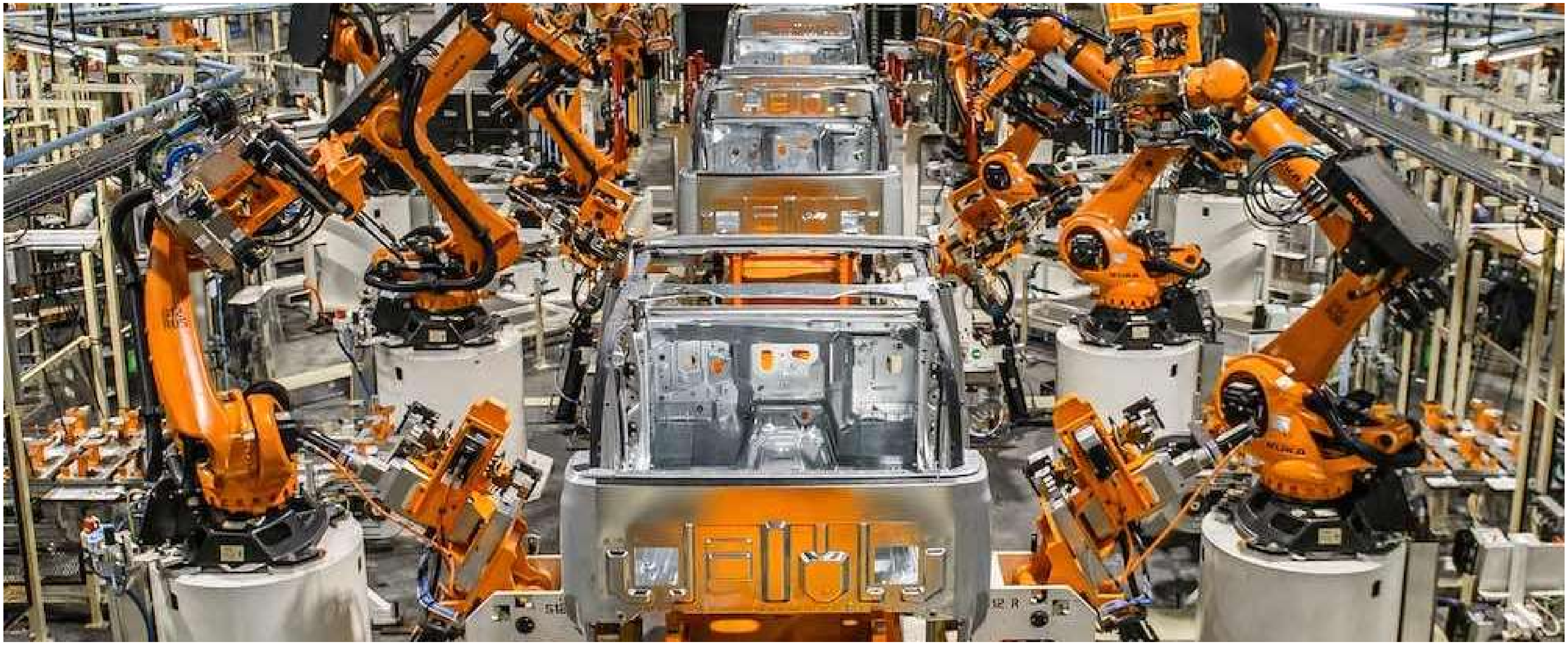
About this course

This course provides a comprehensive overview of the roles of automation and robotics across various industries, including manufacturing, healthcare, transportation, and the food industry. It explores applications in manufacturing, delving into the impact on productivity and efficiency while addressing challenges and opportunities associated with their implementation. The course also examines the ethical and societal implications of these technologies. Besides, this course aims to equip participants with the knowledge and tools to deploy intelligent perception approaches to real-world robotic applications. It mainly focuses on the domains of robotic perception, motion planning, navigation, and system integration, targeting their applications in collaborative Robotics and mobile platforms. The sessions are organized to offer a hands-on experience based on Robotic Operating System and VirtualBox. You will have the opportunity to try MoveIt visualization, Universal Robot Driver, Gazebo simulation, and Turtlebot3 navigation stack, and most importantly, to apply what you learn in this course to solve real-world scenarios.

Main Modules

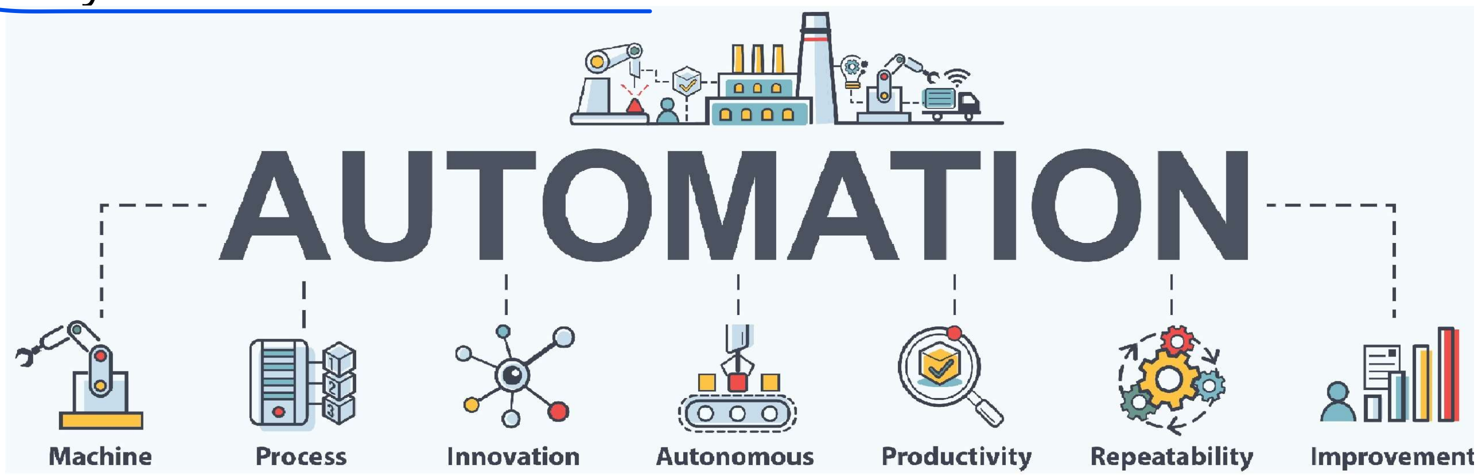


Part 1: Overview of Automation and Robotics in Manufacturing



Definition of Automation

- **Automation:** The use of largely automatic equipment in a system to operate and control processes.
- Automation refers to the application of technology to control and monitor the production and delivery of various goods and services with minimal human intervention. It involves the use of largely automatic equipment, such as machines, computers, and control systems, to carry out tasks and processes. The primary goal of automation is to improve efficiency, precision, and reliability in the execution of tasks.



Benefits and Adoption of Automation

Cost Reduction: Automation can lead to improved resource utilization, as machines can operate continuously without the need for breaks or shifts, though the initial investment in automation technology can be significant. It often results in long-term cost savings by lowering labor costs and increasing production output.

Efficiency Enhancement: Automation aims to streamline repetitive and time-consuming tasks, allowing systems to operate with higher efficiency and speed. By minimizing manual intervention, automation reduces the likelihood of errors, leading to increased accuracy and consistency in processes.

Quality Improvement: Automated systems can maintain a high level of precision and consistency, contributing to improved product quality. Continuous monitoring and control in automated processes help identify and rectify deviations from quality standards in real-time.

Safety Enhancement: Machines can handle tasks that may pose risks to human operators, enhancing overall workplace safety.

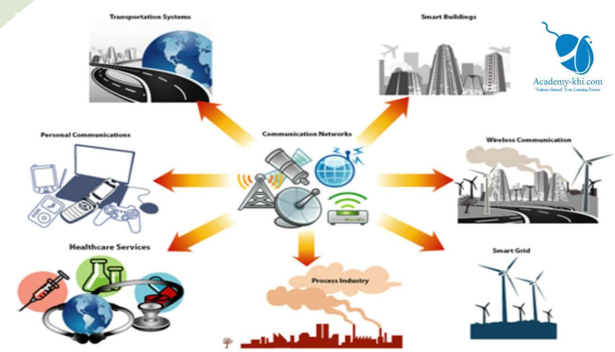
Key Components of Automation Systems

Sensors:
Collect data from the environment.

Actuators:
Execute physical actions based on sensor inputs.

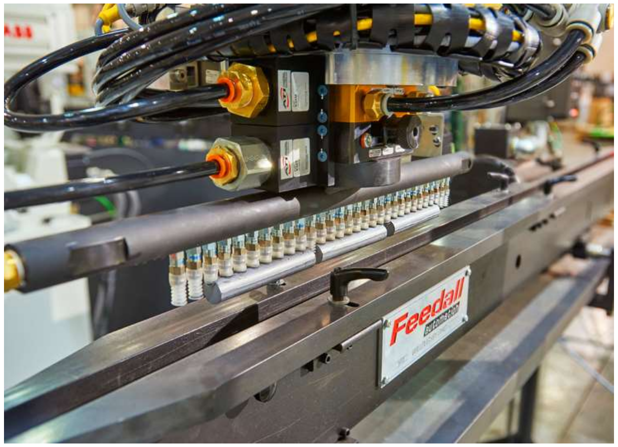
Controllers:
Brain of the automation system, processing information and making decisions.

Communication Systems:
Enable interaction and coordination among system components.



Types of Automation

- **Fixed Automation**: Specialized for a particular task.
- **Programmable Automation**: Can be reprogrammed for different tasks.
- **Flexible or Agile Automation**: Easily adaptable to changes in production.



Fixed Automation

Description:

Fixed automation refers to systems that are designed and optimized for a specific set of tasks or a particular production process. Once set up, these systems operate repetitively and efficiently but lack the flexibility to handle different tasks without significant reconfiguration.

Characteristics:

- Specialized: Tailored for a particular task or set of tasks.
- High Efficiency: Optimized for the specific operations they are designed for.
- Limited Flexibility: Difficult to adapt to changes in production requirements.

Programmable Automation

Description:

Programmable automation allows for the reprogramming of machines and systems to perform different tasks or adapt to changes in the production process. This flexibility is achieved through the use of control systems and software that can be modified to accommodate variations in tasks.

Characteristics:

- Reprogrammable: Capable of being reconfigured for different tasks.
- Versatility: Can handle a range of tasks within its programmed capabilities.
- Moderate Flexibility: Offers adaptability to changes but may require some reprogramming.

Flexible or Agile Automation

Description:
Flexible or agile automation systems are designed to be easily adaptable to changes in production requirements. These systems often integrate advanced technologies, such as sensors, artificial intelligence, and robotics, to respond quickly and efficiently to variations in product specifications or production volumes.

Characteristics:

- High Adaptability: Easily adjusts to changes in production needs.
- Advanced Technologies: Incorporates sensors, AI, and robotics for enhanced flexibility.
- Increased Complexity: Often more complex and sophisticated than fixed or programmable systems.

Challenges in Implementing Automation

High Initial Investment Automation systems often require substantial upfront costs for equipment, software, and training. The initial financial outlay can be a barrier for some organizations.

Workforce Resistance Employees may resist automation due to fear of job loss, concerns about skill obsolescence, or a general reluctance to embrace new technologies. Effective change management is crucial.

Integration Complexity Integrating automation into existing systems can be complex, requiring compatibility with current infrastructure and potential modifications to workflows.

Technical Challenges Technical issues, such as system failures, software bugs, and maintenance requirements, can disrupt operations and necessitate skilled technical support.

Security Concerns Automation introduces new cybersecurity risks, making systems vulnerable to hacking, data breaches, or other malicious activities. Robust security measures are essential.

Skill Gaps and Training Employees may lack the necessary skills to operate and maintain automated systems. Adequate training programs are vital to bridge skill gaps and ensure smooth transitions.

Limited Flexibility Highly specialized automation may lack flexibility to adapt to changes in production requirements, making it challenging to accommodate variations in demand.

Ethical Considerations Issues related to job displacement, ethical use of technology, and the societal impact of automation require careful consideration and ethical decision-making.

Regulatory Compliance Navigating and adhering to regulations governing the use of automation, especially in highly regulated industries, can pose a challenge.

ROI Uncertainty Predicting the return on investment (ROI) for automation initiatives can be challenging, making it difficult for organizations to assess the long-term benefits.

Modern Trends in Automation

Modern Trends in Automation	Description	Examples
Industry 4.0 Integration	Incorporation of digital technologies for smart manufacturing.	IoT in manufacturing, real-time data analytics.
Artificial Intelligence (AI)	Use of AI for decision-making, learning, and problem-solving.	Machine learning, predictive analytics.
Robotic Process Automation (RPA)	Automation of routine, rule-based tasks using software robots.	Automated data entry, invoice processing.
Collaborative Robots (Cobots)	Robots designed to work alongside humans in a shared workspace.	Collaborative assembly, human-robot collaboration.
Edge Computing in Automation	Processing data closer to the source to reduce latency and improve efficiency.	Edge analytics, real-time data processing.
Digital Twins	Virtual replicas of physical systems for simulation and analysis.	Digital twin simulations for product design.
Augmented Reality (AR)	Overlaying digital information onto the physical world for enhanced experiences.	AR-guided assembly, maintenance support.
Blockchain in Automation	Secure and transparent transactional systems for supply chains and processes.	Supply chain transparency, smart contracts.
Cloud-Based Automation	Automation systems and data storage hosted in the cloud for scalability.	Cloud-based control systems, remote monitoring.
Cybersecurity in Automation	Enhanced security measures to protect automated systems from cyber threats.	Secure communication protocols, encryption.

Definition of Robotics

- **Robotics:** The design, construction, operation, and use of robots to perform tasks without human intervention.
- Robotics involves the design, construction, operation, and application of robots to perform tasks **autonomously** or **semi-autonomously**. A robot is a programmable machine that can carry out a range of tasks by manipulating objects or tools, often without direct human control. Robotics encompasses a wide array of applications, from industrial automation to healthcare and exploration.

Benefits and Adoption of Robotics

Industrial Automation: Industrial robots are programmed to perform precise and repetitive actions, improving the overall quality of manufactured goods. In manufacturing, robots are used for tasks such as assembly, welding, and packaging, contributing to increased production speed and efficiency.

Healthcare and Medical Robotics: Rehabilitation robots aid in physical therapy, helping patients regain mobility and strength after injuries or surgeries. Surgical robots assist surgeons in performing complex procedures with enhanced precision, reducing invasiveness and recovery times.

Exploration: Underwater robots, known as remotely operated vehicles (ROVs), are employed for deep-sea exploration and research. Robotics plays a crucial role in space exploration, with robots being used for tasks such as planetary rovers and satellite maintenance.

Autonomous Vehicles: Robotics is integral to the development of autonomous vehicles, including self-driving cars and drones. These robots use sensors, cameras, and advanced algorithms to navigate and make decisions independently.

Key Difference between Automation and Robotics

Key Differentiator	Automation	Robotics
Scope	Broader term encompassing automatic systems and processes. Comprise machines, computers, and control systems	Robotics is a subset of automation. Specific focus on the design, construction, and operation of robots.
Human Involvement	Ranges from minimal human oversight to complete automation.	Involves physical machines (robots) designed to perform tasks autonomously or semi-autonomously (human-in-the-loop).
Physical Presence	Not necessarily involving physical machines; can include software systems.	Involves physical machines with sensors and actuators for interaction, ie. humanoid, industrial arms, drones
Applications	Widely applied across diverse fields, including manufacturing, transportation, and IT. May not involve physical movement or interaction with the environment	Applied specifically to tasks performed by physical machines (robots). Involve physical movement, interaction with the environment, and manipulation of objects.
Examples	Climate control systems, automated manufacturing processes, billing system	Industrial robots, surgical robots, exploration rovers.
Robots	Not necessarily; automation may not involve physical robots.	Can involve the development of robots mimicking human operations.

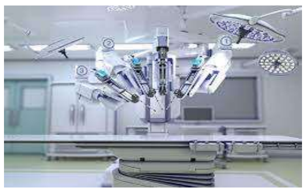
Types of Robots

Type of Robot	Description	Characteristics
Industrial Robots	Designed for manufacturing and industrial tasks like assembly, welding, painting, and material handling.	Typically have articulated arms for precise movement, can be stationary or mobile, and are often programmed for repetitive tasks.
Service Robots	Intended to assist and serve humans in various settings, such as homes, healthcare, and customer service.	Examples include cleaning robots, healthcare robots, and social robots designed for companionship or assistance.
Medical Robots	Used in healthcare settings for tasks such as surgery, diagnostics, and rehabilitation.	Surgical robots offer precision and minimally invasive procedures, while rehabilitation robots aid in physical therapy.
Autonomous Vehicles	Self-driving vehicles that can operate without human intervention.	Include autonomous cars, drones, and unmanned aerial vehicles (UAVs) for tasks such as transportation, surveillance, and delivery.
Military Robots	Deployed for defense and security purposes, including reconnaissance, bomb disposal, and surveillance.	Range from unmanned ground vehicles (UGVs) to aerial drones and may be remotely operated or fully autonomous.

Types of Robots

Type of Robot	Description	Characteristics
Humanoid Robots	Designed to resemble and mimic human movements, used for research, entertainment, and social interaction.	Can walk, talk, and perform tasks similar to humans; examples include ASIMO and Atlas.
Educational Robots	Used in educational settings to teach programming, engineering, and problem-solving skills.	Programmable and often equipped with sensors for interaction with the environment.
Entertainment Robots	Created for entertainment purposes, including theme parks, exhibitions, and performances.	Range from animatronics to interactive robots designed to engage and entertain audiences.
Agricultural Robots	Designed for tasks in agriculture, such as planting, harvesting, and monitoring crops.	May include drones for aerial surveillance and robotic arms for specific tasks like fruit picking.
Underwater Robots (ROVs)	Used for exploration, research, and tasks in underwater environments.	Remote Operated Vehicles (ROVs) are often equipped with cameras and sensors for deep-sea exploration and maintenance.
Space Robots	Deployed for exploration and tasks in outer space, including planetary rovers and robotic arms on space stations.	Designed to withstand harsh conditions in space and operate in low-gravity environments.

Types of Robots



Industrial Robots

Service Robots

Medical Robots

Autonomous Vehicles

Military Robots

Humanoid Robots

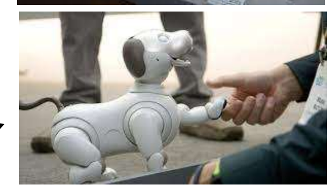
Educational Robots

Entertainment Robots

Agricultural Robots

Underwater Robots (ROVs)

Space Robots



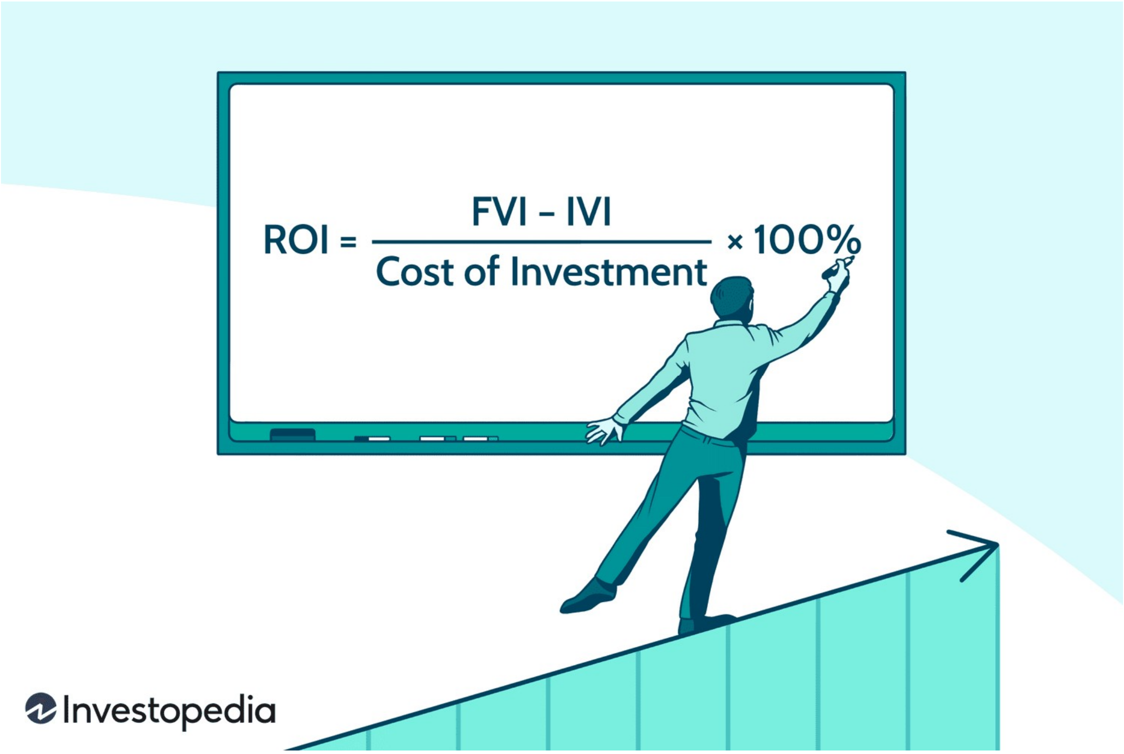
Industrial Robot Applications

Application	Description
Assembly and Manufacturing	Performing repetitive assembly tasks, such as welding, soldering, and joining components in production lines.
Welding	Precise and efficient welding of metal components in industries like automotive, construction, and shipbuilding.
Painting and Coating	Applying paint or protective coatings to products with consistency and precision, improving quality and efficiency.
Material Handling	Moving and transporting materials within a facility, including loading and unloading goods in warehouses.
Palletizing and Packaging	Arranging and stacking products on pallets for storage or transportation, and packaging finished goods.
Machine Tending	Operating and maintaining machines, such as CNC machines, to ensure continuous and efficient production.
Pick and Place	Sorting and placing items in specified locations, commonly used in logistics, warehousing, and assembly.
Quality Inspection	Conducting visual inspections and quality checks to identify defects or inconsistencies in products.
Testing and Measurement	Performing testing and measurement tasks to ensure products meet specified standards and quality requirements.
Material Removal	Removing excess material through processes like cutting, milling, or grinding in precision manufacturing.

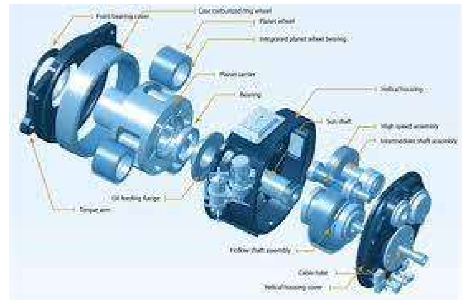
Industrial Robot Applications

Application	Description
Packaging and Palletizing	Packaging finished products and palletizing them for shipment, contributing to the automation of logistics.
Gluing and Sealing	Applying adhesives or sealants with precision, commonly used in the automotive and electronics industries.
Deburring and Polishing	Removing sharp edges (deburring) or polishing surfaces to enhance the final appearance and quality of products.
Inspection and Testing	Inspecting products for defects and conducting various tests to ensure compliance with quality standards.
Injection Molding	Assisting in the injection molding process by handling and manipulating molds and parts for mass production.
Winding and Coiling	Performing winding or coiling operations in the production of electrical components and devices.
Foundry Operations	Handling molten metal and performing tasks in foundry operations, such as casting and molding processes.
Material Inspection and Sorting	Inspecting raw materials and sorting them based on quality criteria before the manufacturing process begins.
3D Printing	Assisting in additive manufacturing processes, including tasks such as material loading and part removal.

Return of Investment (ROI)



Case Studies



Scenarios:

As the Senior Process Engineer at PrecisionGear Pte. Ltd., a local SME specializing in gear assembly, you think that the current manual assembly process may benefit significantly from a transition to automation using robotic arms. Implementing robotic arms would not only streamline production processes but also reduce labor costs and increase overall productivity. This strategic move aligns with industry trends and positions the company for long-term competitiveness, emphasizing the potential for a substantial return on investment (ROI) through improved speed, accuracy, and cost-effectiveness in gear assembly. Justify this shift to the manager and prove that automating the assembly line is expected to enhance efficiency and yield a higher ROI.

Case Studies

Assumption: Let's consider a factory that is considering the adoption of robotic automation for its assembly line, which is currently operated manually.

Investment Costs:

1. **Robot Cost:** $200,000 (cost of the robotic system, including hardware and software).
2. **Installation and Integration:** $50,000 (cost of installation, training, and integration into the existing production line).
3. **Annual Operating and Maintenance Costs:** $20,000.

Financial Benefits:

1. **Labor Cost Savings:** The introduction of robots is expected to reduce the need for manual labor, resulting in annual labor cost savings of $100,000.
2. **Increased Production Output:** Automation is anticipated to increase production output, leading to additional annual revenue of $50,000.

Case Studies

1. **Total Initial Investment:**

   Robot Cost + Installation and Integration = $200,000 + $50,000 = $250,000.

2. **Annual Savings and Benefits:**

   Labor Cost Savings + Increased Production Revenue - Annual Operating and Maintenance Costs = $100,000 + $50,000 - $20,000 = $130,000.

3. **ROI Formula:**

   ROI = (Annual Savings and Benefits / Total Initial Investment) * 100.

   ROI = ($130,000 / $250,000) * 100 = 52%.

- An ROI of 52% means that for every dollar invested in the robotic automation, the company can expect to generate a return of $0.52 within the first year.

Case Studies

- It's essential to consider the payback period, which is the time it takes for the initial investment to be recouped.
- **Payback period** = $250,000 / $130,000 = 1.92 years.

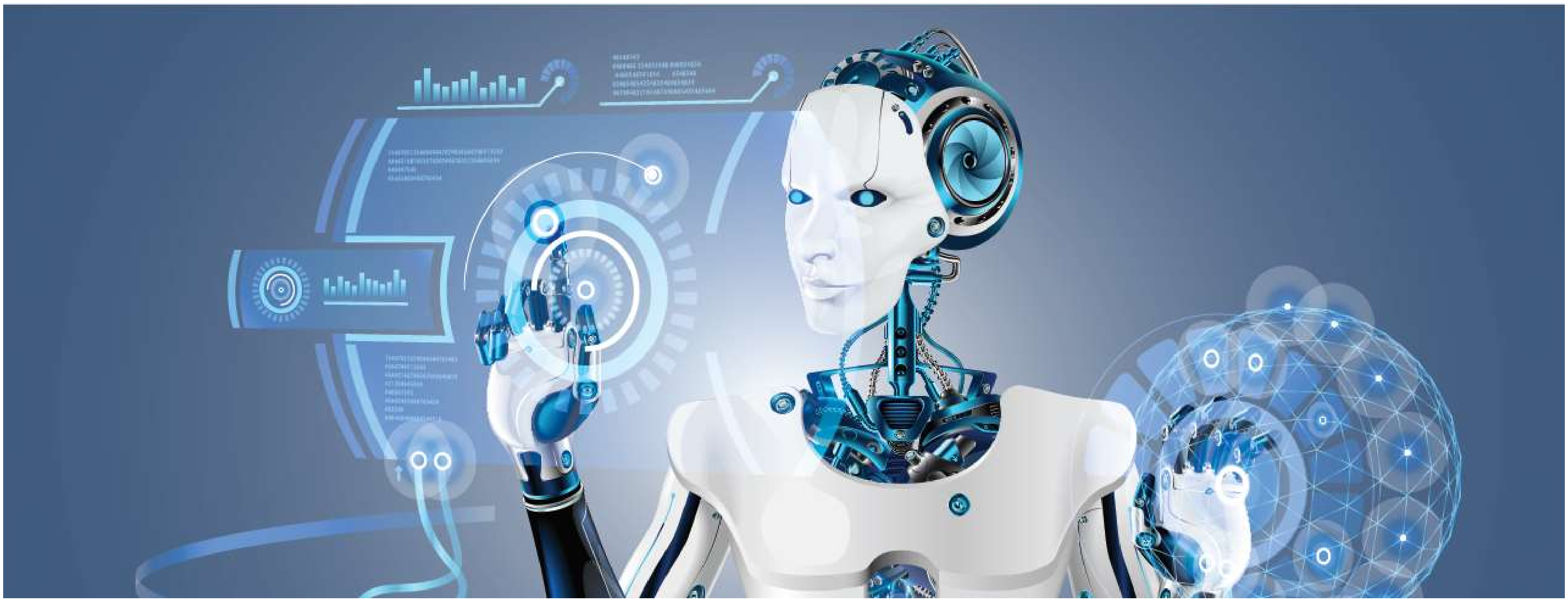
- Not to mention, long-term benefits beyond the first year, such as reduced error rates, improved product quality, and scalability, should also be factored into the decision-making process.

- Presenting such a calculation to management provides a clear financial perspective on the benefits of adopting robotic automation, helping justify the investment by demonstrating its potential for cost savings and increased productivity.

Case Studies

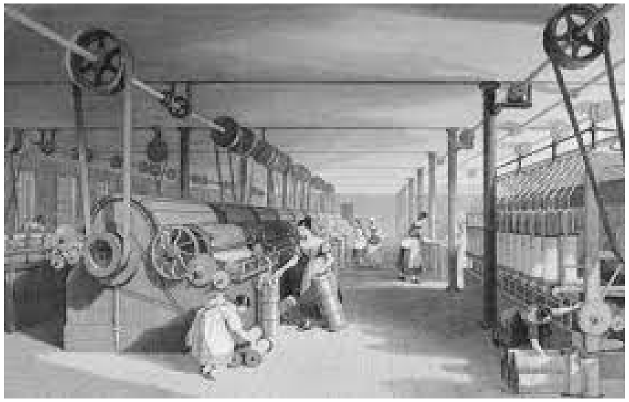
- **Example 1:** Implementation of robotic assembly lines at
- **Example 2:** Automation in the automotive industry.

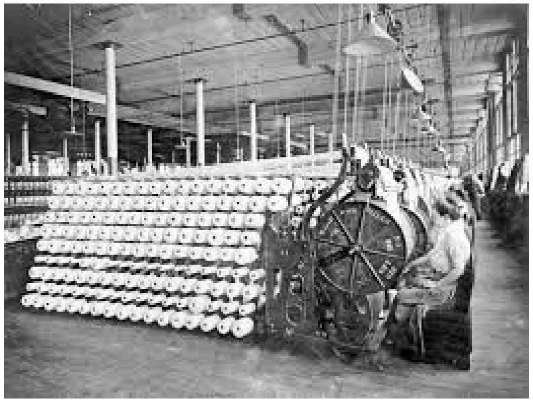
Part 2: History and Evolution of Automation and Robotics in Manufacturing



The First Industrial Revolution (1760-1820)

First Industrial Revolution, first popularized by the English economic historian **Arnold Toynbee** (1852–83), was a period of global transition of human economy towards more widespread, efficient and stable manufacturing processes that succeeded the Agricultural Revolution, starting from Great Britain, continental Europe, and the United States.





Key Features

- **Mechanization:** The transition from agrarian and handcraft-based economies to machine-based manufacturing.
- **Textile Industry:** Innovations such as the spinning jenny and the power loom revolutionized textile production.
- **Steam Power:** The widespread use of steam engines, particularly in factories and transportation (railways and steamships).

Major Impact: Urbanization, the rise of factories, and a shift from agrarian economies to industrial ones.

The Second Industrial Revolution (1871-1914)

The **Second Industrial Revolution**, also known as the Technological Revolution, first introduced by **Patrick Geddes**, **Cities in Evolution (1910)**, also known as the Technological Revolution, was a phase of rapid scientific discovery, standardisation, mass production and industrialisation from the late 19th century into the early 20th century. Advancements in manufacturing and production technology enabled the widespread adoption of technological systems such as telegraph and railroad networks, gas and water supply, and sewage systems, which had earlier been limited to a few select cities.

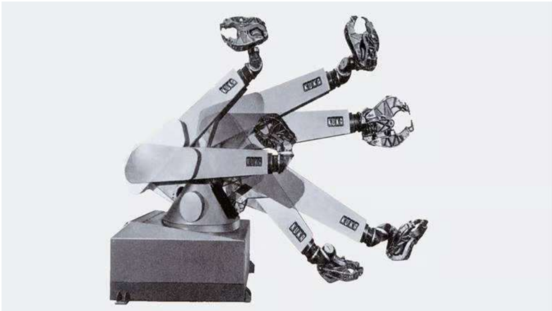
Key Features

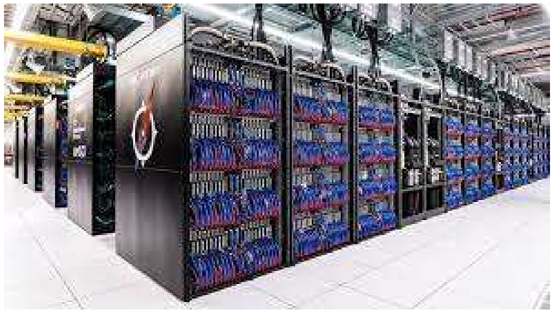
- **Electrification:** The widespread adoption of electricity for manufacturing and homes.
- **Steel and Chemicals:** Advancements in the production of steel and chemicals.
- **Internal Combustion Engine:** The development and use of the internal combustion engine, transforming transportation.
- **Mass Production:** Introduction of assembly lines and mass production techniques.

Major Impact: Rapid industrialization, increased productivity, and the emergence of the modern corporation.

The Third Industrial Revolution (1970s –2000s)

Third Industrial Revolution, also called, **Digital Revolution**, is the shift from mechanical and analogue electronic technologies from the Industrial Revolution towards digital electronics (binary floating-point numbers and Boolean logic) which began in the latter half of the 20th century, with the adoption and proliferation of digital computers and digital record-keeping, that continues to the present day.





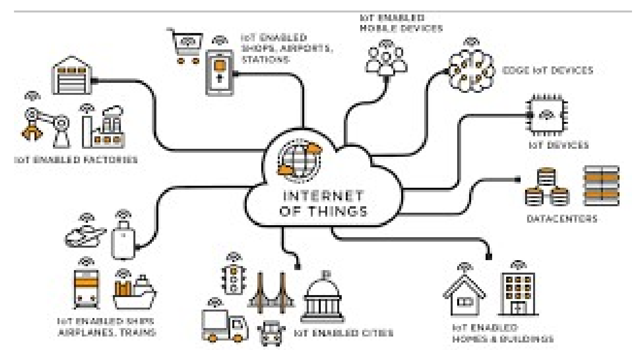
Key Features

- **Computers and Automation:** The rise of computers and automation in manufacturing processes.
- **Digital Technology:** Development of semiconductors, transistors, and the birth of the information age.
- **Globalization:** Increased international trade and interconnectedness.
- **Nuclear power**

Major Impact: Significant advancements in technology, the rise of the service sector, and globalization of markets.

The Fourth Industrial Revolution (ongoing from the late 20th century)

Fourth Industrial Revolution, a.k.a “4IR”, or “Industry 4.0“, The term was popularised in 2016 by **Klaus Schwab**, the World Economic Forum founder. A part of this phase of industrial change is the joining of technologies like **artificial intelligence**, **gene editing**, to **advanced robotics** that blur the lines between the physical, digital, and biological worlds. It is driven by modern smart technology, large-scale machine-to-machine communication (M2M), and the Internet of things (IoT). It can be summarized into 4 categories, which are **cyber-physical systems** (CPS), （**IoTs**）, **cloud computing**, **cognitive computing / artificial intelligenceindustrial internet of things.**

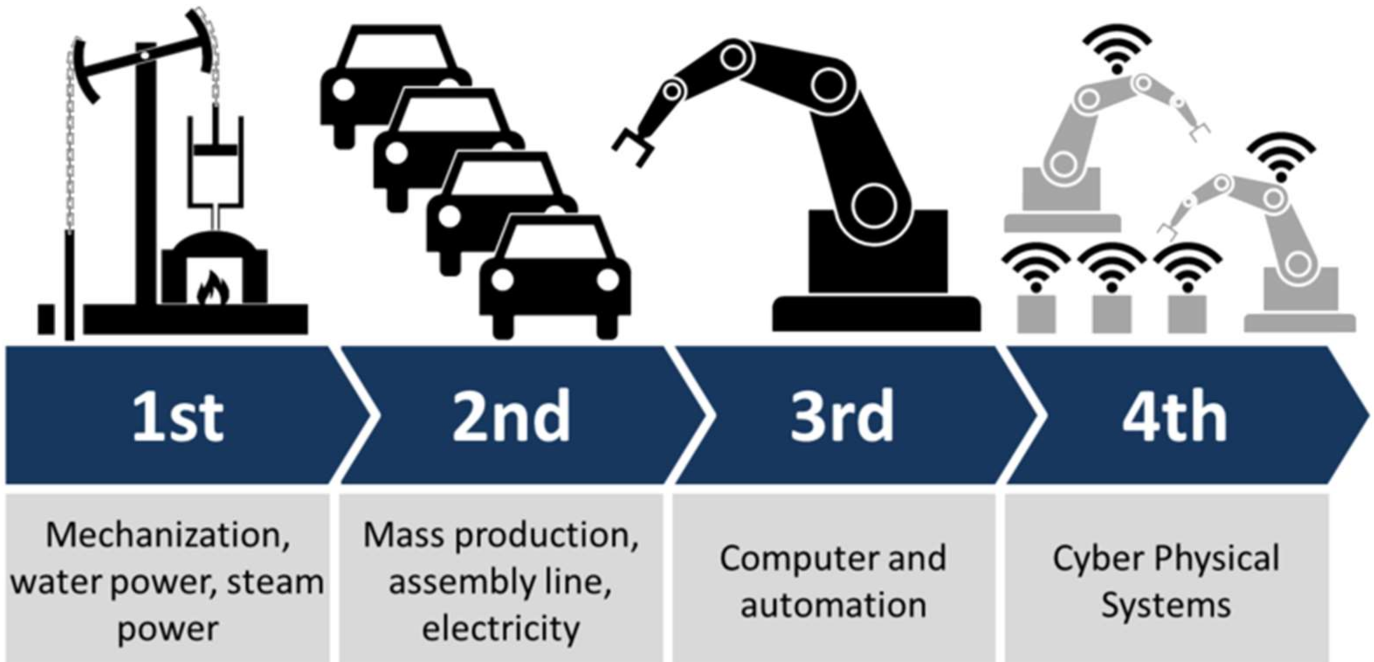


Key Features

- **Digitalization:** Integration of digital technologies, including the internet, cloud computing, and big data.
- **Artificial Intelligence (AI) and Robotics:** The emergence of AI, machine learning, and advanced robotics.
- **Internet of Things (IoT):** Interconnectivity of devices, enabling data exchange and automation.
- **AR/VR**: immersive technologies that enhance or create artificial sensory experiences, blending digital content with the real world (AR) or creating entirely virtual environments (VR).
- **Biotechnology:** Advances in fields such as genetics, bioengineering, and medical technology.
- **Renwable Energy:** Solar, Hydrogen, Wind

Major Impact : Transformation of industries, increased automation, enhanced connectivity, and the fusion of physical, digital, and biological technologies.

Summary


1st
Mechanization, water power, steam power
2nd
Mass production, assembly line, electricity
3rd
Computer and automation
4th
Cyber Physical Systems

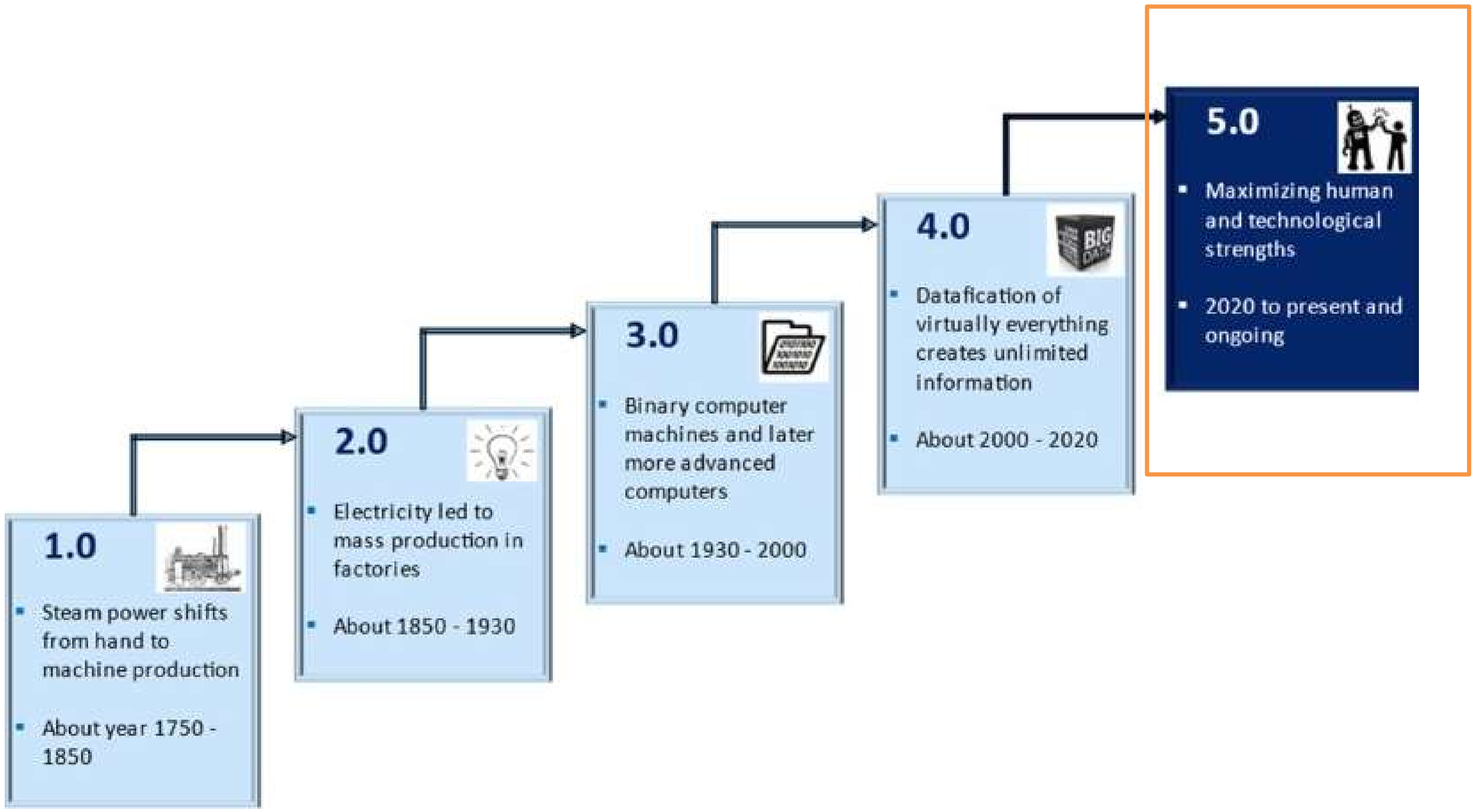
Summary

Industrial Revolution	Time Period	Key Features	Impact
First Industrial Revolution	1760-1840	Mechanization, steam power, textile innovations.	Urbanization, shift from agrarian to industrial.
Second Industrial Revolution	1870-1914	Electrification, steel and chemicals, mass production.	Rapid industrialization, modern corporation.
Third Industrial Revolution	1950s-1970s	Computers, digital technology, globalization.	Technology advancements, rise of the service sector.
Fourth Industrial Revolution	Ongoing (late 20th cent.)	Digitalization, AI, robotics, IoT, biotechnology.	Industry transformation, automation, connectivity.

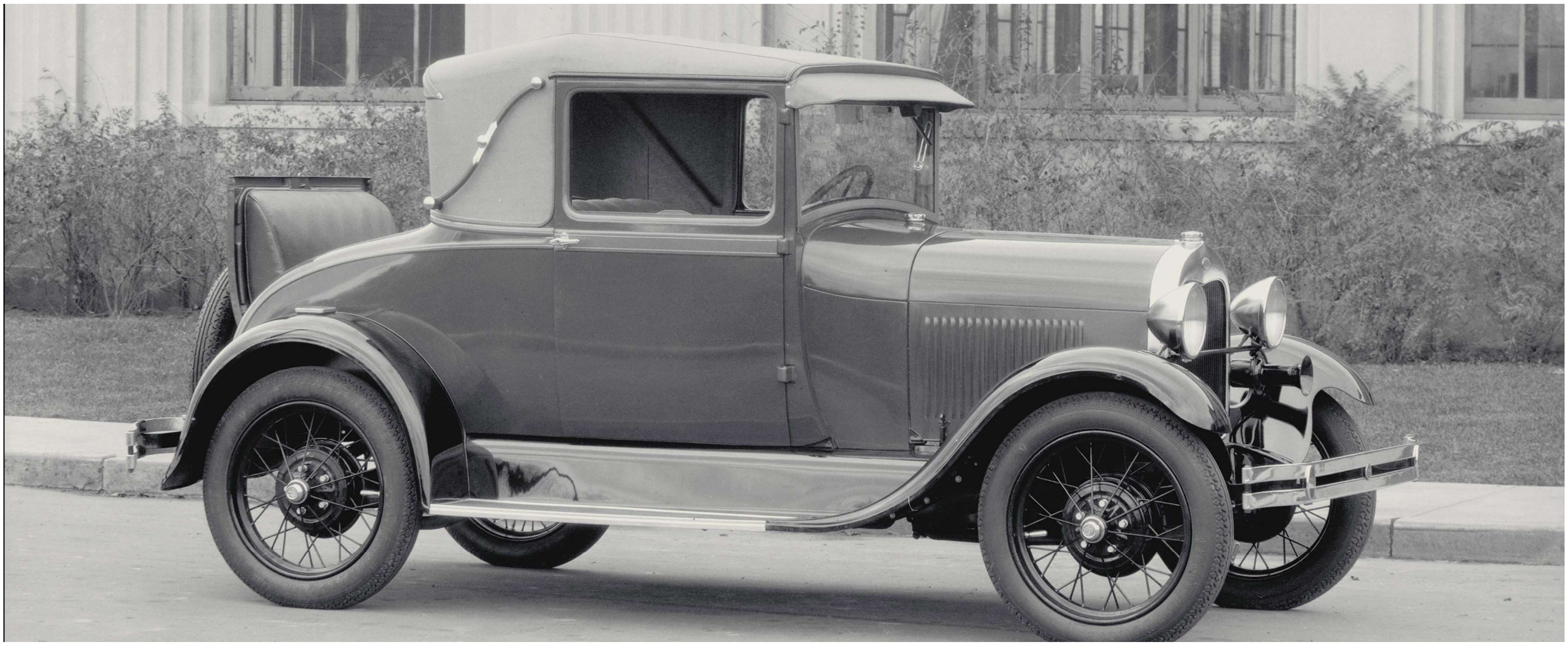
The Fifth Industrial Revolution *

The Fifth Industrial Revolution incorporates concepts such as “sustainability,” “human-centeredness,” and “concern for the environment” in addition to transformation of the industrial structure through the utilization of AI, IoT, big data, etc. It encompasses the notion of harmonious human–machine collaborations, with a specific focus on the well-being of the multiple stakeholders (i.e., society, companies, environment, employees, customers).

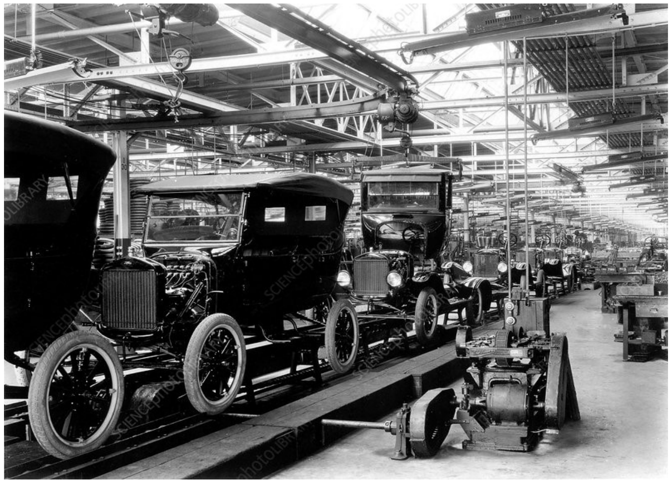
This desire for mass personalization forms the psychological and cultural driver behind Industry 5.0 – which involves using technology to return human value add to manufacturing. With collaborative robots people and machines can work alongside, the robots taking care of all the dull, hard, repetitive work; humans focusing on creativity and quality control. ---- Esben H. Østergaard Founder of UR


1.0
Steam power shifts from hand to machine production
About year 1750 - 1850
2.0
Electricity led to mass production in factories
About 1850 - 1930
3.0
Binary computer machines and later more advanced computers
About 1930 - 2000
4.0
BIG DATA
Datafication of virtually everything creates unlimited information
About 2000 - 2020
5.0
Maximizing human and technological strengths
2020 to present and ongoing

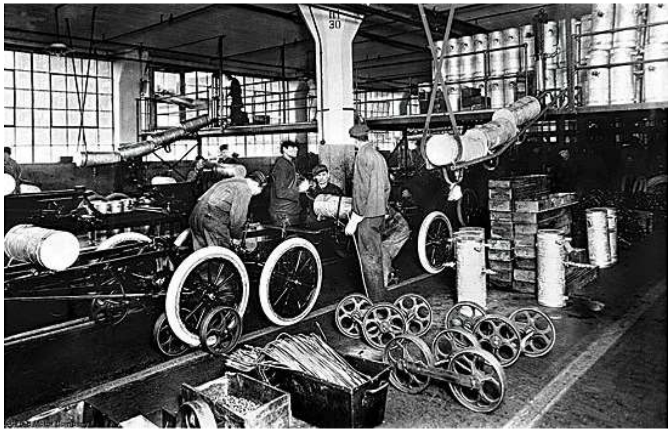
Case Study 1: Early Forms of Automation - Ford Assembly Line



Early Forms of Automation – Ford Assembly Line

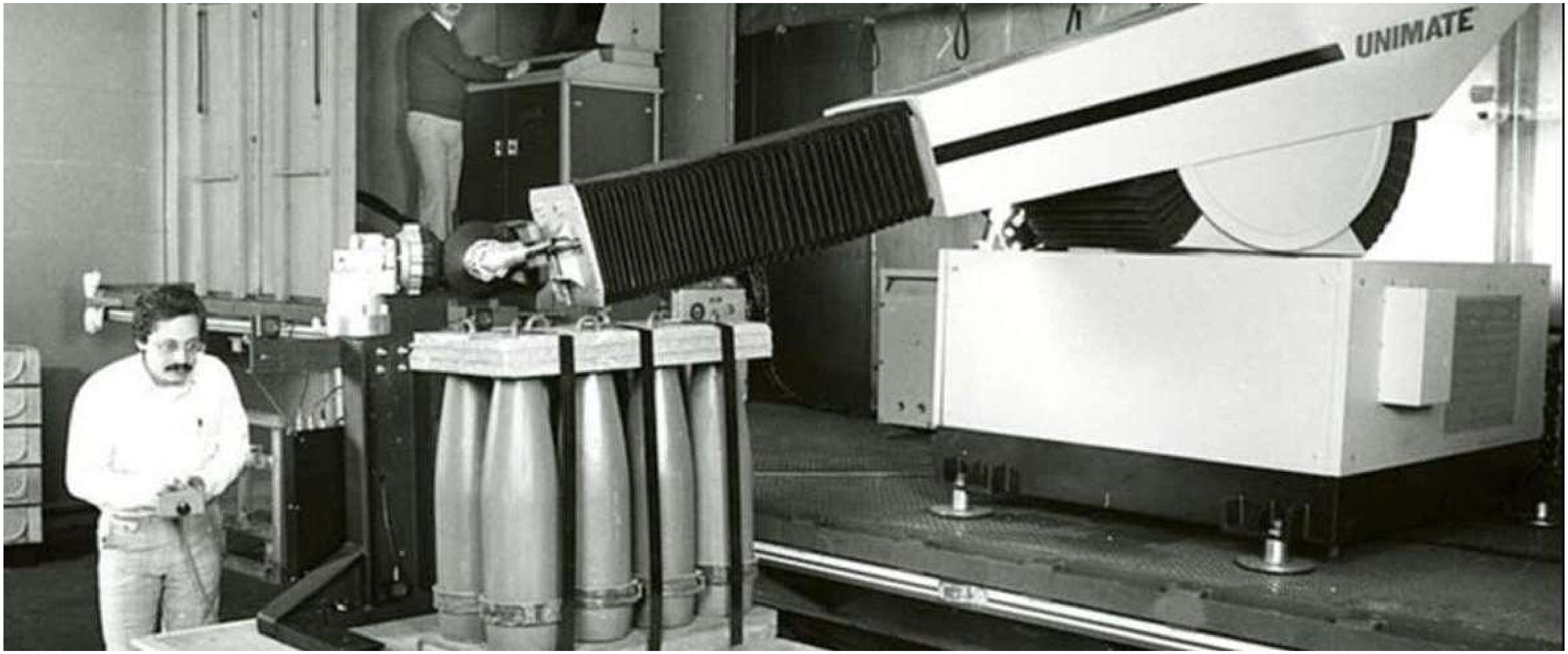


Ford's assembly line, implemented by Henry Ford in the early 20th century, revolutionized manufacturing by introducing a groundbreaking approach to mass production. This innovative system involved the division of automobile assembly into discrete, specialized tasks, with each worker responsible for a specific component or operation. This not only significantly increased the speed of production but also reduced costs, making automobiles more affordable for the general public. Ford's assembly line played a pivotal role in the success of the Model T, the iconic car that became widely accessible to a broad range of consumers. Beyond its economic impact, the assembly line had profound effects on the workforce, as it created a template for modern industrial production, influencing industries far beyond automotive manufacturing and shaping the course of 20th-century industrialization.




FORD
TOURING CAR

Case Study 2: Early Forms of Automation: Early Form of Robotics in Manufacturing -- Unimate



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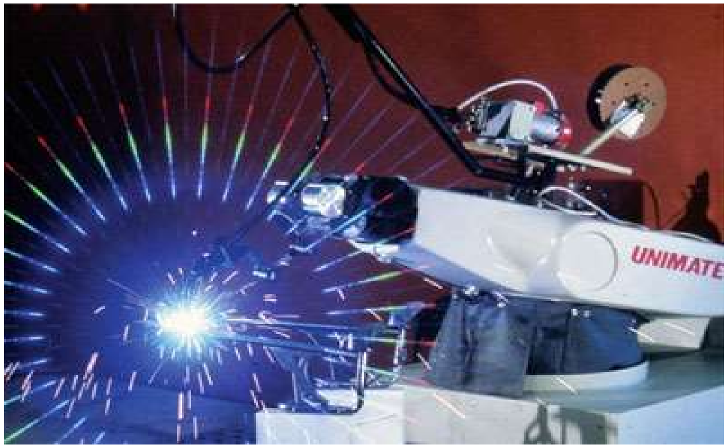
Early Forms of Automation : Robotics in Manufacturing

- **Early Industrial Robots:**
- **Unimate**, patented in 1961 by American inventor **George Devol**, the Unimate was developed as a result of the foresight and business acumen of **Joseph Engelberger** - the **Father of Robotics**.
- In 1959 the 2,700-pound Unimate #001 prototype was installed on an assembly line for the first time at a General Motors diecasting plant in Trenton, New Jersey.
- That same year, Engelberger introduced the Unimate 1900 to the public at a trade show at Chicago's Cow Palace.

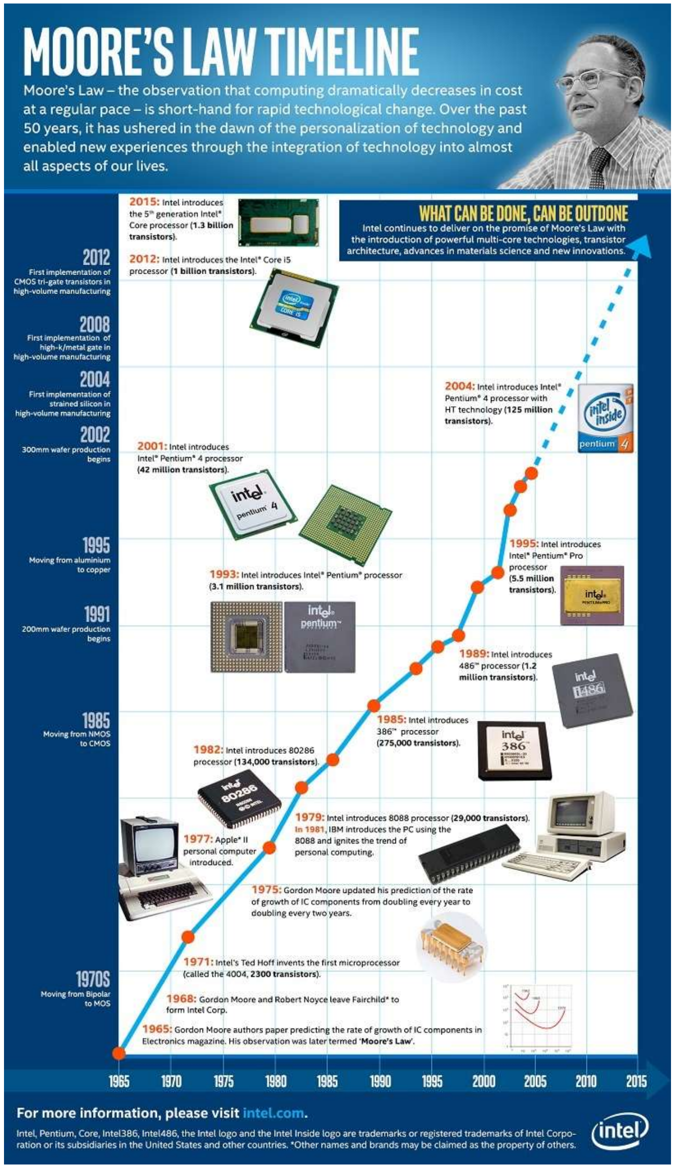



AP
UNIMATE

Modern Car Production Line


THE WINDOW
TESLA MODEL S

Moore’s Law



MOORE’S LAW TIMELINE
Moore’s Law – the observation that computing dramatically decreases in cost at a regular pace – is short-hand for rapid technological change. Over the past 50 years, it has ushered in the dawn of the personalization of technology and enabled new experiences through the integration of technology into almost all aspects of our lives.
WHAT CAN BE DONE, CAN BE OUTDONE
Intel continues to deliver on the promise of Moore’s Law with the introduction of powerful multi-core technologies, transistor architecture, advances in materials science and new innovations.
2012
First implementation of CMOS tri-gate transistors in high-volume manufacturing
2008
First implementation of high-k/metal gate in high-volume manufacturing
2004
First implementation of strained silicon in high-volume manufacturing
2002
300mm wafer production begins
1995
Moving from aluminium to copper
1991
200mm wafer production begins
1985
Moving from NMOS to CMOS
1970S
Moving from Bipolar to MOS
2015: Intel introduces the 5th generation Intel® Core processor (1.3 billion transistors).
2012: Intel introduces the Intel® Core i5 processor (1 billion transistors).
2004: Intel introduces Intel® Pentium® 4 processor with HT technology (125 million transistors).
2001: Intel introduces Intel® Pentium® 4 processor (42 million transistors).
1995: Intel introduces Intel® Pentium® Pro processor (5.5 million transistors).
1993: Intel introduces Intel® Pentium® processor (3.1 million transistors).
1989: Intel introduces 486™ processor (1.2 million transistors).
1985: Intel introduces 386™ processor (275,000 transistors).
1982: Intel introduces 80286 processor (134,000 transistors).
1979: Intel introduces 8088 processor (29,000 transistors).
In 1981, IBM introduces the PC using the 8088 and ignites the trend of personal computing.
1977: Apple® II personal computer introduced.
1975: Gordon Moore updated his prediction of the rate of growth of IC components from doubling every year to doubling every two years.
1971: Intel’s Ted Hoff invents the first microprocessor (called the 4004, 2300 transistors).
1968: Gordon Moore and Robert Noyce leave Fairchild® to form Intel Corp.
1965: Gordon Moore authors paper predicting the rate of growth of IC components in Electronics magazine. His observation was later termed ‘Moore’s Law’.
1965
1970
1975
1980
1985
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2005
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2015
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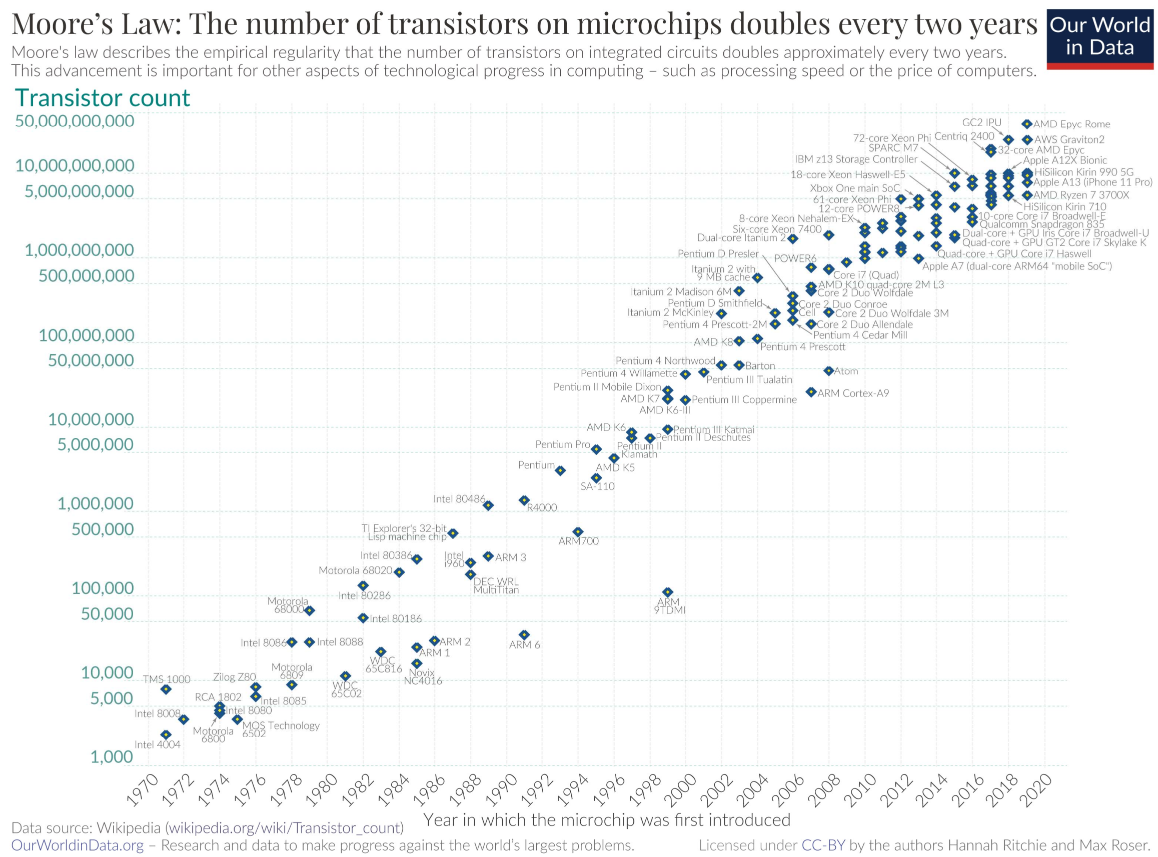
Moore’s Law

- **Gordon Moore**, the co-founder of Fairchild Semiconductor and former CEO of Intel.
- **Moore's law** is the observation that the **number of transistors** in an **integrated circuit (IC)** doubles about every two years.
- Reduction in **quality-adjusted microprocessor** prices, the increase in memory capacity **(RAM and flash)**, the improvement of **sensors**, and even the number and size of **pixels** in digital **cameras**,



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Brief Summary on the Ethic and Societal Implications

Ethical and Social Implications (Job Displacement)

- The adoption of robots and automation technologies has the potential to transform the nature of jobs. While certain routine and repetitive tasks may be automated, new roles may emerge that require human skills, creativity, and problem-solving.
- Job Displacement Concerns: There are concerns about the displacement of certain jobs, particularly those involving routine manual or cognitive tasks. This can lead to unemployment and a need for workers to acquire new skills to remain relevant in the evolving job market.
- Skill Shift: The workforce may need to undergo reskilling and upskilling initiatives to adapt to the changing job landscape. Initiatives in education and training become crucial to mitigate the negative impacts of job displacement.

Ethical and Social Implications (Ethical Considerations in AI and Robotics):

- **Algorithmic Bias:** AI and robotics systems can inherit biases present in the data used to train them. Ethical considerations involve addressing and mitigating biases to ensure fairness and prevent discriminatory outcomes in decision-making processes.
- **Transparency and Accountability**: There is a growing need for transparency in AI algorithms and decision-making processes. Understanding how decisions are made by autonomous systems is essential for accountability and ethical use.
- **Privacy Concerns**: The integration of AI and robotics in various domains, such as surveillance and data analysis, raises concerns about privacy. Ethical considerations involve establishing clear guidelines for the collection, storage, and use of personal data.
- **Autonomous Decision-Making**: Ethical dilemmas arise when robots or AI systems are granted decision-making autonomy. Ensuring that these systems adhere to ethical principles and align with human values is crucial to prevent unintended consequences.
- **Human-AI Collaboration**: The ethical use of AI involves promoting collaboration between humans and AI systems. This includes designing systems that complement human abilities, providing meaningful explanations for AI-driven decisions, and maintaining a level of human control over critical processes.

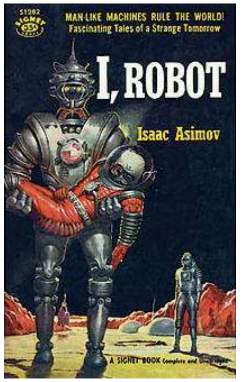
Ethical and Social Implications (Social Impact and Responsibility):

- **Income Inequality:** The adoption of robotics and AI can contribute to income inequality if the benefits of increased productivity are not distributed equitably. Addressing social and economic disparities becomes an ethical imperative.
- **Accessibility and Inclusivity:** Ethical considerations involve ensuring that the benefits of technological advancements are accessible to all segments of society. This includes addressing issues of digital divide and ensuring inclusivity in technology adoption.
- **Security Concerns:** Ethical responsibility extends to safeguarding AI and robotic systems from malicious use. Ensuring robust cybersecurity measures is crucial to prevent unauthorized access, manipulation, or exploitation of these technologies.
- **Global Collaboration:** Addressing ethical challenges requires international collaboration to establish common frameworks, standards, and guidelines. Collaborative efforts can help mitigate the risks associated with the global deployment of AI and robotics technologies.

Ethical and Social Implications

“A robot may not injure a human being or, through inaction, allow a human being to come to harm. A robot must obey orders given it by human beings except where such orders would conflict with the First Law. A robot must protect its own existence as long as such protection does not conflict with the First or Second Law.”

Asimov's "Three Laws of Robotics“



Will Smith in "I, Robot"

Future Outlook

- **Emerging Technologies:** Predictive maintenance, machine learning.
- **Integration of Automation and Human Skills:** Human-robot collaboration for enhanced productivity.

Conclusion

- **Recap of Key Points:** Automation benefits, automation types, key components, ROI, challenges, and future trends. Robotics definition, types, difference between automation and robotics, historical evolution, Ethical and Social impact,
- **Importance of Continuous Learning:** Stay updated with industry advancements.

Q&A

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Linkedin

References

List of sources and recommended readings:

- **Living with Robots What Every Anxious Human Needs to Know** By Ruth Aylett and Patricia A. Vargas
- ***Introduction to AI Robotics, Second Edition*** **by Robin R. Murphy**
- ***Unmanned Systems of World Wars I and II*** **by H. R. Everett**
- **Top robotics conferences, IROS, ICRA, CVPR, ICML, ICLR, ICCV…**