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## Artificial Intelligence in Industry

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**Abstract** Artificial intelligence (AI) refers to computer systems that mimic human cognitive functions. AI-driven systems can discover trends, reveal inefficiencies, and predict future outcomes. These characteristics enable informed decision-making and AI to be potentially beneficial for many industries. Industrial AI deals with the application of AI technologies to address industrial issues such customer value creation, productivity improvement, cost reduction, site optimization, predictive analysis, and insight discovery. This paper provides different applications of AI in industry.

**Keywords** industry, artificial intelligence, artificial intelligence in industry, industrial AI

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### Introduction

Industry is becoming more and more digitalized. As a result, data is continuously generated, processed, and analyzed. It would be great if the machines could gather insights from these volumes of data by themselves and optimize their processes. It is good to know that is already being achieved, step-by-step, using artificial intelligence (AI). From driverless cars to personal assistant and virtual doctors, AI is transforming the way we live, work, travel, and do business. AI offers tremendous potential for industry [1].

Artificial intelligence may be regarded as the part of digital technology that denotes the use of coded computer software routines with specific instructions to perform tasks for which a human brain is usually considered necessary. Industrial AI, usually refers to the application of artificial intelligence to industry. There are many reasons for the recent popularity of industrial AI: More affordable sensors, automated process of data acquisition, more powerful computation capability of computers, faster connectivity infrastructure, and more accessible cloud services [2]. The AI industry is driven by strong economic and political interests. Artificial Intelligence is one of the basic concepts of the Industry 4.0 philosophy and a key technology for factory digitization. Industry 4.0 is a convergence of two worlds: Information Technology (IT) and Operational Technology (OT). The term "Industry 4.0" emerged from the German term "Industrie 4.0," which was first used in 2011 in a project sponsored by the German government that was focused on promoting computerization of manufacturing [3].

### Overview on Artificial Intelligence

The term "artificial intelligence" (AI) was first used at a Dartmouth College conference in 1956. AI emerged as an academic field in 1956. The main goal of AI is to enable machines to perform complex tasks that typically require human intelligence [4]. AI is now one of the most important global issues of the 21<sup>st</sup> century. AI is the branch of computer science that deals with designing intelligent computer systems that mimic human intelligence, e.g. visual perception, speech recognition, decision-making, and language translation. The ability of machines to process natural language, to learn, to plan makes it possible for new tasks to be performed by intelligent systems. The main purpose of AI is to mimic the cognitive function of human beings and perform



activities that would typically be performed by a human being. Without being taught by humans, machines use their own experience to solve a problem.

AI is stand-alone independent electronic entity that functions much like human expert. Today, AI is integrated into our daily lives in several forms, such as personal assistants, automated mass transportation, aviation, computer gaming, facial recognition at passport control, voice recognition on virtual assistants, driverless cars, companion robots, etc. AI is not a single technology but a range of computational models and algorithms.

Some forms of AI that are most commonly used in electrical and computer engineering include the following [5,6]:

- **Expert systems:** They solve problems with an inference engine that draws from a knowledge base equipped with information about a specialized domain, mainly in the form of if-then rules. Expert systems are the earliest and most extensive, the most active and most fruitful area.
- **Fuzzy logic:** This makes it possible to create rules for how machines respond to inputs that account for a continuum of possible conditions, rather than straightforward binary.
- **Neural networks:** These are specific types of machine learning systems that consist of artificial synapses designed to imitate the structure and function of brains. They are similar to the human brain. They are made up of artificial neurons, take in multiple inputs, and produce a single output. The network observes and learns as the synapses transmit data to one another, processing information as it passes through multiple layers.
- **Machine learning:** This includes a broad range of algorithms and statistical models that make it possible for systems to find patterns, draw inferences, and learn to perform tasks without specific instructions. Any changes so that the same work can be done more efficiently than previously can be called learning. Machine learning is a process that involves the application of AI to automatically perform a specific task without explicitly programming it. ML techniques may result in data insights that increase production efficiency. Today, artificial intelligence is narrow and mainly based on machine learning.
- **Deep learning:** This is a form of machine learning based on artificial neural networks. Deep learning architectures are able to process hierarchies of increasingly abstract features, making them especially useful for purposes like speech and image recognition and natural language processing. Deep learning networks can deal with complex non-linear problems.
- **Natural Language Processors:** For AI to be useful to us humans, it needs to be able to communicate with us in our language. Computer programs can translate or interpret language as it is spoken by normal people.
- **Robots:** These are computer-based programmable machines that have physical manipulators and sensors. Sensors can monitor temperature, humidity, pressure, time, record data, and make critical decisions in some cases. Robots have moved from science fiction to your local hospital. In jobs with repetitive and monotonous functions they might even completely replace humans. Robotics and autonomous systems are regarded as the fourth industrial revolution.

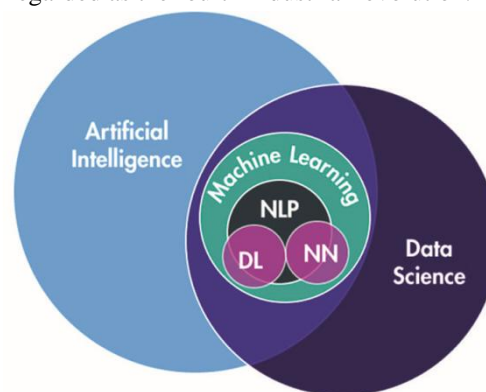


Figure 1: Artificial intelligence encapsulates several concepts including natural language processing (NLP), deep learning (DL), and neural networks (NN) [7]



These AI tools are illustrated in Figure 1 [7]. Each AI tool has its own advantages. Using a combination of these models, rather than a single model, is recommended. AI systems are designed to make decisions using real-time data. They have the ability to learn and adapt as they make decisions.

### Industrial AI

The current surge in AI research, investment, business, and industry applications is unprecedented. AI system in industry are the same technologies you use in daily life but applied to industrial problems. Industrial AI (or IAI) can be embedded to existing products or services to make them more effective, reliable, safer, and to enhance their longevity. IAI tools can be classified into two categories: predefined *rules-based tools* and *machine learning* tools [8]. Rules-based IAI tools are ideal for well-understood processes that allow a small set of possible outcomes. Machine learning is often used in problems with lots of data because it needs examples and trials to determine correct behavior.

The key elements in Industrial AI can be characterized by ‘ABCDE’. These key elements include Analytics technology (A), Big data technology (B), Cloud or Cyber technology (C), Domain knowhow (D) and Evidence (E). Analytics is the core of AI, which can only bring value if other elements are present [9].

Recently, the US government launched an official website AI.gov to highlight its priorities in the AI space. NIST, along with external partners, is developing testing methods and metrics to help industry better pick out useful AI tools from “bad.”

### Applications of Industrial AI

The common applications of AI in industry include the following [9-12]:

- **Manufacturing:** This industry is undergoing unprecedented transformation driven by technologies that help manufacturers to digitize their factories. Without doubt, the manufacturing industry is leading the way in the application and adoption of AI technology. The manufacturing industry is now moving into the fourth revolution of manufacturing:
  - The 1st revolution introduced mechanization through water and steam power
  - The 2nd revolution ushered in mass production and assembly lines using electricity
  - The 3rd industrial revolution introduced the digital era, comprised of computers and automation

The 4th industrial revolution, referred to as “Industry 4.0,” is happening now. AI in the world of manufacturing has limitless potential. In manufacturing, AI is being employed across areas such preventative maintenance, automation of human tasks, production, operations, and workforce planning. Robots serve as an integral part of the production process. AI algorithms are being used to notify manufacturing units of potential production faults that can lead to product quality issues. Figure 2 shows application of AI in manufacturing [13].



Figure 2: Application of AI in manufacturing [13]



- **Automotive Industry:** This industry is one of the largest benefactor of AI. Imagine no accidents, no traffic congestion, and no driver. Tesla and Google have already released self-driving cars, which were well received by their customers. People are already preferring pooling and shared rides over car ownerships. It is only a matter of time before self-driving cars go mainstream. AI-assisted self-driving cars make use of the sensors and cognitive equipment to drive safely, avoiding traffic and accidents. Three areas with the biggest AI potential are autonomous fleets for ride sharing, semi-autonomous features such as driver assist, and engine monitoring and predictive, autonomous maintenance.
- **Healthcare:** AI is currently being applied for a wide range of healthcare services.

The various ways AI-based programs help healthcare organizations include:

- Improvements in medical imaging
- More accuracy when reading test results
- Robot-assisted surgeries
- Administrative support
- Efficient recruiting

Natural language processing (NLP) shows promises in drug safety. AI can be used to identify people at risk and recommend therapy before they fall into depression. The contribution of the technology giants like Microsoft, Google, Apple and IBM in the healthcare sector holds significant importance for the industry. In 2013, the MD Anderson Cancer Center initiated a project in 2013 for diagnosing and recommending treatment plans for certain forms of cancer using IBM's Watson cognitive system. Figure 3 displays application of AI in healthcare [14].



Figure 3: Application of AI in healthcare [14]

- **Retail and E-commerce:** This industry will be one that is most impacted by AI. It may be the only area where the application of AI is the most observable to the majority of end-users because AI applications are increasingly being used to enhance the customer experience. AI technologies are increasingly being used to solve business problems. AI can support three types of business needs: automating business processes, gaining insight through data analysis, and engaging with customers and employees. AI-based tools benefit the e-commerce companies by way of automating data, stock, and inventory analysis that facilitate better forecasting of sales. Behavioral analytics coupled with AI surveillance can help identify, alert, and prevent theft and other malicious practices inside the store. AI in the marketing industry has been so successful that people now expect personalization in their marketing emails, advertising, and website experiences.
- **Food Industry:** The food industry has always been at the forefront of adopting emerging technologies to improve the sector. Artificial intelligence, with the capacity to makes computers to learn from experience, is playing a predominant role in the food industry. Artificial Intelligence (AI) is poised to



revolutionize the food industry. AI has found several applications in the food industry such as farming/agriculture, food processing, food sorting, food packaging, etc.

- *Banking and Financial Services:* This industry is undergoing a massive transformation due to AI applications. For example, human agents are being replaced by intelligent software robots for processing loan applications in fractions of a second. AI-based chatbots are being deployed in the insurance industry to improve the customer experience.
- *Travel:* This industry is deriving significant benefits from the widespread use of AI-enabled chatbots. Chatbots are a proven means for improving customer service and engagement mainly because of their 24/7 presence and instant resolution of queries. Many large travel organizations are turning to AI companies and using machine learning and predictive analytics to build their own AI-based mobile apps and chatbots for improving the customer experience.
- *Real Estate:* The application of AI in this industry is opening new opportunities for agents, brokers and clients alike. Agents are becoming more efficient and effective, brokers are getting more strategic, and consumers are feeling empowered. AI-powered bots can operate 24/7 and help brokers and agents find the perfect match for people looking to buy, rent or sell their properties.
- *Entertainment and Gaming:* AI is helping program producers and broadcasters identify which shows or programs they should recommend to individual users. For example, AI helps Netflix and Amazon provide a more personalized experience to users. In the film industry, AI is being employed to enhance digital effects in movies. In the music industry, large companies like Apple and Spotify implement AI to understand users' engagement patterns and recommend the right music to the right people and at the right time.
- *Telecommunications Industry:* This industry has a natural monopoly character. But things have changed since the 1980s; globalization and technology have all damped monopoly and encouraged competition in the industry. Today, the telecommunications industry is one of the most important areas for AI applications. Different AI techniques have their unique applications in the telecommunications industry. Expert systems and machine learning are the two AI techniques that have been widely used in telecommunications. Expert systems were designed for diagnosing complex equipment in an off-line mode. Software systems in telecommunications have to cope with a great variety of telecommunication protocols, and numerous hardware platforms and network architectures [15].
- *Chemical Industry:* This industry is a complex socioeconomic system that is very difficult to manage. The industry is managed according to three main indices: production quantity, production quality and sales price. It is a fertile ground for applying and developing AI technology. Areas of applications of AI and expert systems include: process control: several industries, chemical synthesis and analysis, manufacturing: planning and configuration, waste minimization, and signal processing. AI technology can effectively control the production process, optimize the process technology, improve production efficiency, and reduce energy consumption [16].
- *Cybersecurity:* There are countless ways in which the adversary can attack. Cybersecurity is the process of protecting computer networks from cyber attacks or unintended unauthorized access. It is the need of the hour. Organizations, businesses, and governments need cybersecurity solutions because cyber criminals pose a threat to everyone. Artificial intelligence promises to be a great solution for this. By combining the strength of artificial intelligence with cybersecurity, security experts are more capable to defend vulnerable networks and data from cyber attackers. AI will be a game-changer in how we improve our cyber-resilience. Various AI tools have been increasingly applied for cyber crime detection and prevention.

There are the industries that have the highest potential for AI applications. Some of them are illustrated in Figure 4 [17]. Other industries that can benefit from AI include pharmaceutical industry, energy industry, oil and gas industry, print industry, media industry, tour and travel industry, apparel industry, hospitality industry, fashion industry, marketing, construction industry, education, legal, diagnostics, business intelligence, city planning, supply chain management, public relations industry, human resources, and the list continues.



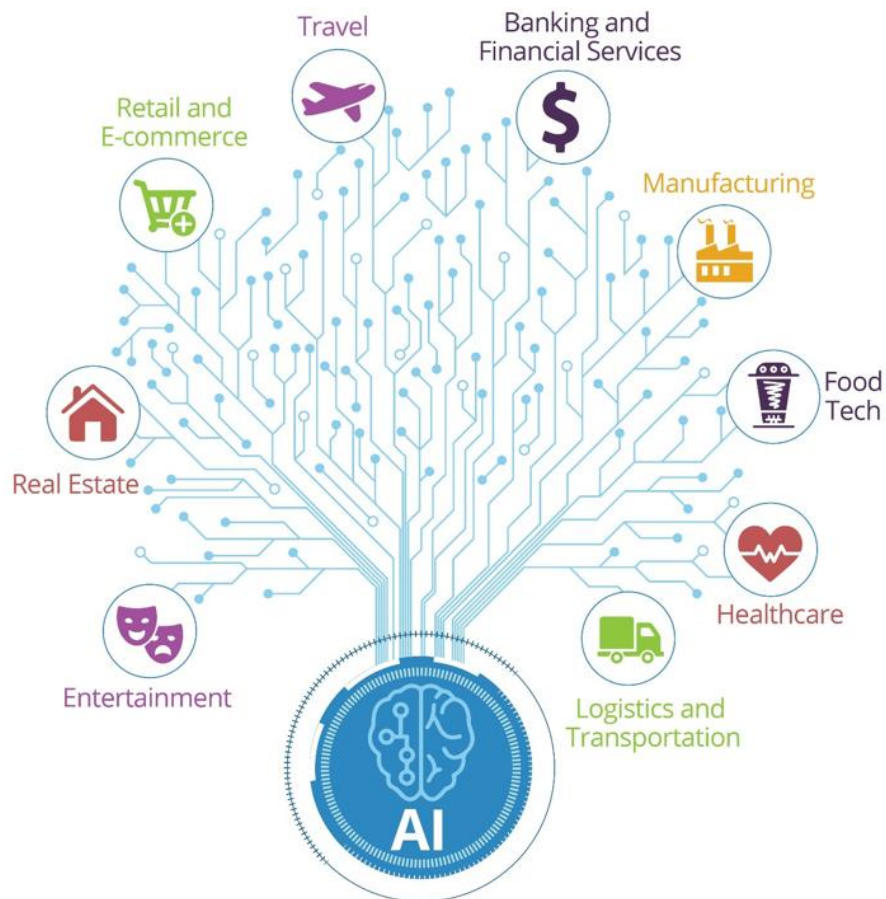


Figure 4: Some of the AI applications disrupting industries [17]

**Benefits**

Industry holds a positive view of AI and sees AI transformation of economy unstoppable. AI is already making production more efficient, more flexible, and more reliable. Some benefits of AI include directed automation, 24/7 production, safer operational environments, and reduced operating costs [18]. Using artificial intelligence creates new opportunities for flexible and efficient production. Adoption of AI is moving fast-paced across industries, where AI will clearly automate many processes that were earlier executed manually. Industrial AI has fundamentally changed the scope and pace of automation. AI applications in industry has improved the human experience as a whole. Figure 5 shows the pros and cons of artificial intelligence [19].



Figure 5: Pros and cons of artificial intelligence [19]

## Challenges

Digitalization and cyber security should go hand in hand. The risks are huge without the right safeguards in place. Standards of AI should be created to match the perspectives of societal acceptance. There are major challenges of industrial AI [2]:

- *Data*: Modern industry is indeed a big data environment. Industrial data usually is structured, but may be low-quality.
- *Speed*: Production process happens fast and the equipment and work piece can be expensive.
- *Fidelity*: A very low rate of false positives or negatives rate may cost the total credibility of AI systems. Industrial AI applications are usually dealing with critical issues related to safety, reliability, and operations.
- *Interpretability*: The industrial AI systems must go beyond prediction results and give root cause analysis for anomalies.
- *Scaling challenges*: It is difficult to integrate AI projects into existing system. The process for using AI takes too long or is expensive to scale. In scaling up, companies may face substantial change-management challenges.
- *Hammer/nail paradigm*: When an AI company has a hammer, everyone else's problem starts to look like a nail. Within industries, different kinds of expertise will be critical to a successful application of AI. These fundamental differences in each industry should not be ignored.

## Future of Industrial AI

Artificial intelligence has a rapidly growing presence in today's world, with applications ranging from heavy industry to education. It is becoming clear that this technology can revolutionize how the everyday world works. AI technology will contribute greatly to this increase in global economic growth and productivity. If you have interest in how developments in AI might impact your business, you must keep an eye on trends of industrial AI.

As AI emerges from science fiction to become the frontier of world-changing technologies, there is an urgent need for standards and systematic development and implementation of AI. Business losses a lot through cyber crime as hackers are growing smarter with time. Comprehensive protection for industrial facilities will play a crucial role in the future.

## Conclusion

Artificial intelligence has gradually become well integrated into many aspects of society and widely adopted in the industry. The disruptive achievements of artificial intelligence (AI) are rapidly and infiltrating into various fields of human activities. AI is getting more sophisticated with time and its programs are revolutionizing the way that some industries operate. Google Maps, LinkedIn, Facebook, Uber, and many other future-looking companies are using AI to improve their services. More information about industrial AI can be found in the books in [20,21].

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