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Artificial Intelligence in Engineering

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Abstract Artificial intelligence (AI) describes computer systems and computer software that are capable of intelligent behavior. It is a machine-exhibited intelligence rather than humans based. The primary goal of AI is to explore how to imitate and execute some of the intelligent functions of the human brain. AI is becoming an essential part of our lives and we are consuming its services consciously or unconsciously. Today, AI is the most important general-purpose technology. It is applied in many fields such as expert system, knowledge base system, intelligent database system, and intelligent robot system, healthcare, transportation, business, finance, and engineering. The paper provides an overview of the advances of artificial intelligence applied in engineering.

Keywords artificial intelligence, artificial intelligence engineering

Introduction

For decades researchers have been fascinated by the notion of creating a machine that can replicate the human brain. Such a machine is known as artificial intelligence. Artificial intelligence (AI) refers to systems that act intelligently, whether in a specific domain (narrow AI), or in general (strong AI). It is a computer system's ability to mimic human behavior, as shown in Figure 1 [1].

Figure 1: Behavior of human intelligence [1]

It is a system that thinks like humans and acts like humans. Machines can perform human-like tasks and demonstrate intelligence that is comparable to natural intelligence that humans and animals demonstrate.

Ever since the field of AI was founded in 1956, it has made explosive, surprising advances. This is evident by the development of AlphaGo, autonomous cars, Alexa, Watson, game playing, robotics, computer vision, speech recognition, and natural language processing. Historically, the term AI is reflected collectively to the following branches [2].

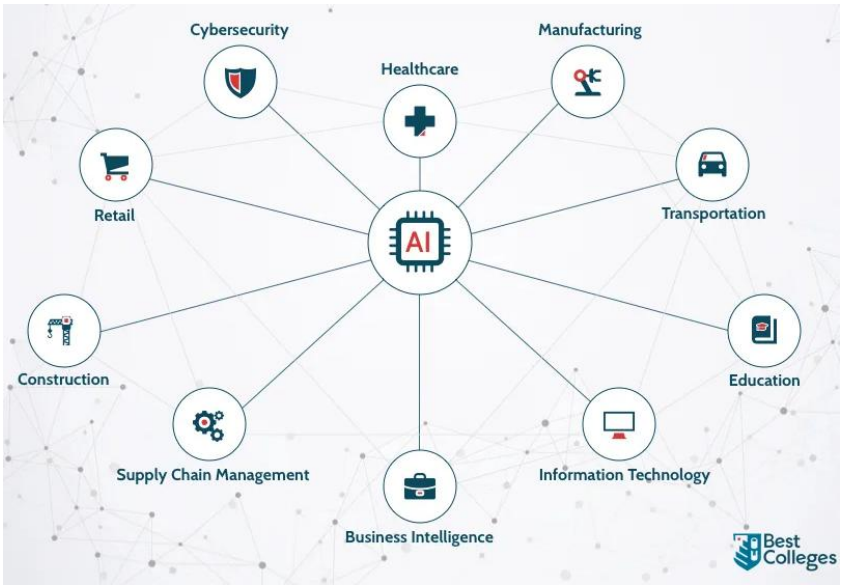

Figure 2: Industries impacted by AI revolution [3].

- Game playing—for example, Chess, Go
- Symbolic reasoning and theorem proving—for example, Logic Theorist, MACSYMA
- Robotics—for example, self driving cars
- Vision—for example, facial recognition
- Speech recognition, Natural language processing–for example, Siri
- Distributed & evolutionary AI—for example, drone swarms, agent based models
- Hardware for AI—for example, Lisp machines
- Expert systems or knowledge based systems—for example, MYCIN, CONPHYDE
- ML—for example, clustering, deep neural nets, Bayesian belief nets

Artificial intelligence has endless potential to handle tasks commonly done by humans, including natural language processing, image recognition and data analytics, visual perception, decision-making, speech recognition, business process management, and even the diagnosis of disease, all of which normally require human intelligence. Artificial intelligence is now everywhere and has a great deal to offer the world of engineering. As shown in Figure 2, AI has had an impact on just about every field, including engineering [3]Some of the most interesting applications of artificial intelligence are in the field of engineering. For this reason, more and more people are becoming AI Engineers.

Overview on Artificial Intelligence

The term "artificial intelligence" (AI) was first used at a Dartmouth College conference in 1956. AI is now one of the most important global issues of the 21st 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 [4,5]:

- ***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. 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. 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.
- ***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. In natural language processing, AI engineers must combine computer science, information engineering, linguistics, and artificial intelligence, while programming systems to process and analyze large data sets.
- ***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.

These AI tools are illustrated in Figure 3 [6]. 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.

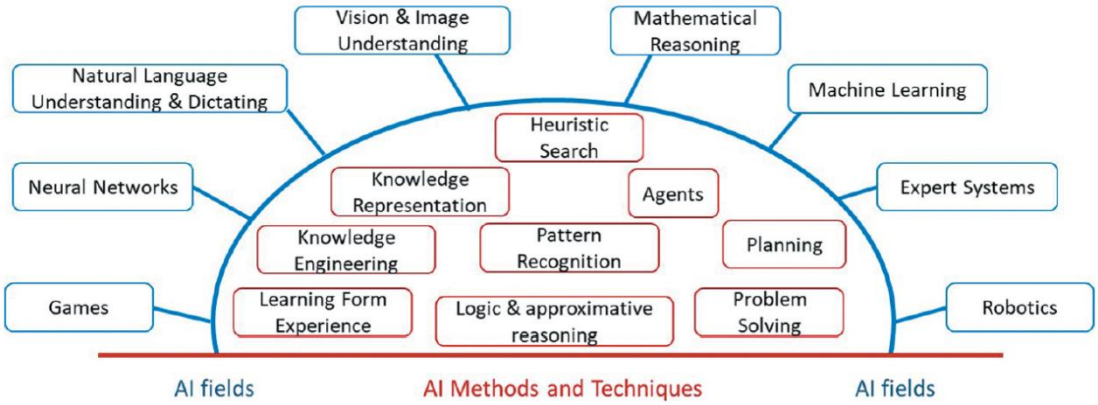

Figure 3: Many branches of artificial intelligence [6]

Artificial Intelligence Engineering

AI engineering is a relatively new field. It is essentially the use of algorithms, computer programming, neural networks, and other related technologies in the development of AI applications and techniques. AI has produced a number of powerful tools to solve difficult problems normally requiring human intelligence [7,8]

Five ways in which AI may impact the engineering profession [9]:

1. History has shown that technological advances in the past have helped create new jobs. This will be especially relevant for those in the engineering community.
2. With the rapid evolution of technology, there will be an increased need for engineers to research, create, and test AI systems.
3. Engineers have an enormous opportunity to showcase their creativity in response to advances in AI.
4. New types of experts will increasingly be in demand in response to the new types of work created by AI technology.
5. New developments in AI will enable engineers to complete their work more efficiently and solve a wide range of problems.

To pursue an AI engineering role within your organization requires that having the knowledge of the business in addition to technical skills. To be relevant and create true value for the organization, artificial intelligence engineering must go beyond the technical to provide applications specific to the business.

AI Engineers

A bachelor's degree is usually required to become an artificial intelligence engineer. AI engineers are responsible for the design, implementation, and management of AI-based tools throughout the organization. They must have a sound understanding of programming, software engineering, and data science. To become well-versed in AI, it is important that AI engineers learn programming languages, such as Python, R, Java, and C++ to build and implement models. AI engineers are in high demand because designing intelligent systems is not an easy task. They are needed to provide the expertise a company needs to build models. Typically, AI engineers design, build, maintain, and deploy AI-based systems. AI engineers design machines that is capable of replicating just about anything that humans can do. They are primarily responsible for implementing machine learning. Depending on the industry, the responsibilities if AI engineers include the following [10,11]:

- Analyze data, design software, create AI algorithms, perform image processing, and implement natural language processing.
- Convert the machine learning models into application program interfaces (APIs) so that other applications can use it
- Build AI models from scratch and help the different components of the organization (such as product managers and stakeholders) understand what results they gain from the model
- Build data ingestion and data transformation infrastructure
- Automate infrastructure that the data science team uses
- Perform statistical analysis and tune the results so that the organization can make better-informed decisions
- Set up and manage AI development and product infrastructure
- Be a good team player, as coordinating with others is a must
- Have excellent problem-solving skills to resolve obstacles for decision making
- Need to communicate well about their products and ideas to stakeholders. An AI engineer needs to be able to speak the language of various groups he will work with in the organization.

AI engineers find job positions in several areas such enterprises,businesses, healthcare, manufacturing, finance, and fraud detection. Figure 4 shows some AI engineers at work [12].

Figure 4: Typical AI engineers at work [11]

Applications of AI in Engineering

With advances in technology, the application of AI engineering is becoming more and more extensive. There are a number of applications of AI that are of considerable use to engineers. The AIs used in the engineering sector combine both software and hardware components. They are used in the following areas.

- ***Manufacturing:*** One popular application of AI in engineering is in the field of automobile manufacturing. AI is increasingly finding its way into manufacturing sector. Robots were originally capable of performing simple engineering tasks that involve large movements. These machines can now perform precision work, emulate intricate tasks, and handle complicated manufacturing tasks. Figure 5 shows a workplace automation and manufacturing [11]

Figure 5: Workplace automation [11]

- ***Autonomous Vehicles:*** One of the main changes in AI engineering is the automation of many low-level engineering tasks. Engineers build systems of connected sensors and cameras that ensure that an autonomous vehicle's AI can "see" the environment. For instance, a self driving car can navigate impressively through traffic, with companies like Tesla, Google, and Uber already testing self-driving vehicles on the road, many of the biggest remaining barriers are legislative rather than technological. Figure 6 is a demonstration of a Tesla Model self- driving without any human intervention [13].

Figure 6: Demonstration of a Tesla Model self- driving without any human intervention [13]

- ***Big Data*:** Data is everywhere. Many processes and functions in engineering requires the usage and storage of data. Most engineers work on big data. Big data analysis can reveal some truth to engineers and help them make decisions that are based on objective scientific analyses. AI engineers will require some knowledge of big data technologies such as Apache Spark, Hadoop, Cassandra, and MongoDB.
- ***Business:*** AI engineers can quickly add machine learning capabilities to business-critical systems such as enterprise resource planning (ERP), customer relationship management (CRM), and mobile device management (MDM). Artificial intelligence engineering is enabling organizations to create hybrid operating environments that combine data science, data engineering, and software development. Successful AI projects will deliver value to the enterprise and address the relevant pain points of the business [14].
- ***Signal Processing:*** The adoption of machine learning in engineering has been especially valuable for signal processing. Signal processing techniques can also be used to improve the data fed into machine learning systems. By cutting out much of the noise that would otherwise be included in these inputs, engineers achieve cleaner results in the performance of Internet-of-Things devices and other AI-enabled systems. Life-changing possibilities that can come from applying AI to investigations in signal processing [5].
- ***Civil Engineering:*** AI-based solutions can provide valuable means for efficiently solving problems in the civil engineering. AI tools used in civil engineering include evolutionary computation, neural networks, fuzzy systems, expert system, reasoning, classification, and learning. AI technology is widely used in many areas for civil engineering field, such as civil building engineering, road and bridge, construction engineering, underground engineering, road engineering, geological exploration, disaster prevention project, material engineering, petroleum chemical industry, etc. [15].

- ***Chemical Engineering:*** Many issues in chemical engineering can benefit from AI techniques. Major efforts to developing AI tools for chemical engineering problems started in the early 1980s. Today, chemical engineering is at an important crossroads and is undergoing an unprecedented transition. Many chemical engineers are excited about the potential applications of AI. They realize that AI will play an increasingly dominant role in chemical engineering research and education. Chemical engineers have always prided themselves on their modeling capabilities, but, in this new era, modeling would go beyond the differential and algebraic equations [DAEs]. AI will play a major role in chemical engineering in the coming years [2].
- ***Mechanical Engineering:*** This is a branch of engineering dealing with design, construction, and machines. Within this field, mechanical design or engineering works is the area that mostly applies artificial intelligence. Mechanical design is a process to design the required component, system, or process. It embraces product design, machine design, mechanical component design, tooling and fixture development, mold design, and casting design. Other areas of AI impact include manufacturing, production, product characteristics, big data storage, stress estimation of 3D structures, material evaluation for different services, and structure generation [16].
- ***Software Engineering:*** This is a knowledge-intensive activity that cuts across all the stages of the software development phases. It presumably requires intelligence and it seems natural to use AI techniques to build systems. AI techniques like artificial neural networks, fuzzy logic, machine learning and data mining have been used for solving several software engineering problems. They have continued to have considerable impact on computer software development. Software products become pervasive in all areas of society. AI is potentially a game changer that improves software quality. Applications of AI in software engineering form a new class of tool support called software analytics [17]. AI provides robust approaches for software development in order to evaluate complex software. AI has been used to reduce human efforts in software engineering activities.

Other applications include software engineering, engineering education, concurrent engineering, electronic engineering, geotechnical engineering, engineering knowledge, petroleum engineering, tissue engineering, optical engineering, structural engineering, product engineering construction engineering, biomedical engineering, informatics, pattern recognition, contextual advertising, language translation, visual identification or perception, fault diagnosis, microscopic defect identification, oil and gas, and risk management.

Benefits

There is no denying that AI engineering has been successful. Even though these successes may be in narrow domains, they have caused massive disruptions. Compared to human speed, AI is much faster. AI will cause some positive big changes to the engineering profession. When combined with data analysis, AI and ML facilitate predictive analytics. A knowledge of deep learning provides AI engineers with the skills necessary to build AI models with unstructured data. AI engineers can design systems optimized to perform machine learning tasks efficiency. This opens the door for new possibilities in autonomous vehicle guidance, customer relationship management, fraud detection, and several other applications.

Challenges

In many places, there are widespread fears and anxieties surrounding the impact of automation on jobs. It is estimated that half of the jobs in the United States are at risk of being automated over the next decade or two. AI is poised to replace people in certain kinds of jobs, such as in the driving of vehicles and repetitive manufacturing tasks. It can be the source of disruptions as new types of tasks are created and other kinds of work become less needed due to automation. This may dramatically affect the job descriptions of engineers [13]. As machines begin to replace humans in certain jobs, there are worries that we will eventually have no need to hire people any more. However, researchers tend to agree that the long-term benefits of automation outweigh the potential drawbacks. It is not likely that engineers will be replaced by the machines they created.

Conclusion

The term "artificial intelligence" refers to a variety of systems built to imitate how a human mind makes decisions and solves problems. These are promising times for artificial intelligence engineering. Artificial intelligence is gradually changing our world. Today, expectations for AI are sky high. With more and more organizations relying on AI tasks as part of their daily operation, demand for AI engineers to work with AI-related technologies will only increase AI is poised to create many exciting job opportunities in the coming years.

AI engineering as an academic program is offered by some universities at the undergraduate and graduate levels, providing graduates who can provide the desired mix of programming experience, mathematical knowledge, and statistical skills. More information on artificial intelligence in engineering can be found in the books in [1,18-23] and following related journals:

- *Artificial Intelligence Review*
- *Artificial Intelligence in Engineering*
- *Engineering Applications of Artificial Intelligence*

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