

Artificial Intelligence Applications in Engineering

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Introduction

With the introduction of the computer and later the internet, we have experienced a digital transformation in our social life and we continue to live with advancing technologies. Nowadays, we have started to hear the name of artificial intelligence (AI) from computer science a lot and all of us that it has become a rapidly growing subject in many different fields know it.

The history of the concept of artificial intelligence dates back to ancient times. The idea father said, “Can machines think?” It is Alan Mathison Turing, who brought up the problem of machine intelligence and opened it up for discussion. Artificial intelligence terminology was first used in 1956 by John McCarthy et al. has revealed (McCarthy et al. 2006).

Although the definition of artificial intelligence cannot be fully revealed, it can be expressed as machines with human-like perception and cognition, since it initially refers to creating a “humanoid” machine. To clarify this expression, it can be said that artificial intelligence is a discipline that studies the computer simulation process of some human-specific behaviors such as reasoning, learning, perception and communication (Pannu 2015; Gabriel 2016; Li & Jiang 2017).

Looking at the literature, definitions have been made for artificial intelligence in 4 different perspectives. These definitions are given in Table 1.

Table 1. Definitions Made for Artificial Intelligence

	Definition	References
System that think like humans	“The automation of activities that we associate with human thinking, activities such as decision-making, problem solving, learning...”	(Bellman 1978)
	“The exciting new effort to make computers think ...machines with minds, in the full and literal sense.”	(Haugeland 1989)
Systems that act like humans	“The art of creating machines that perform functions that require intelligence when performed by people.”	(Kurzweil et al. 1990)
	“The study of how to make computers do things at which, at the moment, people are better.”	(Rich and Knight 1991)
System that think rationally	“The study of mental faculties through the use of computational models.”	(Charniak and McDermott 1985)
	“The study of the computations that make it possible to perceive, reason, and act.”	(Winston 1992)
Systems that act rationally	“A field of study that seeks to explain and emulate intelligent behaviour in terms of computational processes”	(Schalkoff 1990)
	“The branch of computer science that is concerned with the automation of intelligent behaviour”	(Luger and Stubblefield 1992)

Advantages and Disadvantages of Artificial Intelligence

The advantages of artificial intelligence applications are huge and can lead to revolutionary changes in professional industries. But looking at the other side of the coin, artificial intelligence also has some disadvantages (Khanzode & Sarode 2020; Bhbosale, Pujari, & Multani 2020).

Advantages of Artificial Intelligence

- *Elimination or minimization of the human error factor:* When systems such as violation detection with the help of weather forecast systems or video cameras are considered, the effects of human errors can be minimized with the help of artificial intelligence.
- *Reducing the risk factor that people may face in risky areas or areas:* Considering artificial intelligence-assisted robots, it can help eliminate the risk of death of people as a result of the detection or destruction of a bomb. In situations such as natural disasters, the risks that may be encountered in dangerous interventions can be minimized.
- *Effective and efficient working time:* When you think of human-assisted machines in an industry, these machines can be operated for as long as humans can

perform effectively. In addition, these periods can be shortened in repetitive jobs. Considering the machines working with artificial intelligence decision support system or artificial intelligence supported robots, it is possible to operate these machines 7/24 without a break and get efficiency. Another example is artificial intelligence supported customer support software. With the help of these systems, it is possible to respond to the requests and demands of the customers regardless of time.

- *Quick decision-making ability:* Systems using artificial intelligence technology offer faster and more practical solutions thanks to the algorithms they contain and due to the lack of emotional analysis as in humans.
- *Leading new solutions or inventions:* Artificial intelligence is also frequently used in the field of medicine. Thanks to artificial intelligence-based technological systems, more effective or different solutions can be offered than experts in terms of disease detection or diagnosis.

Disadvantages of Artificial Intelligence

- *Costs:* With the rapid development of technology, the field of artificial intelligence is also updating itself with different innovations every day. In order to keep up with these updates, making the necessary updates in the hardware and software area causes the costs to increase.
- *Lack of emotion:* Artificial intelligence systems, which lack human-specific emotions, cannot develop a bond with people in team management.
- *People getting lazy:* Thanks to systems or applications that are automated in many areas of life with artificial intelligence technologies, people get used to laziness.
- *Unemployment:* thanks to the innovations provided by artificial intelligence technology, automated machines replace the human factor. This may lead to a decrease in the demand for human labour.

Research Areas of Artificial Intelligence

The place of artificial intelligence in our lives is increasing day by day and continues to show itself in different fields. Areas of common use are given in the following sections.

Natural Language Processing

Natural language processing can be expressed as the ability of computers to perceive the language we speak, to process the perceived language, and then to produce sentences by making comments. In general, texts are used as input, as well as combined with speech

recognition. Today, it has many uses. Examples are translation programs, call services, or smartphone assistant applications (Nadkarni, Ohno-Machado, & Chapman, 2011; Maulud et al. 2021) & Chapman 2011; Maulud et al., 2021).

Computer Vision

In computer vision, a digitized input image is captured by the computer and converted for analysis and interpretation. Important aspects of computer vision can be expressed as pattern and object recognition, extraction of depth information, edge detection and motion detection. In addition to standard camera images, satellite images, medical images, as well as computer modelling of three-dimensional objects are also of interest to computer vision. Promising applications in computer vision can be given as examples of many uses such as autonomous vehicles (automobile, drone, etc.), humanoid robots, security systems for biometric verification (Zhang, 2010; Rybchak & Basystiuk, 2017).

Robotics

Traditionally, industrial robots are programmable machines to perform manual tasks automatically. However, unlike pre-programmed industrial robots, autonomous robots equipped with artificial intelligence often have the ability to make their own decisions to achieve a goal or perform a task.

Autonomous robots are equipped with texture and motion sensors, video/image input and various sensors specially designed for specific tasks. In this way, inputs from different sensors are coordinated to perform various actions with artificial intelligence algorithms and software. Autonomous robots are equipped with intelligence capabilities for sensing their environment and planning their movements by exhibiting independent behaviours with the developing artificial intelligence technology (Brady, 1984; Perez et al., 2018; Vrontis et al., 2021).

Games

The ability of computers to play certain games was demonstrated in the early days of artificial intelligence with games such as checkers, backgammon and chess. In such games, the probability of a large number of moves was systematically calculated and the calculations were repeated according to the position of the opposing player, aiming to reach the best solution. So much so that a computer specially designed for the game of chess defeated Gary Kasparov, the world champion in chess, in the late 90s.

Today, the game industry is perhaps one of the areas where artificial intelligence shows the most impact. For example, events such as the passing of a different character in the game, the fact that the game difficulty levels can be adjusted according to the current situation of the player, or the enemy soldiers seeing and shooting the opponent in a

war game are realized thanks to the learning, analysis and inferences of the computers (Schaeffer & Van den Herik, 2002; Mateas 2003).

Speech Recognition

Speech recognition is the process of recognizing speech sounds spoken by the speaker and converting them into text in a verbal form. By mapping the digitally represented acoustic signal to a string of words, it provides automatic and accurate conversion into text via keywords or phrases. The voice typing feature in the messaging applications of smartphones can be given as an example as one of the most used applications among the applications using speech recognition technology (Forsberg, 2003; Huang, Baker, & Reddy, 2014).

Knowledge Discovery and Data Mining

Knowledge discovery and data mining is an organized interdisciplinary field focused on methodologies for extracting useful information from data using large data pools, identifying new, useful and understandable patterns. While many of the techniques used for knowledge discovery and data mining are similar to machine learning or some types of neural networks, the goals here are different. The key here lies in identifying interesting bits of information in a large dataset, rather than finding a representation that specifies key aspects of the entire sample set (Mining, 1996; Maimon & Rokach, 2009).

Genetic Algorithm

The Genetic Algorithm is one of the first of the population-based stochastic algorithms. These algorithms work by encoding a potential solution to a particular problem on a simple chromosome-like data structure. It also applies recombination operators to these constructs to preserve critical information. Although the range of problems to which genetic algorithms are applied is quite wide, they are generally seen as function optimizers. It includes approaches such as inheritance, mutation, selection and crossover to look for a better alternative to the problem. Genetic algorithms have wide application areas in different research fields such as management, engineering, industrial design and so on (Mirjalili, 2019; Mathew, 2012; Wang 2003).

Expert Systems

They are computer programs developed to simulate human-specific design, planning, problem solving and reasoning abilities by designing intelligent models and algorithms. Expert systems can store human knowledge and experience within a limited area by including them in the artificial intelligence system and reach the solution of the problem by inferring from the results.

While expert systems were originally designed as separate systems for specific tasks, they can now be integrated into larger systems and have an advantage over traditional programs when it comes to dealing with incomplete, inconsistent or uncertain information (Jackson, 1986; Lucas & Van Der Gaag 1991; Gupta & Nagpal 2020).

Machine Learning

Machine learning is a technology designed to mimic human intelligence by learning from the surrounding environment, improving the performance of its system not only by following the program's instructions, but also depending on the data. The purpose of machine learning can be expressed as extracting useful information from a set of sample data and representing this information in a way that can be used in a reasoning system (Yao & Liu, 2014; El Naqa & Murphy, 2015).

It draws inspiration from work in a variety of disciplines, including machine learning, computer science, statistics, information theory, cognitive science, philosophy, and biology. Machine learning has a wide range of uses in areas such as manufacturing, sales and marketing, finance, defence, transportation and healthcare (Sarker, 2021).

Applications of Artificial Intelligence Technology in Engineering

Artificial intelligence is a collective of advanced computational techniques. In addition to the advantages of artificial intelligence technology such as reducing costs, increasing efficiency and ensuring safety, there are also effects such as reducing the labor intensity of workers. Engineering fields, business, medicine, defence etc. Artificial intelligence technology is frequently used in today's technologies to solve complex problems in the field.

Artificial Intelligence Applications in Medicine

With the development of technology, artificial intelligence supported medical technologies produce viable solutions for clinical applications. Artificial intelligence has uses in diagnosis, treatment and predicting outcome in many clinical scenarios. When the literature is examined, the use of artificial intelligence in drug development (Mak & Pichika, 2019), in health monitoring (Smarsly, Lehner, & Hartmann, 2007; Sun et al., 2020) in the management of medical data (Greengard, 2018), in the diagnosis of disease (Vashistha, Chhabra, and Shukla 2018), in personalized treatment (Schork, 2019), in the analysis of health plans (Mahmic) and surgical treatment (Loftus et al., 2020) such as it is frequently used in fields

Artificial Intelligence Applications in Defence Industry

Countries are closely following and developing artificial intelligence technology, which

has potentially important effects in the field of national security and is growing rapidly. Artificial intelligence is used to improve the features of critical systems in the field of defense, thanks to its integrated computing and decision-making capabilities (Hoadley & Lucas, 2018; Bistron & Piotrowski, 2021). Intelligence gathering and analysis (Hoppa et al., 2019; Xi, Lingyu, & Jiapeng, 2021), information operations (Telley, 2018; Paterson & Hanley, 2020), cyber security (Alhayani et al., 2021), logistics and transportation (Bujak, Smolarek, & Gębczyńska, 2011; Amir & Ahmad, 2019), target recognition (Min et al., 2019; d'Acremont et al., 2019), simulations and training (Ernest et al., 2016; Fawkes 2017), in command and control areas (Schubert et al., 2018; Wang 2019) and also in various semi-autonomous and autonomous vehicles (Gare 2016, Mori 2018; Amir & Ahmad 2019) work continues on the use of artificial intelligence.

Applications of Artificial Intelligence in the Field of Business

Computing systems with programmed intelligence can solve different real-world problems much more accurately and efficiently than deterministic and hard-coded computing systems. Artificial intelligence plays an important role in overcoming the problems in the business world, as many problems in business cannot be solved with deterministic systems (Bai, 2011; Ghimire et al., 2020). Looking at the usage areas of artificial intelligence, marketing (Martínez-López & Casillas, 2013; Vlačić et al., 2021) and product recommendation (Shahbazi & Byun, 2019; Sharma et al., 2021), fraud detection (Bao, Hilary & Ke, 2020; Yazici 2020), algorithmic trading (Hara et al., 2018; Li, Zheng, & Zheng, 2019), insurance (Riikinen et al., 2018; Guimaraes, 2020), customer service (Ping, 2019; Li et al., 2020), such as it is seen that it is widely used to solve and optimize many problems in the business world.

Artificial Intelligence Applications in Agriculture

Interest in artificial intelligence technologies in the field of agriculture has been increasing recently. Examining this area, there are many challenges to maximizing yields, including improper tillage, underproduction, diseases, pest infestation, and the knowledge gap between producers and technology. At this point, the flexibility of artificial intelligence in solving agricultural problems, its high performance, accuracy and cost effectiveness come to the fore with its tight learning capabilities (Bannerjee et al., 2018; Eli-Chukwu, 2019).

When the areas where artificial intelligence technology is used in the field of agriculture are examined, the yield estimation (Raorane & Kulkarni 2012; Kuwata & Shibasaki, 2015; Chlingaryan, Sukkarieh, & Whelan, 2018), disease detection (Kothari, 2018; Patil & Kumar, 2020), weed detection (Sarvini et al., 2019; Sohail et al., 2021), and species recognition applications (Taner et al., 2018; Cinar & Koklu, 2019; Koklu, Cinar, & Taspinar, 2021; Kong et al., 2021), animal welfare and livestock management

(McCloughlin, Stewart, & McElligott, 2019; Neethirajan, 2020; Neethirajan & Kemp, 2021), water management (Grundmann et al., 2012; M Sánchez Céspedes, Espinosa Romero, & P Rodríguez Miranda, 2019) with soil management (Prithviraj et al., 2020) it is seen that there are studies on these issues.

Artificial Intelligence Applications in the Field of Transportation

The developments in the field of artificial intelligence offer unprecedented opportunities in the transportation sector as well as in different fields and lead the way in finding solutions to many different challenges. Some of the difficulties encountered, capacity problems, safety problems, environmental pollution, noise pollution, wasted energy and economic losses due to all these are the first ones that come to mind. With the use of artificial intelligence, various studies are carried out such as eliminating possible congestion in transportation, making travel times more transparent and reliable for customers, reducing environmental and noise pollution, and improving productivity in transportation (Sadek, 2007; Abduljabbar et al., 2019).

When the literature is examined, the use of artificial intelligence in the field of transportation, traffic management (Chowdhury et al., 2006; Lendel et al., 2017; Astarita, Festa, & Giofrè, 2018), traffic safety (Zhang, 2020; Yao & Ye, 2020) and accident forecast (Yasin Codur & Tortum, 2015; Zhou, 2019; Yu et al., 2021), vehicle control (Korjagin and Klachek, 2017; Sambana & Ramesh, 2020), public transport (Heppe & Liebig, 2017; Minea, Dumitrescu, & Chiva, 2019) and urban mobility (Ceder, 2020; Smith, 2020; Cho & Kim, 2021) such as collected under the headings.

The Future of Artificial Intelligence

Today, artificial intelligence has found many different uses in many different fields. Research and development will continue in the future, new software techniques will be discovered and we will come up with different models. It will be possible to come up with professional software development tools that make it easier to develop expert systems and other artificial intelligence applications. These developments will occur not only in the field of software, but also in the field of hardware. Much larger capacity and faster microprocessors and memories will be offered; completely new and more advanced devices will be created in addition to the development of semiconductor technology. The new parallel processing with many processors working at the same time, and especially their architectures suitable for artificial neural networks processing will add a completely new dimension to artificial intelligence. Natural language interfaces will become a common feature in many application programs and intelligent databases will be developed. Symbolic language programs will increasingly use artificial intelligence technologies to make some performance improvements. Expert systems advising on many important issues will become much more common. In short, artificial intelligence

will continue to act as a technological innovator in the future (Haenlein & Kaplan, 2019; Bundy, 2017; Dhar, 2016; Floridi, 2020).

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To Cite This Chapter

Cinar, I., Taspinar, Y.S., & Koklu, M. (2021). Artificial intelligence applications in engineering. In M. Ozaslan & Y. Junejo (Eds.), *Current Studies in Basic Sciences, Engineering and Technology 2021*(pp. 107–125). ISRES Publishing