Artificial Intelligence & Adaptive Learning: The Power of Being So Personalized in Education

By

Dr. Eman Ahmed Azmi

A. Prof. of Business Administration, King Saud University
(Formerly)

Doi: 10.33850/ejev.2020.73465

استلام البحث : ١٥ / ٢ /٢٠٢٠ قبول النشر: ١ / ٣ / ٢٠٢٠

Abstract

This research paper aims to provide the fundamental concepts, recent and personal thoughts and information about the artificial intelligence (AI) in its relationship with adaptive learning (AL) e-environments and applications in education. It contains a bunch of six points presenting the history of artificial intelligent, the relationship with adaptive learning, the main to the point definition of AI, with the key component areas of AI respectively. The research then show the types of artificial intelligence as evolving stages, showing the application of AI in selected sectors in general and in education in particular through the types of AI systems. The research includes eight demonstration figures with five tables and a list of research paper abbreviations for the concepts presented on it.

Introduction

This research paper aims to provide the fundamental concepts, recent and personal thoughts and information about the artificial intelligence (AI) in its relationship with adaptive learning (AL) e-environments and applications in education. It contains a bunch of six points presenting the history of artificial intelligent, the relationship with adaptive learning, the main to the point definition of AI, with the key component areas of AI respectively. The research

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The History of AI

According to the distinguish literature review of Jaakkola, Henno, Mäkelä, and Thalheim's work: "*Artificial Intelligence Yesterday, Today and Tomorrow*" (2019), they divided the history of artificial intelligence (AI) into four cycles from their paper viewpoints as demonstrated in figure (1).

AI and AL

For AI systems, the essential element in adaptive learning (AL) systems is the ability to learn from past big data coming from the three basic components of any AL electronic system that aim to provide learning items tailored to the behaviour and needs of individual learners. Those basic components include (Khamies, 2018, p.471; Forsyth, Kimble, Birch, Deel, and Brauer, 2016; and Kara and Sevim, 2013):

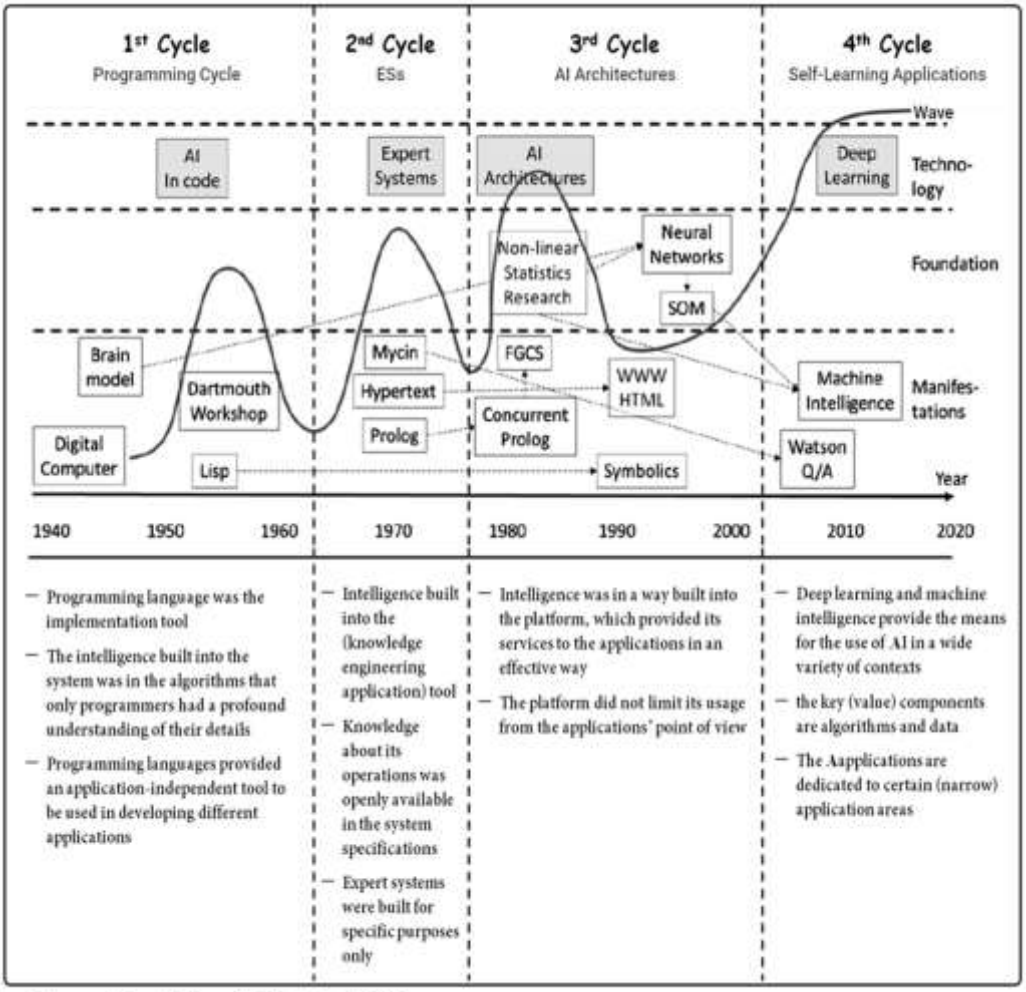
- Learner models (whether individual or group learners; also called user profiling model)
- Content models (including meta data specification; also called domain model)
- Adaptation Models (also called narrative and instructional models).

In this regard, there are three broad types of AI learning processes demonstrated in the following table (1) based on Kaplan & Haenlein (2019), Pliakosa, Joob, Parkb, Cornillieb, Vensa, and Noortgateb (2019), and Jaakkola et al (2019) works.

The key to make AL systems so adaptive and personalized is AI systems built into them which monitors student's inputs and responses and adjusts the difficulty of content accordingly. As shown in figure (2) the relationship between AL system and AI is enhancing

smarter AL applications through the dynamic, just in time, and sound interaction between the elements of data modelling, cloud computing, and big data. This will create a smart personalized adaptive learning (PAL) environment.

Figure (1): The Four Cycles of AI History from Jaakkola et al (2019) Viewpoints



Source: Adapted from Jaakkola et al, 2019

The smarter AL applications formed through the capabilities of AI allow customization of standardized training and teaching contents by providing unique pathways through the curriculum and creating small chunks of modularized content that can be assembled and used in a variety of ways based on the experience and learning ability of each person (Pliakosa et al, 2019; and TEM, 2018).

The interesting fact in this regards that the machines' ability to learn is much more related to adaptive learning through its final stage of development and improvement. Figure (3) shows the idea of machines' adaptive learning evolve through the history of AI.

Table (1): Types of AI Learning Processes

Types of Learning Process	How it works	Methods	Examples
Supervised Learning (SL)	SL methods map a given set of inputs to a given set of labelled outputs	Familiar methods like linear regression or classification trees and more complex methods like neural networks	Using a large database of labelled images to separate between images showed different entities
Unsupervised Learning (UL)	Input are labelled while the output are not. the algorithm needs to infer the underlying structure from the data itself. So, he output is derived by the algorithm itself. That why it is not possible to assess the accuracy or correctness of the resulting output. Therefore, users need to place greater trust and confidence into the AI system	Cluster analysis, giving that it groups elements in similar categories but neither structure of those clusters nor their number is known in advance	Speech recognition application in Apple's Siri and Amazon's Alexa
Reinforcement Learning (RL)	System receives an output variable to be maximized and a series of decisions that can be taken to impact the output	AI system aims to learn playing Pac-Man* game by knowing that Pac-Man can move up, down, left and right and that the objective is to maximize the score obtained in the game	Microsoft uses reinforcement learning to select headlines on MSN.com by rewarding the system with a higher score when more visitors click on a given link

* Pac-Man is a maze game that need the player to control Pac-Man, who must eat all the dots inside an enclosed maze while avoiding four colored ghosts. Eating large flashing dots called power pellets causes the ghosts to turn blue, allowing Pac-Man to eat them for bonus points. For more information about this game and real playing, visit: https://www.webpacman.com and http://www.freepacman.org

The Definition of AI

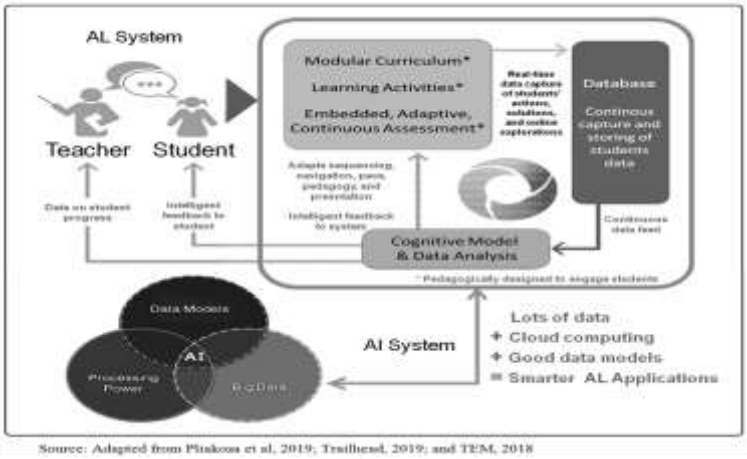
Based on the works of Kaplan & Haenlein (2019), Jaakkola et al. (2019), Future Advocacy (2018), and Panchal (2018), along with the author point of view, artificial intelligence (AI); which so called also machine intelligence, can be defined as the following:

A computer system's ability to think and behave smartly in different situations by interpreting external data correctly, learning from such data, and using those learnings to achieve specific goals and tasks through flexible adaptation. Such behaviour includes but not limited to solving problems, visual perception, speech recognition, decision-making, and translation between languages. In other words, it is the idea of giving machines the ability of learning.

That is why AI as a field combines variety and integrated disciplines like computer science, engineering, pedagogy, communication, and many other related disciplines to give such ability of learning to machines so called "artificial intelligence".

The data used to be interpreted and processed to learn are much more related to the concepts of Internet of Things (IoT) and big data (Researcher, 2019[1] and 2019[2]). The following table (2) describe the interrelationship between AI, IoT, and Big Data.

Figure (2): Enhancing the Smart Personalization of AL through AI System



Source: Adapted from Pinkcon et al, 2019; Trailhead, 2019; and TEM, 2018

Figure (3): Machine AL Evolves

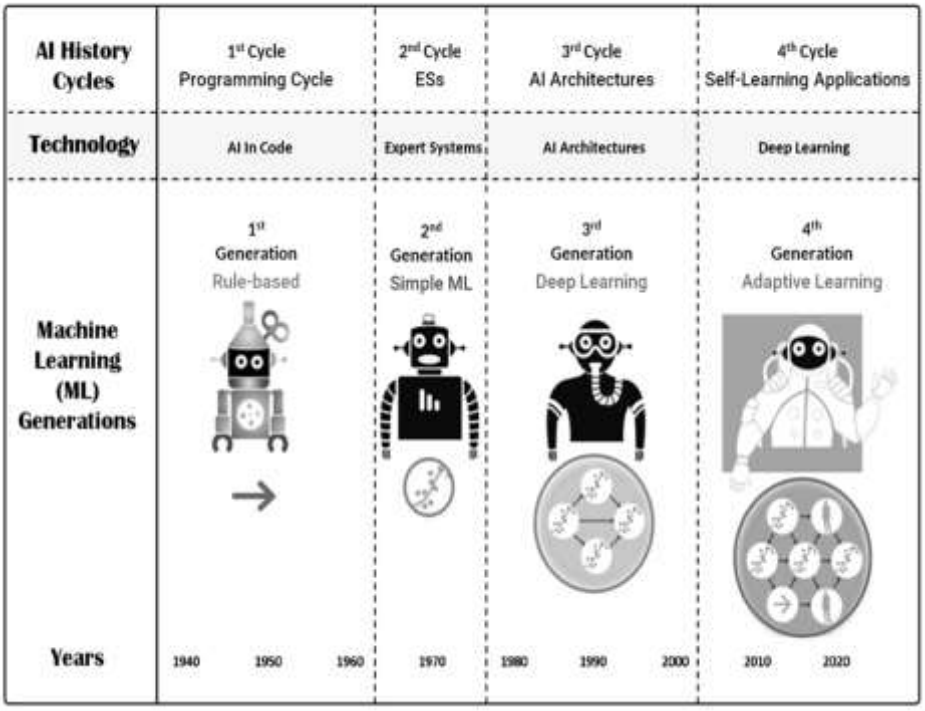


Table (2): AI, IoT, and Big Data

IoT	Big Data	AI
- Describes devices around here and there that are equipped with sensors and software to collect and exchange data - Those external data came from IoT are one input toward big data and serve as an input for AI - So, IoT are one specific way of obtaining the external data required as an input for AI	- Describes data sets characterized by huge **volume**, **velocity**, and **variety** that is, characterized by huge amounts of frequently updated data in various formats, such as numeric, textual, or images/videos - Big data is wider than IoT because it includes data collected through other means, such as mobile, social media applications, or an institution's internal database	- Uses external information obtained through IoT or other big data sources as an input for identifying underlying rules and patterns by relying on approaches from machine learning, which describes methods that help computers learn without being explicitly programmed*

* Such methods described in the AI learning processes shown in table (1) of this research

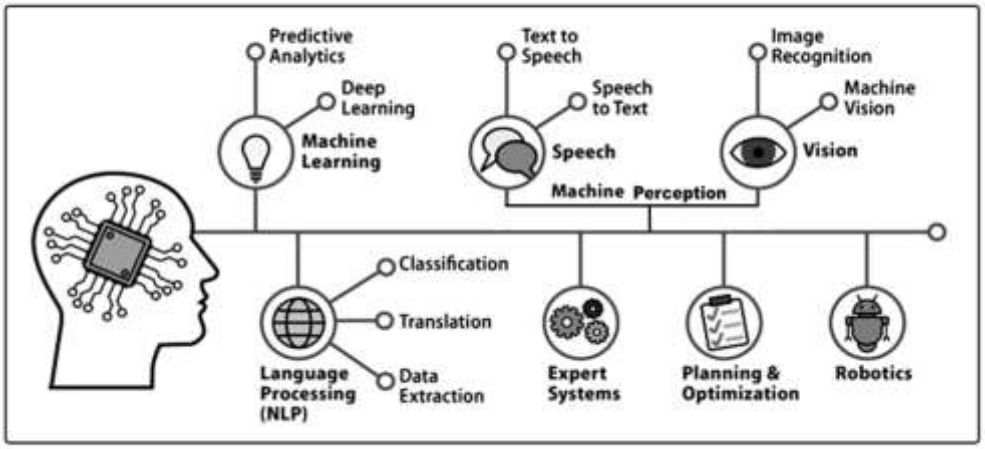
The Components of AI

The ability of computing systems to learn needs to be incorporated with advanced data analytics and big data applications. As a software driven system, AI works through intelligent agents with cloud-based AI services in a continually dynamic way that made "optical character recognition" and "computer chess" examples for routine computing. IoT technologies connect the wide variety of AI application systems include robotics, image recognition, natural language processing, real-time analytics tools and many others to deliver more advanced features and capabilities that already change the nature of work and generate a new relationship between human and machine.

To know how it works, it is important to identify the components of AI. All of them are based on the simple idea of algorithm that is, a set or sequence of step by step operations aimed to perform a calculation, process a set of data, or test a logical statement. Figure (4) shows the components of AI that include the following (Researcher, 2019[1] and 2019[2]; Greengard, 2019; Teich, 2018; and Future Advocacy, 2018):

- Machine Learning (with sub-field components of predictive analytics & deep learning)
- Machine Perception (with the ability of machine to speak and to recognize images)
- Natural Language Processing (whether for classification, translation, or data extraction)
- Expert Systems
- Planning and Optimization
- Robotics

Figure (4): The Components of AI



Source: Adapted from Greengard, 2019; and Future Advocacy, 2018

This component of AI uses statistical methods and algorithms to discover patterns systems to make predictions or decisions without explicit programming. As demonstrated before in table (1) of the types of AI learning processes, ML may consists supervised (or semi-supervised), unsupervised, and reinforcement learning processes that aim to recognize patterns in data, learn from these patterns, and subsequently make calculations and anticipations based on these data using various techniques to allow the ML algorithm to continuously improve its pattern-finding and predictive abilities. Further demonstration to those types of ML that shown how it works can be presented through their examples in the real business and education life in figure (5).

At this point, there is an interesting and more interactive concept that useful to know related to ML called online machine learning (OML) which is a method of ML in which data becomes available and used to update the model continuously, so the AI algorithm changes as it is used where and when it is necessary to dynamically adapt new patterns in the data, or when the data itself is generated as a function of time

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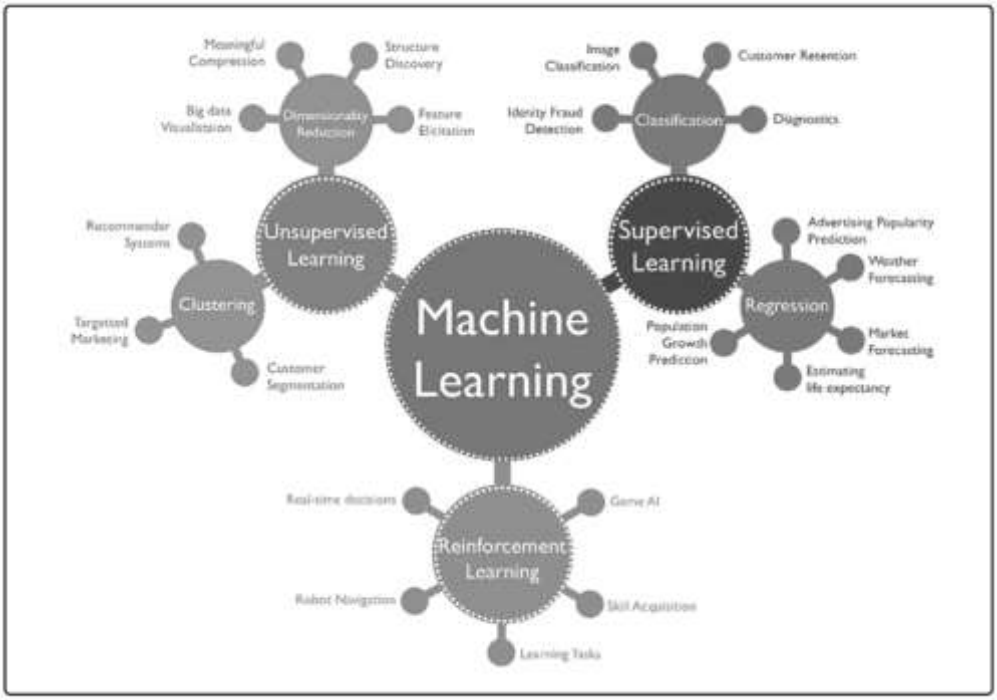
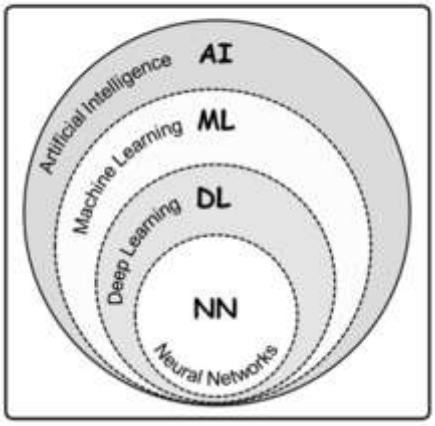
Figure (5): Examples of ML Types



Source: Jha, 2017

The approach of deep learning (DL) relies on artificial neural networks (ANNs) to approximate the neural pathways of the human brain. DL systems are particularly valuable for developing computer vision, speech recognition, machine translation, social network filtering, video games and medical diagnosis. In other words, DL systems are vital for machine perception. The corresponding figure (6) shows the

Figure (6): The Relationship Between AI, ML, DL, & NN



relationship between AI, ML, DL, and NN.

Machine Perception

These AI technologies enable a computing device to inspect, recognize, evaluate and identify speech (machine speech) and still or moving images (machine vision), using automated image capturing, evaluation and processing capabilities. Machine perception have been powered over the last few years by the huge advances in sensors cameras, microphones, accelerometers, global positioning system (GPS), radar and more, which encompasses speech recognition and computer vision used for facial and object recognition.

One of the surprisingly simple AI example of machine perception is the Google "Clips" camera that automatically shoots photos from wherever it's placed. It has machine learning built-in that learns to recognize the people who matter most to the person and decides the best moments to capture and keep.

- **Natural Language Processing (NLP)**

This technology allows machines to read, understand, and interpret human language using statistical methods and semantic programming to understand grammar, syntax, and even the emotions of the writer or those interacting with systems like Chat Bots, Siri, and Alexa. The following table (3) shows famous examples of NLP applications.

- **Expert Systems (ESs)**

In AI, expert system is an interactive and reliable computer-based and decision-making system which uses both facts and heuristics to solve complex decision-making problems in a way that emulates the decision-making ability of human expert which solves the most

complex issues in a specific domain based on knowledge obtained from an expert.

ESs are designed to solve complex problems by reasoning through bodies of knowledge, represented by "if – then" rules rather than traditional procedural code. ESs considered as the grandfather of AI, ML, and DL systems.

Table (3): Examples for NLP Well-Known Applications

NLP Application	Chat bots* 	Siri** 	Alexa*** 
Description	A computer programme that conducts a conversation via auditory or textual methods. There are two types of chatbots: 1. those that operate on a set of rules, and 2. those that are powered by AI	A virtual assistant that uses voice queries and a natural language user interface to answer questions, make recommendations, and perform actions by delegating requests to a set of Internet services	A virtual assistant developed by Amazon that has the capability of voice interaction, music playback, making to-do lists, setting alarms, streaming podcasts, playing audiobooks, and providing weather, traffic, sports, and other real-time information, such as news

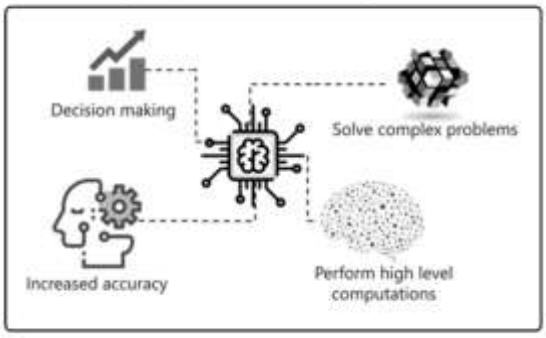
* For more information about chat bots, visit: https://www.chatbot.com
** For more information about Siri application, visit: https://www.apple.com/siri
*** For more information about Alexa software, visit: https://www.alexa.com

- **Planning and Optimization**

With the huge increase in computer performance, many AI systems used to discover many things about data and have been combined with other systems to get the desirable benefits in many business and education areas. Planning and optimization are the main benefits of using AI, giving that planning is a long-standing sub-area of AI. It is the task of finding a procedural course of action for a declaratively described system to reach its goals while "optimizing" overall performance measures.

Optimization here is a mathematical way of finding the maximum or minimum value of some function. It takes a set of costs, constraints and goals to determine an award scenario that maximizes the goals subject to the constraints and the costs provided. This may had be done in more efficient, effective, and productive way that generates the main advantages of AI shown in figure (7).

Figure (7): The Main Advantages of AI



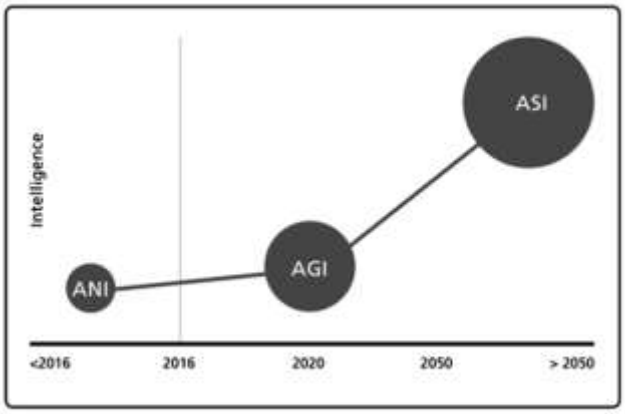
Source: Lateef, 2019

- **Robotics**

Robotics is the field of design, construction, operation, and application of robot devices that are widely used in factories, hospitals and other settings. These robot systems rely on sophisticated mapping and complex programming, and use machine perception to navigate through tasks.

Types of AI

Figure (8): The Evolution of AI Types



Source: Jonker, 2019

Theoretically, there are three types of AI that present actually the stages of artificial intelligence. Figure (8) demonstrates the evolution of those AI types, and table (4) shows the area of differences between each of them. They are (Kaplan and

Haenlein, 2019; Jonker, 2019; and Panchal, 2018):

- Artificial Narrow Intelligence (ANI)
- Artificial General Intelligence (AGI)
- Artificial Super Intelligence (ASI)

Applications of AI in Education

Based on the AI systems; analytical, human-inspired, and humanized AI demonstrated in previous table (4), Kaplan and Haenlein (2019) illustrate some AI applications from their visualization within specific sectors include universities, corporations, and governments. The following table (5) shows those applications.

Holmes (2019), and Lu and Harris (2018) argue that in some cases, AI performs functions independently of teachers, while in others it augments teaching capabilities. They show some applications of AI-based education technology to include the following:

- **Tutoring:** AI programs commonly referred to as Intelligent Tutoring Systems (ITS) or adaptive tutors engage students in dialogue, answer questions, and provide feedback.
- **Personalizing Learning:** ITS and adaptive tutors tailor learning material, pace, sequence, and difficulty to each student's needs. AI can also provide support for special needs students, for example by teaching autistic children to identify facial expressions.

Table (4): Types of AI

Types of AI	ANI Artificial Narrow Intelligence	AGI Artificial General Intelligence	ASI Artificial Super Intelligence
Human level	Weak Below Human level AI	Strong Human level AI	Conscious and Self-Aware Above Human level AI
AI System	Analytical AI Related to cognitive intelligence	Human-Inspired AI Related to cognitive as well as emotional intelligence	Humanized AI Related to all types of cognitive, emotional, and social intelligences*
Feature	Can recognize the voice but cannot perform other tasks like driving a car Well-known in performing a single task with smartness	Evolves into a humanoid robot with wide capabilities including voice recognition, coffee preparation, and writing skills Applied to do various tasks with learning and improving itself	Develops super human capabilities such as solving complex mathematical problems at once or writing a best seller books Can think in matters impossible for humans to think with computer superior cognitive ability to a human's
Charact-eristics	• Applies AI only to specific areas • Unable to autonomously solve problems in other areas • Outperforms or equals humans in specific area	• Applies AI to several areas • Able to autonomously solve problems in other areas • Outperforms or equals humans in several areas	• Applies AI to any area • Able to solve problems in other areas instantaneously • Outperforms humans in all areas
Examples	• Speech Recognition: can only recognize speech • Voice Assistants: only act upon voice commands which perform a certain action	The application of AlphaGo**: able to play the game of Go, but its intelligence could be applied in various other fields also	Matter of the time when the capability of computers will exceed humans

* Such AI systems that able to be self-conscious and self-aware in their interactions with others are not available yet

** AlphaGo is a computer program that plays the board game Go which is an abstract strategy board game for two players, in which the aim is to surround more territory than the opponent. AlphaGo was developed by DeepMind Technologies and later acquired by Alphabet Inc.'s Google. For more information about AlphaGo, visit: https://deepmind.com and https:// www.alphagomovie.com

Table (5): AI Applications in Universities, Corporations, and Governments

AI Systems	Analytical AI	Human-Inspired AI	Humanized AI
Universities	Virtual teaching assistants able to answer student questions and tailor reactions to individual data	AI-based career services able to identify emotions to improve interview techniques of students	Robo-teachers animating a student group by acting as moderator and sparring partners
Corporations	Robo-advisors leveraging automation and AI algorithms to manage client portfolios	Stores identifying unhappy shoppers via facial recognition at checkouts to trigger remedial actions	Virtual agents dealing with customer complaints and addressing concerns of unhappy customers
Feature	Automation systems to set the brightness of streetlights based on traffic and pedestrian movements	Virtual army recruiters interviewing and selecting candidates based on emotional cues	AI systems able to psychologically train soldiers before entering a war zone

Source: Kaplan and Haenlein, 2019

- **Testing:** Computer adaptive assessments adjust the difficulty of successive questions based on the accuracy of the student's answers, enabling more precise identification of a student's mastery level.
- **Automating Tasks:** AI can perform routine tasks such as taking attendance, grading assignments, and generating test questions.

Conclusion:

Artificial intelligence (AI) as a computer system has the ability to think and behave smartly in different situations. The main processes for doing such thinking and behaviour are done by interpreting external data correctly, learning form those data, and using the result learning to achieve specific goals and tasks through flexible adaptation. Whether solving problem, visual and speech recognition, decision making, or translation between languages, the process of giving machines the ability to learn has been evolved through four historical cycles over the time. Starting with programming cycle in 1940s to 1960s, then the expert systems cycle

in 1970s, and AI architectures cycle in 1980s to 2000s, till the fourth cycle of self learning application in 2010s and beyond.

The relationship between AI and adaptive learning (AL) is quite interrelated and integrated from the author point of view. The way that artificial intelligent machines learn is a kind of adaptive learning process with any of the types of machine learning that supervised, unsupervised, or even reinforced. The data models of big data hand on hand with processing power of those data as a strong capabilities of AI could result in smarter, so personalized AL applications. The key components area of AI in this regard to do so are machine learning (ML), machine perception, natural language processing (NLP), expert systems, planning and optimization, and robotics.

In the near future, the evolution of AI systems from the narrow and general intelligences to the supper one could be a reality so soon with conscious and self aware machines that humanized to the extent of having the crucial kind of cognitive, emotional, and social intelligences. The applications of AI in education may be varied between AI independent functions of teachers and the AI functions that augmenting human teaching capabilities. The main AI-based education technologies include the intelligent tutoring systems (ITS), personalizing adaptive learning (PAL), testing, and automating administrative and educational routine tasks.

List of Abbreviations

AGI: Artificial General Intelligence
AI: Artificial Intelligence
AL: Adaptive Learning
ANI: Artificial Narrow Intelligence
ANNs: Artificial Neural Networks
ASI: Artificial Super Intelligence
DL: Deep Learning
ESs: Expert Systems

GPS: Global Positioning System
IoT: Internet of Things
ITS: Intelligent Tutoring Systems
ML: Machine Learning
NLP: Natural Language Processing
NN: Neural Networks
OML: Online Machine Learning
PAL: Personalizing Adaptive Learning
RL: Reinforcement Learning
SL: Supervised Learning
UL: Unsupervised Learning

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