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Artificial Intelligence and Innovative Applications in Special Education

Nihal Şen*[1], Tuncer Akbay [2]

* *Corresponding, nihalllsennn@gmail.com*
[1]*Bolu Abant İzzet Baysal Üniversitesi, Türkiye*
[2]*Burdur Mehmet Akif Ersoy Üniversitesi, Türkiye*

Abstract

Artificial intelligence can be defined as systems that imitate human intelligence to fulfil tasks and can iteratively improve themselves according to the data they collect. Artificial intelligence applications, which are among innovative technologies, are widely used in the field of education as well as in many different fields such as entertainment, medicine, cyber security, transport, tourism, e-commerce, banking, and finance. Developments in artificial intelligence applications have brought different innovations in the field of special education as in other fields of education. This research aims to evaluate the role of various artificial intelligence applications in meeting the needs and wishes of individuals with special needs. In the current research, narrative inquiry research method was preferred to develop an in-depth understanding of artificial intelligence applications in special education. According to the results of the research, it can be concluded that artificial intelligence applications successfully meet the needs and wishes of individuals with special needs. Artificial intelligence adapted to the needs of individuals offers personalized assistance to identify their deficiencies and support their development. In addition, AI applications help individuals with special needs to interact emotionally with their parents, teachers, psychologists, and other people around them in a more comfortable way.

Keywords: Artificial intelligence, Machine learning, Deep learning, Special education, Disability

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Özel Eğitimde Yapay Zekâ ve Yenilikçi Uygulamalar

Özet

Yapay zekâ, görevleri yerine getirmek için insan zekasını taklit eden ve topladıkları verilere göre kendini yinelemeli olarak geliştirebilen sistemler olarak tanımlanabilir. Yenilikçi teknolojiler arasında yer alan yapay zekâ uygulamaları, eğlence, tıp, siber güvenlik, ulaşım, turizm, e-ticaret, bankacılık ve finans gibi birçok farklı alanda olduğu gibi eğitim alanında da yaygın olarak kullanılmaktadır. Yapay zekâ uygulamalarındaki gelişmeler eğitimin diğer alanlarında olduğu gibi özel eğitim alanında da farklı yenilikleri beraberinde getirmiştir. Bu araştırma, çeşitli yapay zekâ uygulamalarının özel gereksinimli bireylerin gereksinimlerini ve isteklerini karşılamadaki rolünü değerlendirmeyi amaçlamaktadır. Mevcut araştırmada, özel eğitimde yapay zekâ uygulamalarına yönelik derinlemesine bir anlayış geliştirmek amacıyla anlatı incelemesi araştırma yöntemi tercih edilmiştir. Araştırma sonuçlarına göre, yapay zekâ uygulamalarının özel gereksinimli bireylerin ihtiyaçlarını ve isteklerini başarılı bir şekilde karşıladığı sonucuna ulaşılabilir. Bireylerin ihtiyaçlarına göre uyarlanan yapay zekâ, eksikliklerini tanımlamak ve gelişimlerini desteklemek için kişiselleştirilmiş yardımlar sunmaktadır. Ayrıca, yapay zekâ uygulamaları özel gereksinimli bireylerin ebeveynleri, öğretmenleri, psikologları ve çevrelerindeki diğer kişilerle daha rahat bir şekilde duygusal etkileşimde bulunmalarına yardımcı olmaktadır.

Anahtar Kelimeler: Yapay zeka, Makine öğrenme, Derin öğrenme, Özel eğitim, Yetersizlik

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1. Introduction

With the rapid progress of technology and science, people's interest in technology products is increasing day by day, regardless of what age they are and what environment they live in. The use of technological products that affect every aspect of daily life is also frequently encountered in the field of education. Developments in technology have brought different innovations in the field of special education as well as in other areas of education. Beside the proliferation of information sources in technology and the increase in the variety of technological products, technology secures its position in the field of special education day by day through its various effects, such as easy accessibility, rapid use, and appealing to more than one sense.

Rapid technological development has caused significant changes in the lives of individuals with special needs. The use of technology in special education offers individuals the opportunity to learn without the restriction of time and place. In technology-supported special education environments, instruction can be carried out according to students' own interests and needs, taking individual differences and learning styles into account. In such environments, individuals can learn by themselves according to their own learning speed and develop the ability to access information without the help of another individual. Through the effective use of technology, individuals with special needs can express themselves more easily in any subject or field in which they want to express themselves.

Artificial intelligence (AI) has played an undeniable role in most of the technological developments of recent years. AI-based computer applications, robots, and other technological devices provide users with great convenience in all areas of human life. In recent decades, AI applications have also begun to find a place in the field of special education. It is anticipated that AI applications will be useful for the diagnosis and evaluation of individuals with special needs, the design of instructions by taking individual differences and learning speeds into account, and the development of independent living skills. Recent developments in AI applications in special education can enable the development of collaborative, interactive environments for individuals with special needs and facilitate their lives and those of their caregivers. Applying AI, it is possible for individuals with special needs to improve their quality of life in school, home, and work environments.

Looking at the AI studies in the special education literature, one may realize there are several studies conducted in the field. Yet, a closer look suggests that few of them review studies (Barua et al., 2022; Chassignol et al., 2018; Drigas & Ioannidou, 2013; Drigas & Ioannidou, 2012). Barua et al., (2022) summarize the diversity and effectiveness of artificial intelligence-assisted tools developed using machine learning models to address learning difficulties in students with neurodevelopmental disorders. Chassignal et al., (2018) conducted research to determine the impact of AI on education and to offer a broad perspective on this issue. Drigas and Ioannidou (2013) present some studies between 2001 and 2010 using AI methods for accurate diagnosis and intervention in individuals with special needs. Drigas and Ioannidou (2012) present some studies between 2001 and 2010 that were used for diagnosis and intervention in different disability groups. When the studies are examined, it should be seen that there is no current and comprehensive study on artificial intelligence applications in special education. The current review study examines the current situation of AI applications to meet the needs and desires of individuals with special needs and to provide a broader perspective on this issue. This study is expected to contribute to the literature and increase awareness of the developments in artificial intelligence applications in the field of special education. In addition, this study explicates the connection between artificial intelligence and special education. It is also expected that the study will guide the use of artificial intelligence in special education and contribute to the design of artificial intelligence applications to be developed for individuals with special needs.

1.1. Artificial Intelligence

Artificial intelligence is a complex concept in its use, configuration, and development processes. It is defined in different ways by many researchers. John McCarthy, one of the pioneers of artificial intelligence, stated in 1955 that the purpose of artificial intelligence was to develop machines that acted as if they were intelligent (Ertel, 2017). Sağıroğlu et al. (2003), on the other hand, define the human brain as thinking, interpreting, and learning situations by imitating them with the programming method and using them for problem solving. According to another definition in the literature, artificial intelligence is all activity dedicated to making machines intelligent (Wang et al., 2015). In this definition, artificial intelligence is defined as the attribute enabling an entity for working appropriately and predictably. Şen (2018) expressed artificial intelligence as the conversion of human intelligence into computer software by making simplifications, emphasizing that artificial intelligence was inspired by the functions of the

human brain to facilitate social and economic life. Although the definitions of artificial intelligence are made in different ways, the common point is that computers with artificial intelligence software use existing data to behave in a way that can be considered intelligent.

1.2. Sub-Branches of Artificial Intelligence

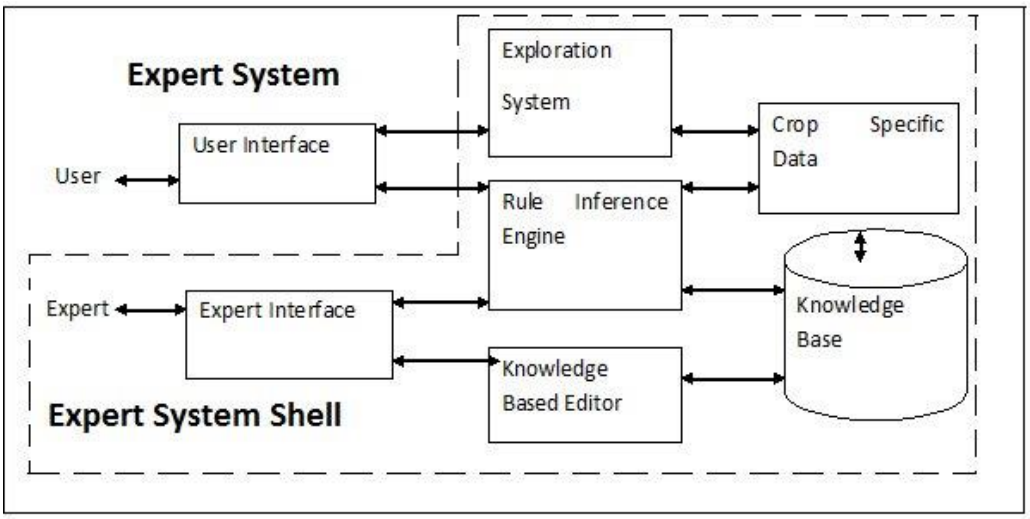
The definition of artificial intelligence covers extensive area. The necessity of conducting field-specific studies has led the emergence of sub-fields of artificial intelligence such as expert systems, intelligent agents, machine learning, artificial neural networks, deep learning, genetic algorithms, fuzzy logic, intelligent teaching systems, and natural language processing.

Expert Systems

An expert system is a computer program designed to imitate the judgment and behavior of someone with vast knowledge and experience in a particular field (Gupta & Nagpal, 2020). Expert systems indeed consist of a knowledge base that contains cumulative experiences, and rules that guide how to use that knowledge base in each specific situation. Gupta and Nagpal (2020) described the qualities of a good expert system as: meeting a specific need, being user-friendly, allowing users to increase their own expertise by using the system, explaining the reasoning process, asking questions to the user to obtain additional information, providing high-quality output, producing decisions just in time, and using heuristics.

Figure 1.

Expert systems architecture (Source: Islam, 2013; ShellAg: Expert System Shell for Agricultural Crops.).



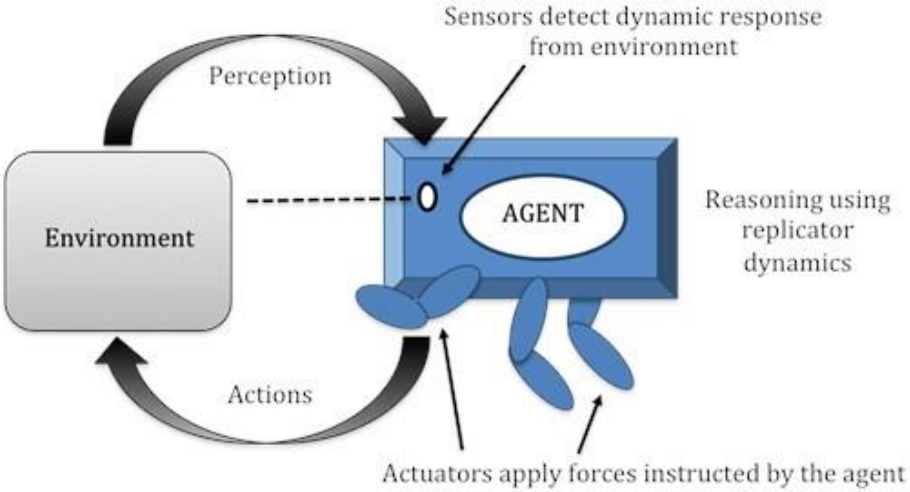
Expert systems are generally comprised of the following elements: the interface that provides communication between the user and the system; the knowledge base that contains the information obtained from the field experts; the database where the data of the problem to be solved is kept, the inference engine that produces the reasoning of the rules; and the rules used in inference (Islam, 2013). It consists of an explanation facility, where it is explained to the user, and a knowledge base editor that enables experts and information specialists to exchange data with the data system. The model of the components in the expert system architecture is shown in Figure 1.

Intelligent Agents

Intelligent agents, also known as systems making decisions autonomously based on the current situation using a variety of artificial intelligence techniques, may be defined as software that carries out operations for users or programs after detecting the environment (Mbaabu, 2020). An agent generally refers to a system that can process data to produce outputs from inputs (Ertel, 2017). An agent perceives its environment through sensors and acts in that environment through actuators (Russell & Norvig, 2020). Relying on this definition, literature suggests three different types of agents: human, robot, and software agents. People have organs and limbs that enable them to perceive the environment (e.g., eye, ear, etc.) and move in the environment (e.g., arm, foot, etc.). These features are sufficient to consider them agents. The reason why robots are considered agents is that they have sensors such as cameras and infrared range finders that they use to sense the environment, and motors that provide them with movement (Nayak & Das, 2020). Software agents, on the other hand, use input from humans and other file contents that are received through input units to detect the environment. In addition, they take actions such as sharing, displaying, and printing the outputs they produce, that is why software may also be considered intelligent agent (Russell & Norvig, 2020). An intelligent agent basically consists of an architecture with sensors and actuators (a robotic car, a computer, etc.) and an agent program (Soto & Adeli, 2017). Intelligent agents take various perceptions or pieces of information from the environment, process them using machine learning algorithms, and then act as programmed or trained. The structure of an intelligent agent is shown in Figure 2.

Figure 2.

Structure of intelligent agents (Soto & Adeli, 2017).



Machine Learning

Machine learning is a collection of algorithms that learn from recorded data which enables them to (1) make predictions based on the data, (2) optimize a certain utility function under uncertainty, (3) extract hidden structures from data, and (4) classify data (Amazon, 2021). The idea of transferring the necessary skills to the computer through examples that the machine can learn, instead of giving the instructions to the computer directly, allowed the machine to learn (Kubat, 2017). Machine learning techniques are divided into three categories: supervised machine learning, unsupervised machine learning, and reinforcement learning. They can develop a model with supervised machine learning using algorithms such as decision trees, support vector machines, linear regression, logistic regression, and nearest neighbor. To create a solution (model) of a problem with supervised machine learning algorithms, a training dataset is required. The training dataset must include both output and input data related to the problem that is expected to be solved. Due to training data set, machines can learn the relationship between input and output data. Based on the input-output relations it learned, it can perform operations like classification and regression. The goal of this type of machine learning algorithm is to predict the output data from known input data using the learned input-output data relationship. On the contrary, using datasets that do not contain specified input-output relationships, unsupervised machine learning algorithms such as clustering, principal component analysis, and association rules aim to discover patterns, identify relationships

among data, and group data within datasets. Semi-supervised learning perceives the situation or environment it is in, matches the situation with alternative actions, and focuses on systems that can decide which action to take for long-term benefit (Kaur et al., 2021). Machine learning has a wide range of applications. The most preferred ones are applications such as face recognition, understanding spoken language, optical character recognition, mail filtering, medical uses, prognosis and diagnosis, object recognition, etc. (Rende et al., 2016).

Artificial Neural Networks

Artificial neural networks are parallel and distributed information processing structures that are connected to each other through weighted connections and comprised of processing elements that each have their own memory (Montesinos López, 2022); in other words, they are computer programs that imitate biological neural networks (Elmas, 2003). Artificial neural networks can use biological brain abilities such as learning and making fast and situational decisions to solve nonlinear problems. Just as external stimuli are needed for learning to occur in biological organisms, artificial neural networks also require external stimuli which is provided with training data containing examples of input-output pairs of the function to be learned (Aggarwal, 2018). Many input-output pairs provide information about the problem to be solved. Artificial neural networks can make solution-oriented generalizations using the provided information. As long as they are fed with enough training data, artificial neural networks produce outputs from single inputs based on previously learned input-output pairs in the problems. The ability of artificial neural networks to learn from input-output pairs and generalize from what they have learned has allowed them to be widely used in many fields such as image and sound recognition, fault analysis, prediction and estimation, control and system identification, medicine, communication, and traffic (Pirim, 2006). Artificial neural networks basically consist of processing units called nodes located in the input layer, the output layer, and the hidden layers between those two. The nodes in each layer are connected to the nodes in the previous and following layers. Connections between nodes have certain weights. The data progresses from the input layer to the output layer. The data is multiplied by the weighting coefficient between the relevant nodes. At each node, the weighted values obtained from the nodes in the previous layer and bias are summed together and used as input for an activation function (Ahmed, 2023). The output of the function is then passed as input to the processing unit in the following layer. The function result of the output layer produces a

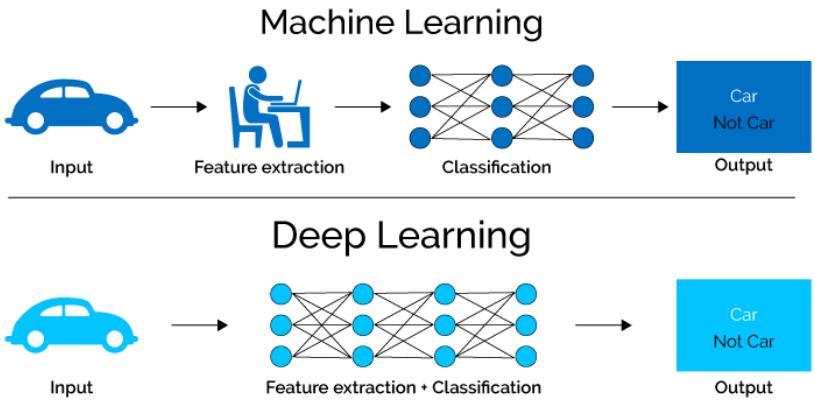
solution to the problem (Shrestha & Mahmood, 2019). Most basic machine learning models, such as linear regression, classification, support vector machine, and logistic regression are simulated with neural networks with a single layer. While artificial neural networks comprised of two- or three-layers are considered simple artificial neural networks, artificial neural networks containing more than three layers can be considered deep learning (Skansi, 2018).

Deep Learning

Deep learning is a special approach that tries to learn high-level abstractions using hierarchical architectures produced by increasing the number of hidden layers in simple artificial neural networks (Guo et al., 2016). Deep learning aims to expand the scope of supervised, unsupervised, and reinforcement learning to solve other problems in the field of artificial intelligence that simple machine learning algorithms are unable to solve, such as reasoning and planning (Skansi, 2018). Deep learning is used for many different processes, such as signal processing, image processing, language processing, and voice recognition. Figure 3 depicts the comparison between machine learning and deep learning.

Figure 3.

Comparison between machine learning and neural network (Source: Mao et al., 2020).



Genetic Algorithms

The use of metaheuristic algorithms, such as genetic algorithms, that allow one to find solutions to real-life problems in many fields, including education, is becoming increasingly common (Kumar, Chhabra, & Kumar, 2014). Genetic algorithms, one of the best-known AI subfields, are a family of computational models inspired by biological evolution. These computational models optimize the search tool for real-life problems by imitating the natural selection

principle to find one of the best possible solutions (Lambora, Gupta, & Chopra, 2019). Since genetic algorithms mimic the theory of survival of the fittest in nature, they yield solutions for successive generations (Katoch, Chauhan, & Kumar, 2021; Lambora, Gupta, & Chopra, 2019). To find one of the best solutions, genetic algorithms go through the following main phases (Mathew, 2012; Mirjalili et al., 2020):

1. Initialization: To solve a problem through a genetic algorithm, the population of chromosomes must be defined first. Each chromosome can be depicted as an alternative solution point in the solution space.
2. Fitness Function: This is the phase in which the suitability of each solution is calculated and evaluated.
3. Selection: According to fitness values, the chromosomes are selected as many times as it takes to obtain enough progenitor chromosomes that will produce offspring solutions to replace the solution set.
4. Crossover: In this phase, fixed sections of progenitor chromosomes are swapped to produce offspring solutions to the problem.
5. Mutation: It is the phase where random tweaks occur within the chromosomes to prevent the algorithm from getting stuck at local optima.

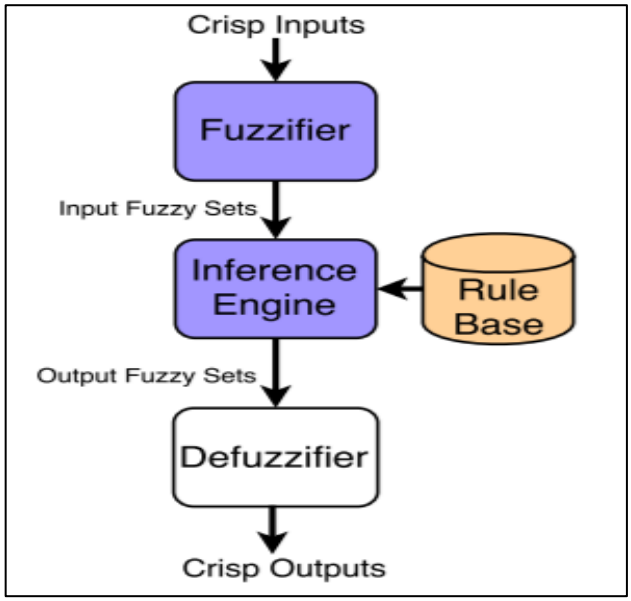
Fuzzy Logic

In classical logic, every entity belongs to a certain set. The elements of the set are determined. One entity is either a member of a set or it is not. In fuzzy logic, there is the concept of partial membership. In fuzzy logic, an entity can be a partial member of more than one set (Eğrisöğüt Tiryaki, & Kazan, 2007). Here we come across the concept of fuzzy sets. In fuzzy sets, the membership degrees of the set elements can take values ranging from zero to one (Zadeh, 1965). While determining the degree of membership, a generalized characteristic function known as the membership function is used (Eğrisöğüt Tiryaki, & Kazan, 2007). In classical logic, there are sharp limits to the set. The existence of partial membership differentiates fuzzy sets from classical sets. Fuzzy logic is a logical system that can explain the properties of any entity by looking at which set belongs to and to what extent; thus, it produces results for unclear situations (Kambalimath & Deka, 2020; Özdemir & Kalınkara, 2020). From a fuzzy logic point of view, there are degrees of right or wrong, so it is possible to get more accurate results when

fuzzy logic algorithms are used instead of classical logic in cases where right and wrong are intertwined. The basic workflow implemented in fuzzy logic systems is shown in Figure 4.

Figure 4.

Fuzzy logic workflow (Source: Bhattacharjee et al., 2018).



In order to apply the fuzzy logic technique, according to Bai, Zhuang, and Wang (2006), the following steps should be carried out:

1. Fuzzification: transform classical data or clear data into fuzzy set data or membership functions.
2. Fuzzy inference process: membership functions are combined with control rules to get fuzzy output.
3. Defuzzification: using different methods, each associated output is calculated and created into a chart like a lookup table. During an application, the appropriate output is reached from the chart according to the available input.

Natural Language Processing

Natural language processing is defined by Liddy (2001) as a set of computational techniques used to analyze naturally occurring texts at one or more levels of linguistic analysis in order to achieve human-like language processing. The purpose of natural language processing is to analyze the rules of natural languages to be understood or reproduced. Working in the

background of many services, from chatbots to virtual assistants, Natural language processing enables machines to find the complex meaning in our sentences (Ambroz, 2019).

Natural language processing enables machines to perform many functions, such as translating written documents, understanding, and responding to verbal/textual commands, synthesizing speech, producing text, grading essays, summarizing texts etc.

2. Method

This study was conducted using the narrative analysis method. Narrative inquiry is a qualitative research method that involves a comprehensive information collection and synthesis process (Green et al., 2006). This method does not require the identification of a definite research question or hypothesis in advance. Therefore, it offers a more flexible approach and allows researchers with the freedom of conducting a comprehensive examination on various topics or problems as long as provide synthesis in a readable format (Green et al., 2006). Narrative literature review is considered a useful research method when it is difficult or inappropriate to formulate a specific research question or search strategy. This method can serve a variety of research purposes and offer researchers greater flexibility and freedom of exploration (Ferrari, 2015; Green et al., 2006).

In this study, the narrative inquiry method was adopted to gain a comprehensive understanding in the fields of special education and artificial intelligence. The research was conducted following the steps suggested by Demiris, Oliver, and Washington (2019). Firstly, a search was conducted in reputable databases such as Web of Science, Scopus and Springer eBooks using general subject keywords such as special education, artificial intelligence and virtual assistant. Then, more specific keywords were defined by reviewing these documents and searches were conducted in other sources with these keywords. The documents were meticulously analyzed and carefully selected to obtain the intended information, which was then synthesized and summarized to report the findings. Following steps increased the accuracy, reliability, and the ability of the research to provide a detailed review. The research has the potential to provide greater understanding of important issues and topics at the intersection of the fields of special education and artificial intelligence. A careful review of the documents yielded the intended information, which was then summarized, and the findings reported. Following these steps has increased the accuracy, reliability, and capacity of the

research to provide a detailed review. The research has the potential to provide a deeper understanding of important issues at the intersection of special education and artificial intelligence.

3. Result

Indeed, almost all the artificial intelligence technologies mentioned above have been developed for purposes other than special education. Nevertheless, their use in the special education field has become increasingly widespread over time. The following sections are about the use of artificial intelligence for the purpose of facilitating the lives of individuals with special needs.

Artificial Intelligence Applications in Individuals with Visual Impairments

For centuries, people have resorted to technology to facilitate the lives of individuals with visual impairments. One of the focal points of recent technological innovations is to help individuals with visual impairments. To allow individuals with visual impairments to live independently, many wearable technologies and mobile applications based on artificial intelligence technology have been developed and offered to users. Some advantages of using these products for people with visual impairments may be considered as recognizing and communicating with people around them; identifying money and objects, which allows them to shop independently, and allowing them to read text. Thus, AI-supported technology enables them to interact with the world.

One of those innovative products that improves the lives of visually impaired individuals is Aipoly. In 2015, it started to attract people's attention after winning the Consumer Technology Association's Innovation Award in 2017 (Rego, 2017). Relying on AI technology, the Aipoly application helps people with visual impairments recognize and interact with people as well as objects around them. The application captures the image of the object to be defined and transforms it into words or sentences in a short time using certain algorithms. This may seem like a simple task, but various artificial neural network models are running in the background of the application to provide immediate responses to users (Mao et al., 2020). People can easily recognize the appearance of new things, remember their names, and categorize things that look similar using their senses such as sight, hearing, and touch. Aipoly is used to identify people, food, household items, store packaging, plants, animals, colors, text, etc. (Najafzade, 2020). The biggest handicap of this application is that users have to point the camera at the object they

wish to identify (Mulfari, Minnolo, & Puliafito, 2017). Santoki and Patvardhan (2019) conducted mixed research with 40 visually impaired people to evaluate the effectiveness of Aipoly vision. They found that 80 percent of the participants are extremely happy with Aipoly vision. They stated that Aipoly's vision is "completely helpful, whereas the rest have faced certain inconveniences" (p.271). They also reported that "a set of people are not fully convinced of the AI-based apps functioning. These were typically based on incorrect object identification, difficulty in understanding the accent and a lack of facility for regional language conversion" (p. 271).

OrCam company, which defines its mission as benefiting from the power of machine vision by incorporating innovative technologies into wearable technologies to make the lives of those with visual impairment and those having reading difficulties, developed the MyEye device in 2015 and the second generation MyEye 2.0 in 2017 (OrCam, 2021). Using advanced artificial intelligence technology, MyEye helps visually impaired individuals read text, recognize faces, distinguish products and brands, and identify currency. It aims to increase the quality of life of individuals with visual impairments and those having reading difficulties through advanced machine vision technology. MyEye is a small wearable device that can read digital text as well as printed text on physical media such as newspapers, books, food labels, street signs, and restaurant menus (Sprogis, 2019). The first generation Orcam MyEye has an 8-megapixel camera, and the text-to-speech feature is initiated with the "trigger" button on the device (Granquist et al., 2021). Its face recognition system can recognize faces previously saved in the device's memory, thus, once a recognized face enters the MyEye view, the name of the recognized face is announced. MyEye is comprised of two parts, (1) a head unit has a camera, which can be attached to any eyeglass, and a speaker, whereas (2) a processing unit has a charger port and buttons (e.g., power, trigger, and volume) to operate the device (OrCam, 2021). The user can read the text by either clicking MyEye's "trigger button" or simply pointing their finger at the text (Sprogis, 2019) which makes it an assistive technology tool that can be activated by hand gestures. With AI supported devices, it is possible for visually impaired people to read books or their own emails anytime, anywhere. Face recognition is another technology that makes visually impaired individuals more comfortable and active in their social environments. Wearables like the OrCam MyEye can help people with low vision read books (text and pictures), recognize faces, and even distinguish between products and brands

using face recognition technology (Chen et al., 2019). It has a potential to help individuals with visual impairments to meet other people and socialize in society. It may give them greater mobility by enabling them to recognize objects around them.

Seeing AI, a device like OrCam MyEye, allows visually impaired individuals to recognize faces and money, to read texts, to scan barcodes, and to distinguish products (Granquist et al., 2021). Granquist et al., (2021) conducted a study to compare the performances of these two devices, which both rely on artificial intelligence technology. Their study reported that,

> "Both aids achieved greater than 95% accuracy in text recognition for flat, plain word documents and ranged from 13 to 57% accuracy for formatted text on curved surfaces. Both aids could read print sizes as small as 0.8M (20/40 Snellen equivalent, 40 cm viewing distance). Individuals successfully completed 71% and 55% ($p = .114$) of tasks while using Orcam MyEye 1 and Seeing AI, respectively. There was no significant difference in time to completion of tasks ($p = .775$). Individuals believed both aids would be helpful for daily activities" (p. 277).

AI technology is also used to enable individuals who cannot drive a motor vehicle due to their mental or physical disabilities to travel independently and safely. There are some a self-driving vehicle project relying on artificial intelligence technology that is still under development. The first fully functional prototype that is 100% autonomous without a steering wheel, brake pedal, or accelerator pedal and collects information through many cameras and sensors on it was produced by Google (Waymo, 2019). The first fully autonomous vehicle used on public roads was tested in the state of Texas, USA, with its only visually impaired passenger named Steve Mahan (Goggin, 2019). The autonomous vehicle developed by Google is just one of many self-driving cars that depends on artificial intelligence technology. Such cars may also serve to ease the life of individuals with special needs.

Artificial Intelligence Applications in Individuals with Hearing Impairments

AI technology changes the lives of individuals with hearing impairments as well. AI-based smart hearing devices such as Widex's Evoke provide a hearing aid wirelessly. While the hearing device is connected to the EVOKE application running on the smartphone, EVOKE can receive surrounding sounds and classify them as "background noise" or "significant noise" (WS Audiology, 2022). This app allows individuals with hearing impairments to focus on the sound

they want to hear. The app (e.g., EVOKE) that comes with the hearing aid allows individuals with hearing impairments to set their preferences for the sound they want to hear (Widex, 2023).

EVOKE is designed to meet the wearer's real-life listening intent through a combination of automation and personalization by SoundSense Learn (SSL), a real-time machine learning algorithm that quickly and intuitively adjusts hearing aid parameters to provide the user with the best listening experience (Balling, Townend, & Switalski, 2019). SSL is a feature in Widex MOMENT™ and Widex EVOKE™ devices that optimizes sounds using artificial intelligence according to the environment the user is in (Balling et al., 2021; Nielsen, Nielsen, & Larsen, 2014). Balling, Townend and Switalski (2019) conducted a large-scale multinational survey to investigate users' experiences of Widex EVOKE and evaluate the effectiveness of this artificial intelligence-based hearing aid. The study revealed that 88% of the participants stated that the performance of the artificial intelligence-based Widex EVOKE hearing aid in noisy environments is better than the hearing aids they use. Their study (2019) proved particularly the advantages of the SoundSense Learn feature, which personalizes sound in the moment via a machine learning algorithm. In addition, it was emphasized in the study of McCormack and Fortnum (2013) that the EVOKE device provides significant advantages in noisy situations, which are known to be very difficult for hearing aid users.

With the help of smart hearing aids, adults and children with hearing impairments can live a more comfortable life with their parents, employees at work, students in the classroom, and others. For students with hearing impairments, this means that they can fully participate in classroom activities and engage in social interaction with other students.

Artificial Intelligence Applications in Individuals with Language and Speech Disorders

Voula et al. (2003) proposed a fuzzy cognitive map or soft computation model to determine the differential diagnosis of individuals with speech and language disorders. Fuzzy cognitive maps are a flexible computational tool comprised of the synergy of fuzzy logic and neural network methodologies, utilizing the experience of expert scientists (Dickerson and Kosko, 1997). Speech and language disorder is difficult to define because it has signs and symptoms similar to those of other diseases (Sprogis, 2019) however, with the help of this computational tool, experts may distinguish between speech and language disorders and other types of disabilities such as autism and dyslexia.

Schipor et al. (2010) designed a computer-based speech therapy system using a fuzzy expert system to assist students with hearing and speech impairments. This clinical tool can recommend optimal therapeutic actions (number, length, and content of training sessions) for each individual and create an optimal exercise set based on available data (test scores and social, cognitive, and affective parameters). In the experiment conducted by Schipor et al. (2010), there was no statistically significant difference in therapy success between the experiment group using the fuzzy expert system and the control group. It, however, revealed some other advantages of using the expert system, such as interpretability, predictability, and a longer treatment duration (Schipor et al., 2010).

In 2017, a Tel Aviv-based startup developed a hands-free voice recognition application called Voiceitt which translates elusive speech into clear words using artificial intelligence technology for real-time communication (Sherbin, 2018). Unlike language-dependent regular speech recognition systems, Voiceitt is a speaker-dependent system because it uses personalized deep learning algorithms such as pattern classification (Morero et al., 2020). The technology is designed to be integrated into smart speakers, smart homes, and other assistive and advanced communication devices, the user is prompted as soon as the device started to write a short helpful sentence and then read it aloud, such as "turn off the light" or "I'm thirsty" (Sprogis, 2019). The app records the pronunciation of the speaker (i.e., speech-impaired person) and starts learning. After some training, the Voiceitt app converts the user's expression to a standardized voice, and the output is generated as text or voicemail (Sprogis, 2019). In short, Voiceitt helps people communicate face-to-face with others by making sense of the non-standard speech of people with congenital or acquired language and speech disorders, including cerebral palsy, autism, cerebrovascular accidents, Parkinson's disease, brain tumors, and traumatic brain injuries (Murero et al., 2020).

Artificial Intelligence Applications in Individuals with Learning Disabilities

Another good example of the use of artificial intelligence in special education is a model called PLEDOR (Perceptron-based Learning Disability Detector). PLEDOR is an artificial neural network model consists of 11-unit input layer and an output unit that can detect reading, writing, and math learning difficulties through curriculum-based tests conducted by special educators (Jain et al., 2009). The study with 240 participants in India showed that PLEDOR

provides easy use and yields comparable results in accordance with acknowledged test measures (Jain et al., 2009).

Pavlopoulos et al., (2008) used an artificial neural network to develop an assessment system for students and then optimized it using genetic programming. This system, relies on genetically programmed neural networks (GPNN), is designed to evaluate users' responses to questions in an e-learning environment and assess the following learning domains: (1) reading, (2) writing, (3) spelling/vocabulary, (4) grammar/sentence and letter recognition, and (5) alphabetical order (Sprogis, 2019). This assessment system successfully evaluates the user's response. Additionally, this assessment system may lead to other innovations in e-learning.

Artificial Intelligence Applications in Individuals with Autism Spectrum Disorder

Children with autism spectrum disorder may experience avoidance of eye contact and a certain lack of facial expression. The following behavioral tendencies are observed in these children: inability to express one's feelings and emotions|; inability to recognize the feelings of others; passivity in interaction; interacting in an aggressive, destructive, or inappropriate way. In addition to not being able to initiate or maintain a dialogue spontaneously, they may also experience other problems such as not speaking, speaking late, or losing the ability to say previously acquired words or phrases. Despite these problems experienced by children with autism spectrum disorder, studies in the literature provide some evidence that artificial intelligence technologies are helpful in overcoming these difficulties (Şen, 2021).

TecO, a 50-cm-tall artificial intelligence robot resembling a cartoon bear, records the signals from the child with autism spectrum disorder and translates those signals into information that can be evaluated by a psychologist or neurologist (Sadauskaite, 2017). Because the robot TecO is emotionless, static, and predictable, it is aimed at connecting with children with autism spectrum disorder more easily. TecO observes the child, and as soon as the child begins to lose interest, it moves and makes sounds to attract the child's attention again. It also has a camera that can record the number of eye contact points and quantitatively measure the child's progress (Sadauskaite, 2017). Two more robots (e.g., Bandit and Darwin-OP2) similar to TecO are under development. They can record every word of a child with autism spectrum disorder and monitor their development (Sadauskaite, 2017).

Kaspar is a humanoid robot designed as a social friend to improve the lives of children with autism spectrum disorder or any other communication difficulties (Wood et al., 2019). This robot helps teachers and parents support children with autism spectrum disorder to overcome the difficulties they face in socializing and communicating with others. QTrobot is another humanoid social robot designed to help teach social skills to children with autism spectrum disorder (Costa et al., 2018). Robots can help to speak directly and facilitate instructions without having to explain social cues which helps children with autism spectrum disorder focus on the skills being taught rather than explaining the social cues. In the future, these humanoid robots are expected to play the roles of playmate and therapist at the same time. They are also expected to help children with autism spectrum disorders participate more in social activities.

Wearable devices can also be used to predict diseases, provide advice on how to stay healthy, and even help people overcome their growing social challenges. In a project at Stanford University, Google Glass equipped with artificial intelligence technology to create a device called Autism Glass, which allows children with autism spectrum disorder to understand the facial expressions of others (Haber et al., 2020). Autism Glass allows a person to recognize others' emotions and act accordingly. This tool is designed to reduce the level of anxiety that people with autism spectrum disorder experience during social interaction. Once an individual wears Autism Glass, artificial intelligence software can read the facial expressions of the person in front of him. Each pair of these smart glasses has an overhead display that can reflect emotions appropriate to the human face, and users need to read emotions so they can identify how others are feeling (Singh et al., 2022). Catalin Voss et al. (2019) examined the effect of a wearable AI intervention designed for home use on improving socialization to strengthen facial interaction and emotion recognition in children with autism spectrum disorder. In their study of 71 children with autism spectrum disorders, children treated with the wearable intervention at home showed significant improvement in socialization compared to children who received standard-care behavior therapy alone.

4. Discussion and Conclusion

Artificial intelligence applications used in different disability groups such as visual impairment, hearing impairment, language, and speech disorder, learning disability and autism spectrum disorder and important research findings in these areas are mentioned above.

Based on the findings of the study, artificial intelligence applications are effectively used to suit the demands and desires of people with special needs. Artificial intelligence, which is individualized based on the needs of individuals, analyzes their weaknesses and provides the benefit of personalized growth assistance. Furthermore, owing to artificial intelligence apps, persons with special needs may express themselves more simply by connecting with their parents, teachers, psychologists, and others. These programs also allow people to find their hidden skills. It is also noted that artificial intelligence provides some significant benefits, such as saving time and money, as well as generating more efficient and effective learning settings. However, there is a need for more research on artificial intelligence applications due to the multiplicity of difficulties encountered in special education and the different needs and wishes of each individual. This research was limited to artificial intelligence applications in individuals with visual impairment, hearing impairment, language and speech disorders, learning disabilities and autism spectrum disorders. Future studies can contribute to the literature by examining artificial intelligence applications used in other disability groups. Artificial intelligence applications provide promising benefits in special education, and if these applications are developed more and more each day, they can help solve the problems of individuals with special needs, their parents, educators, and researchers.

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