Review Article ISSN 2639-9474

Nursing & Primary Care

A Possibility of Application of Human Cognitive Psychology to Artificial Intelligence to Improve Dermatological Diagnostics and its Accuracy

Alina M. Jacob[2]*, Sneed KB[1] and Yashwant Pathak[1]

[1]*Taneja College of Pharmacy, University of South Florida, Tampa Florida, USA.*

[2]*Judy Genshaft Honors College, University of South Florida, Tampa Florida, USA.*

***Correspondence:**
Alina M. Jacob, Judy Genshaft Honors College, University of South Florida, Tampa Florida, USA.

Received: 09 Jan 2023; **Accepted:** 17 Feb 2024; **Published:** 25 Feb 2024

Citation: Alina M. Jacob, Sneed KB, Yashwant Pathak. A Possibility of Application of Human Cognitive Psychology to Artificial Intelligence to Improve Dermatological Diagnostics and its Accuracy. Nur Primary Care. 2024; 8(1): 1-6.

ABSTRACT

Looking into the state of the human mind and cognitive psychology, pattern recognition is a skill that we excel at. The neocortex, the outermost part of the brain only found in mammals, is responsible for this ability. With the development of advanced neural networks, humans can have better processing of visual and auditory patterns. Being able to look for patterns is typically considered part of what we consider to be superior pattern processing (SPP). As we evolved, our capabilities became increasingly sophisticated, allowing for the creation of artificial intelligence. Artificial intelligence has taken the world by storm, being a large part of creation and recognition. AI is notable for standard pattern recognition tasks as it has an abundance of data and advances in data-driven machine learning. However, there is a large gap within AI to overcome for it to reach human-level skill processing abilities. This creates the question of how we will be able to build a bridge to cross that gap by applying cognitive psychology principles to AI and advancing the pattern processing systems and whether it is even possible. If it is possible, can it increase the accuracy and precision of AI diagnostic abilities within healthcare?

There have been significant advancements within healthcare that necessitate the need for AI such as in radiology images and detecting potentially cancerous lesions. It is important to note that these diagnosing systems do not work independently; they work in unison with healthcare professionals and are a guide and tool in the diagnosing process. This concept of AI aiding healthcare professionals can be applied within the medical specialty of dermatology. With skin diseases increasing daily, healthcare professionals must treat patients with utmost care while also providing accurate diagnoses. With improved AI systems, it can potentially find early warning signs of diseases that the human eye did not catch. However, there are some downsides to utilizing AI within healthcare, which reduces its reliability but, in the end, the pros could potentially outweigh the cons. With an increase in AI systems within healthcare, it could increase productivity and help people in lower-income communities and areas by providing economic benefits. Overall, the introduction of more advanced AI pattern recognition structures can provide more accurate diagnostic results in a quicker time and will allow for more accurate treatment for skin disease.

Keywords

Dermatology, Human-Level learning, Machine-Level learning, Deep Learning Techniques, Healthcare.

Introduction

This paper provides an insight into the developments within artificial intelligence, relating it to medicine and the human brain. This paper aims to provide more context and ideas into the possibilities of benefits that artificial intelligence could pose within medicine, specifically AI with human-level concept learning. The main consideration for this idea is the use of cognitive psychology and understanding the way the human brain works. To harness the full potential of AI in dermatological diagnostics, it is imperative to apply cognitive psychology principles that

govern human perception, cognition, and decision-making into artificial intelligence to optimize the design and user experience of AI-powered skin disease-diagnosing systems. Through this interdisciplinary approach, it is possible to uncover innovative solutions that bridge the gap between human cognition and machine intelligence, fostering a future where AI-powered skin disease diagnosing systems can play a pivotal role in transforming the landscape of dermatological healthcare.

Cognitive psychology within AI

What is cognitive psychology?

Cognitive psychology is a subfield of psychology that focuses on the study of mental processes, particularly how humans think, perceive, remember, learn, and problem-solve. It overall seeks to understand the intricacies of cognition. It explores how individuals acquire, process, and utilize the information given to them, delving into the underlying mechanisms that govern human thought and behavior. This is why the human mind is superior in pattern recognition and problem-solving. This was a concept strengthened through evolution. It has been stated through research that the "cognitive repertoire of humans far exceeds that of all other animals" and that "the size of their cerebral cortex expanded" allowing our pattern-processing capabilities to emerge [1]. Often referred to as SPP, Superior Pattern Recognition, is crucial in the foundation of human sociocultural evolution as it is an aspect that allows us to problem-solve and advance in ways in societies and cultures in ways other beings could not.

Specifically referring to pattern recognition, humans have an advanced brain, notably in the prefrontal cortex and the parietal-occipital-temporal juncture. The cortex of the brain is involved with processing visual inputs. This section of the brain is considerably smaller than other anthropoids, giving humans the evolutionary advantage of pattern processing [1].

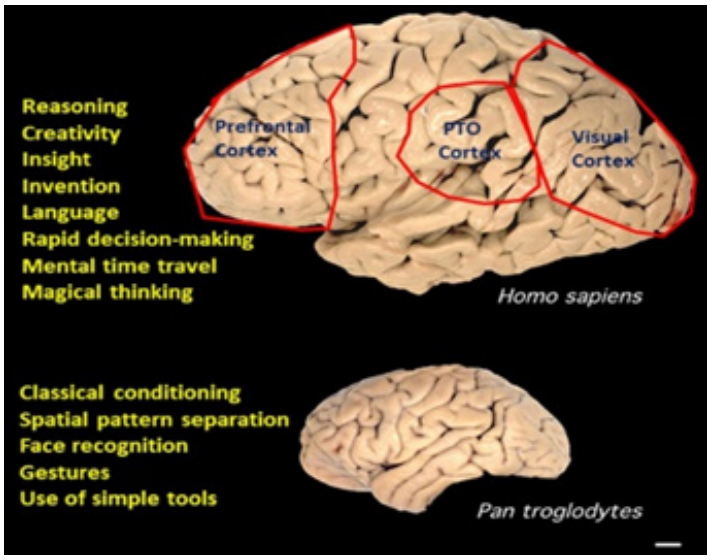

Figure 1: The Superior Pattern Processing (SPP) capabilities of the human brain have evolved in relation to the expansion of the cerebral cortex…….....……2.

The Superior Pattern Processing (SPP) capabilities of the human brain have evolved in relation to the expansion of the cerebral cortex. It is seen that the human brain (*Homo sapiens*), the three regions, the prefrontal cortex, the visual cortex, and the parietal-temporal-occipital juncture (PTO) are enlarged compared to the chimpanzee brain (*Pan troglodytes*). The source of brain images is Wikimedia Commons. Scale bar, 1 cm [1]. The image belongs rightfully to its owner. There are specialized sections that relate to the cortex that were studied for how long-term experience aids in perceiving objects. Early research was reconfirmed stating that there are two specific brain regions, the posterior middle temporal gyrus (pMTG) and collateral sulcus (CoS), which are linked to chess players' superior object and pattern recognition [1]. Through further research, they identified that the pMTG serves in object recognition while the CoS helps in skilled pattern recognition by linking the position of individual objects with typical spatial-functional layouts of their environment stored in memory.

Through looking at the systems of the human brain and how we operate to have SPP and human-level cognition, it is understandable why AI at its current level cannot compete with human pattern processing. Humans have a superior neural system, learning adaptations, contextual understanding, and even innate knowledge that AI at its current level cannot compete with.

Human Pattern Recognition versus AI Pattern Recognition

Artificial intelligence is widely known for its capabilities of pattern recognition and problem-solving which rely on algorithms and computational methods to identify and interpret said patterns in the data whether it be text, images, or signals. With its statistical data-driven machine learning (using immense amounts of data to learn and identify patterns), AI has the advantage of being able to process vast amounts of data quickly and consistently making it a suitable tool for data analysis. However, AI lacks the nuanced contextual understanding and generalization capabilities inherent in human pattern recognition leaving a large gap between AI and humans. Human pattern recognition is more versatile, adaptable, and contextually sensitive, allowing us to recognize complex patterns, draw inferences, and make informed decisions. AI models are highly dependent on the input of data provided it and is crucial for them to be high-quality training data [3]. In contrast, humans learn through interaction within their environment [4] an aspect that AI lacks. The human ability to be present within the situation presents us with more spatial awareness, allowing us to understand and explain novel concepts. AI systems are built based on certainty and to perform specific tasks whereas humans are excellent at dealing with uncertainty and unknown possibilities and situations.

Human Pattern Recognition	AI Pattern Recognition
• Recognizes complex patterns • Draws inferences • Ability to make informed decisions • Interaction with environment expands the knowledge base	• Lacks contextual understanding and generalization capabilities • Highly dependent on the input of data • May not be able to deal with uncertainty

Section Two: Application of Human Concept Learning in AI And its Application in the Medical Field

Artificial Intelligence Capabilities and Possible Improvements in Healthcare

Types of AI Being Utilized within Healthcare.

Within healthcare, AI is utilized to alleviate the workload of physicians and to mitigate diagnostical errors and times that may be present. The introduction of AI into this domain enhances the accuracy and efficiency of disease prediction and detection. There are two levels of AI learning used within healthcare: Machine Learning (ML) and its sublevel, Deep Learning (DL).

ML is defined as "any type of computer program that can 'learn' by itself without having to be explicitly programmed by a human" [5]. For ML, there can be two learning methods: supervised and unsupervised learning. Supervised learning involves training a program with labeled data to generate specific answers, utilizing classification algorithms such as random forests, decision trees, and support vector machines (visual seen in Figure 2) which all have high accuracy. Said classification algorithms are formats that the AI will follow in order to learn the material.

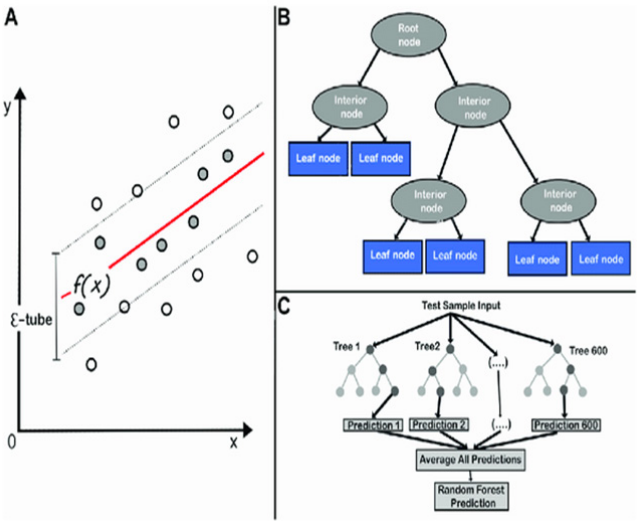

Figure 2: The graphics shown in the image are the formats used within supervised machine learning algorithms. (A) support vector regression, (B) decision tree regression, (C) random forest.....5.

The graphics shown in the image are the formats used within supervised machine learning algorithms. (A) support vector regression, (B) decision tree regression, (C) random forest. All three are effective formats for algorithms used within ML. It is a sort of plan used to enhance AI learning abilities. The image belongs rightfully to its owner.

The latter of the learning methods, unsupervised learning, deals with unlabeled data and aims to discover new patterns within the data sets. Utilizing clustering algorithms, data scientists can uncover hidden insights within the unstructured information that is fed to the program [6]. ML learning is one of the most common techniques and is normally applied in precision medicine where healthcare professionals will utilize the tool to predict which treatment would lead to the best results based on the patient's attributes and the context of the treatment [7]. The complicated sub-level, deep learning (DL), is defined as a "form of machine learning that can utilize either supervised or unsupervised algorithms or both" [6]. This form of learning is rooted in representation learning where it involves intricate, high-level abstractions from data through a layered learning approach. DL has a multi-layered structure of neural networks such as convolutional neural networks (CNNs), where each layer processes and passes information to the next layer, resulting in more efficient data analysis [8]. Within healthcare, deep learning is being utilized in cancer analysis of malignant tumors and even analysis of potentially cancerous lesions. By utilizing deep learning AI, there is a possibility of analyzing these images to a level that is beyond what the human eye can see.

With the current learning levels applied within healthcare, there seems to be a potential for AI within healthcare, helping physicians as a diagnostic tool to quicken diagnosing time and accuracy. It may be more beneficial to use AI with a deep learning approach as it will ensure more accuracy and precision within diagnosing systems as compared to the machine learning technique.

Challenges of the Deep Learning Technique

The Volume of Data Availability

Deep learning requires a large dataset meaning there needs to be the availability of vast amounts of data. However, at times it is found that there is limited infrastructure or formatting for data storage and access. Although data storage is commonly used with data storage applications such as Amazon Web services and Microsoft Azure [9], it is often seen that data is not formatted and stored in such accessible means making data exchange difficult. Known as interoperability (exchange and access of said data) [10], healthcare industries value their systems would require a large volume of data. Within healthcare, these systems would need a prominent level of interoperability in order to take into account all factors. However, at this time, the majority of the systems being used are at a low level of interoperability [11]. For this to be more universally available, data formatting and storage mechanisms would have to be more universalized, a challenge that needs to be overcome.

The Quality of Data

DL requires data that is structured and well organized whereas data within healthcare can be incomplete due to variability within cases. Within a DL model, it is oftentimes hard to estimate how well that model will interpret those results, leading to challenges within the system, redundancy, and even missing items/values [12]. It is important to note that the analysis of the AI model will only be as good as the data that is fed to it. If the training data is biased, incomplete, or of inadequate quality, there will be inaccurate and biased results. Moreover, if there are not sufficient amounts of high-quality data, the AI cannot produce results that are feasible within a diagnostic setting.

Analysis of Data

DL models have been quite successful in some domains such as identifying cancerous lesions [13]. Within most domains in healthcare, the algorithms that drive the pattern recognition or prediction process are important. Many of these DL models would have to have similar algorithms for pattern recognition and prediction abilities in order for healthcare professionals to understand the reasoning for the diagnosis of the diagnosing tool. By doing this, it would also allow them to use it more often. If this is not done, there may be discrepancies within the models, which would cause distrust, misunderstanding, and faulty analysis within the healthcare fields.

The Possibilities of Advancing Human Concept Learning within AI

Human concept learning (HCL) refers to the way that humans acquire and understand abstract concepts, categories, or ideas based on their experiences and observations of the world. The process involved recognizing similarities and differences within objects, groups, and events, allowing for categorization into meaningful groups or concepts. This is a fundamental cognitive ability that AI models lack. In the context of the AI model, HCL serves as a goal and model for improving the learning and generalization abilities of artificial intelligence systems. There have been several attempts to get AI to the level of human cognition.

DL learning takes a step in this direction, by mimicking the human brain's basic pattern recognition abilities. However, more learning methods are being developed to enhance AI to a level of human cognition. There is Bayesian Program learning, or the BPL approach, which, unlike DL, is inspired by the ability of the human brain to infer actions that can produce a pattern although fairly new and not at a level to use within healthcare, over time, this learning model can be prominent within healthcare. Another more advanced example is a program made by Brenden M. Lake and the team who created a model that achieves "human-level performance while outperforming recent deep learning approaches" which follows the Bayesian criterion [14]. There is a slow takeoff in the research and advancement of the AI learning models giving hope for the future of advanced AI and healthcare.

The Impact of Human Concept Learning AI in Healthcare

With this, many critics believe that AI will not be able to compete with human-level cognition unless it develops connections with the real world. Professor Tony Prescott, professor of Cognitive Robotics at the University of Sheffield stated that AI is not likely to develop human-like cognition unless it is given the architecture it needs to interact with the real world like a human can do [15]. A solution for this is robotics. By including robotics and creating mechanisms such as cameras and microphones which the AI systems can use, the AI will be able to create more real-world connections, allowing it to learn like a human brain would. However, how realistic is it to have robotic/ HCL AI in the healthcare field? There are questions of safety/ethics and even economic standpoints that need to be considered. Regarding ethics, AI, specifically DL and HCL models need an abundance of data. The storage and use of this data can pose several ethical issues. The data that is being used needs to be consented to and the systems need to maintain data privacy. The issue with this is that the current laws that are set around the world regarding medical data such as the General Data Protection Regulation (GDPR) enacted by the European Union and the Genetic Information Non-discrimination Acts (GINA) in the United States and others are not strong enough to protect patient's health data [16]. The clinical data that can be stored within these AI systems have the possibility of being hacked into, minimizing privacy. There is the fear of companies not obliging to data consenting as they are not closely monitored, selling information to pharmaceutical and biotechnology companies. Economically, AI within healthcare is significantly beneficial. A model created by Narendra Khanna and the team highlighted that integrating AI resulted in extreme savings in cost within treatment and diagnosis [17]. AI within healthcare would help areas such as the United States save money. As it was seen, the United States had wasted over a quarter of healthcare dollars in 2020 [17]. If more AI is integrated into healthcare systems, there is the potential for not only saving money but also saving the time of healthcare professionals and patients (these two concepts go hand-in-hand). The study by Khanna and the team showed that in their model, the number of patients per day in each hospital and the number of hospitals is increasing linearly shown in Figure 3.

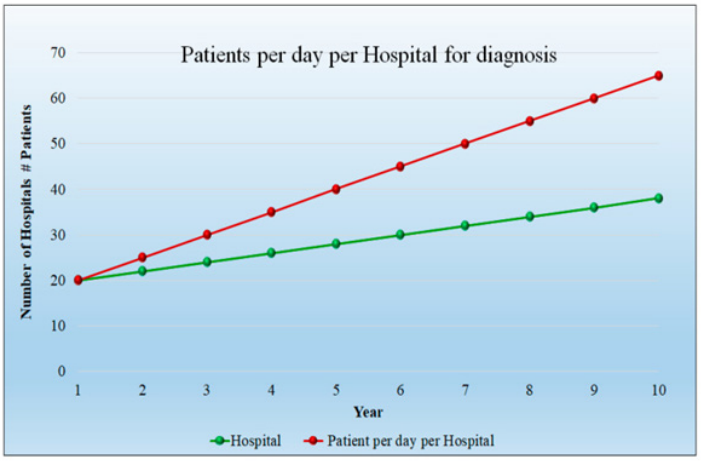

Figure 3: The number of patients per day per hospital for a diagnosis is seen to be linearly proportional..... 10. The number of patients per day per hospital for a diagnosis is seen to be linearly proportional. Source: Khanna *et al.,* 2022

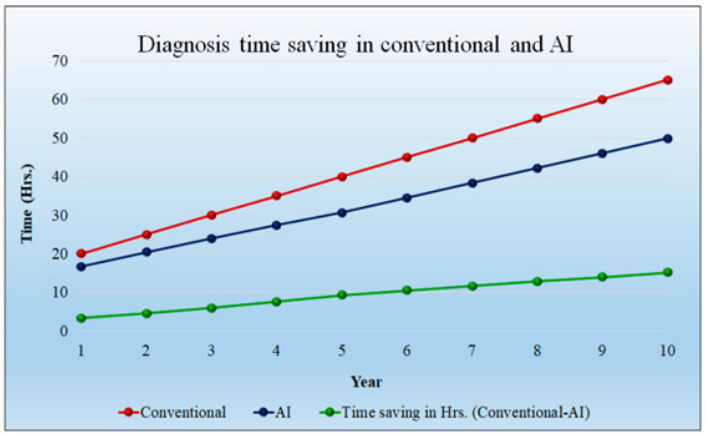

Figure 4: The timesaving for AI-based diagnosis model.....11.
The timesaving for AI-based diagnosis model.
Green- Conventional-AI, Conventional model (red) vs. AI (blue), showing year vs. time (in hours)
Source: Khanna et al., 2022

When AI is integrated, they highlight that there is a significant amount of time saved. Initially, there will be around 3.33 hours per day and after 10 years, it is estimated that the savings will be around 15.17 hours per day as shown in Figure 4. If more time is being saved, more money can also be saved by avoiding unnecessary treatments and tests and enhancing patient and doctor experiences.

There is still a large path that needs to be walked in order to get to a level where AI within healthcare is advanced enough with HCL and is also trusted by healthcare professionals and patients. With due time, HCL in AI will be more prominent as more researchers are looking into ways where AI can gain human-level cognition with innovative programs and ideas such as incorporating robotics.

Section Three: Artificial Intelligence And Dermatology

The Current Use of AI in Dermatology

AI is used throughout the medical field, especially in dermatology. AI could analyze multiple images of skin diseases and present dermatologists with potential diagnoses. Its use in dermatology as of right now is new and limited. Dermatology presents a good field for AI due to its large image database. In the last decade, there has been the use of AI as a diagnosing tool for dermatologists in cases of skin cancer, eczema, and psoriasis. There have been many researchers creating DL programs for certain skin disease identifications such as melanoma and nonmelanoma skin cancer (NMSC). The first note of this was in the creation of a neural network to detect melanoma [18]. In 2017, there were more thorough studies done by Standford University which made a model of DL for skin tumors. They trained the system with 129,450 clinical images of 2,032 different diseases [19]. They were able to receive results that alluded to the AI being competent and having equivalent results to the board-certified dermatologists in identifying and classifying skin cancer. There is an abundance of other studies being done regarding DL models within dermatology.

The benefits of using HCL AI in dermatology

Although it has not been fully made or tested, the potential of HCL AI in dermatology would be profound. Allowing the AI to reach human-level cognition will allow it to analyze not just the disease, but consider possible risk factors, treatments, and outcomes. With improved AI, it leads as a tool for dermatologists, reducing wait time and reducing the possibility of a failed treatment. This could either be used as a pre-screening process for dermatologists to observe the skin conditions before the appointment or could be used during the process of diagnosing within the appointment. HCL AI could also notice patterns and data sets that the human eye has not picked up on yet, advancing the dermatological field. As of right now, the DL AI that is being utilized can only assess a few specific skin conditions. Implementing cognitive psychology principles, understanding how the human brain works, and implementing it within technology can allow for more developed AI systems such as an HCL AI, allowing only a small dataset to be implemented for the AI to reach an accurate diagnosis and treatment option.

Benefits of using HCL AI in dermatology
• Analysis of possible risk factors, treatments, and outcomes • Reduced wait time for patients • Reduced risk of failed treatment • Increased analysis of skin conditions, reducing excessive testing

Section Four: Conclusion and Plan for the Future

The Plan for HCL AI

How do we reach the goal of HCL AI?

Several steps need to be taken as achieving AI with human-level cognition and pattern recognition is an extremely ambitious goal. The first step is to analyze and understand human cognition itself. To replicate how humans think, researchers need to understand the mechanisms including perception, reasoning, problem-solving, etc. There also needs to be general AI development. It is plausible to use the existing AI models and further develop them to create newer system learning. With this, there should be access to vast and diverse datasets, similar to the way that humans learn from differing experiences. Another factor that is required is creating an AI system that allows it to have an intuitive view of the world

(implementing robotics), a task that is difficult. In the creation of this system, interdisciplinary collaboration must occur between AI researchers, cognitive scientists, neuroscientists, psychologists, and experts in various other domains. While creating this, safety measures need to be considered regarding the ethics and privacy of the data being used. For HCL AI, transparency and reasoning are necessary. AI systems should be designed to explain their decisions and "thought" processes to enable humans to understand and trust their reasoning. This process will be long-term and require an investment of time and money. However, over time, it could have a considerable payoff, being beneficial not only within the medical field but in all disciplines.

Conclusion

Exploring the intersection of artificial intelligence, human cognition, and their potential applications in the field of medicine, specifically dermatological diagnostics introduces the idea of an AI system that has human-level cognition and the ability to detect and decipher patterns like that at a human level. By harnessing the principles of cognitive psychology, we can bridge the gap between human cognition and machine intelligence, paving the way for more advanced AI. Cognitive psychology, with a focus on how humans think, learn, and look at patterns, sets a high standard for AI to achieve, especially in complex nuanced tasks. AI's pattern recognition, while powerful, differs significantly from human pattern recognition in terms of adaptability, contextual understanding, and handling uncertainty. The application of human concept learning in AI, with a focus on deep learning, holds promise for improving healthcare, particularly in diagnosis and treatment prediction. However, there are challenges, including the vast and well-structured datasets that are required, data quality, and standardized analysis methods.

Looking at AI applications in dermatology, AI has shown promise in diagnosing skin diseases and extreme benefits. These AI systems could consider risk factors, treatment options, and outcomes, thereby enhancing the accuracy and efficiency of skin disease diagnosis and treatment. To reach the goal of human-level cognition AI, it is essential to understand human cognition thoroughly, develop general AI, ensure access to diverse datasets, and prioritize interdisciplinary collaboration. While the journey is long-term and resource-intensive, the potential benefits for healthcare and other fields make it a worthwhile endeavor. It is imperative to continue advancing the field of AI to unlock its full potential and revolutionize the future of healthcare and beyond.

References

1. Mattson MP. Superior pattern processing is the essence of the evolved human brain. Front Neurosci. 2014; 8: 265.
2. Cogn B, Simon BE, Robert Langner. A network view on brain regions involved in experts object and pattern recognition Implications for the neural mechanisms of skilled visual perception. HHS Public Access. 2019; 131: 74-86.
3. Paullada A, Raji ID, Bender EM, et al. Data and its contents a survey of dataset development and use in machine learning research. Patterns. 2021; 2: 100336.
4. Misra I, Girshick R, Fergus R, et al. learning by asking questions. Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition. Cvf. 2018; 11-20.
5. Woodie A. Machine Learning, Deep Learning, and AI What's the Difference. Datanami. 2017.
6. Wehle HD. Machine Learning, Deep Learning, and AI What's the Difference. Data Scientist Innovation Day. 2017.
7. Lee IC, Safiye C, Sylvia C, et al. A machine learning approach to integrate big data for precision medicine. Nat Commun. 2018; 3: 42.
8. Fakoor R, Ladhak F, Nazi A, et al. using deep learning to enhance cancer diagnosis and classification. 2013.
9. Maier-Hein LE, Matthias E, Duygu S, et al. Surgical data science from concepts toward clinical translation. Med Image Anal. 2022; 76: 102306.
10. Bates DW, Samal L. Interoperability What Is It, How Can We Make It Work for Clinicians, and How Should We Measure It in the Future. Health Serv Res. 2018; 53: 3270-3277.
11. Taher H, Grasso V, Tawfik S, et al. The challenges of deep learning in artificial intelligence and autonomous actions in surgery: a literature review. Open Access with Excellence. 2022; 2: 144-158.
12. Miotto R, Wang F, Wang S, et al. Deep learning for healthcare review, opportunities and challenges. Brief Bioinform. 2018; 19: 1236-1246.
13. Goyal M, Knackstedt T, Yen S, et al. Artificial intelligence based image classification methods for diagnosis of skin cancer: Challenges and opportunities. Comput Biol Med. 2020; 127: 104065.
14. Lake BM, Salakhutdinov R, Tenebaum J. Human-level concept learning through probabilistic program induction. Science. 2015; 11: 1332-1338.
15. Prescott TJ, Wilson SP. Understanding brain functional architecture through robotics. Sci Robot. 2023; 8: 6014.
16. Farhud DD, Zokaei S. Ethical Issues of Artificial Intelligence in Medicine and Healthcare. Iran J Public Health. 2021; 50: 1-5.
17. Khanna NNM, Sudip P, Vijay V, et al. Economics of Artificial Intelligence in Healthcare Diagnosis vs. Treatment. Healthcare. 2022; 10: 2493.
18. Nasr-Esfahani E, Samavi S, Najarian K, et al. Melanoma detection by analysis of clinical images using convolutional neural network. Annu Int Conf IEEE Eng Med Biol Soc. 2016; 1373-1376.
19. Andre Esteva, Brett Kuprel, Roberto A Novoa, et al. Dermatologist-level classification of skin cancer with deep neural networks. Nature. 2017; 542: 115-118.