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A Review On Applications Of Deep Learning And Computer Vision Techniques In Healthcare Domain

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Abstract: Artificial intelligence (AI) is the ability of machines to carry out tasks by imitating human intelligence. In recent years, AI methods have begun to be applied in many different areas, with healthcare being one of the most prominent. Diagnosis, treatment, patient care, new drug production, and preventive care can be listed as some of the applications of AI in healthcare. In this review, deep learning and computer vision methods, which are a sub-branch of AI, are mentioned. Deep learning methods frequently used in the literature are convolutional neural networks (CNNs), stacked autoencoders (SAEs), and recurrent neural networks (RNNs). These deep learning methods include CNNs for image recognition and classification, SAEs for unsupervised feature learning and dimensionality reduction, and RNNs for analyzing sequential data like time-series. However, it should be noted that these methods can also be applied to other application areas. This paper presents studies in the literature on medical image analysis, drug discovery and development, and remote patient monitoring in which these deep learning methods are used.

Keywords: Artificial Intelligence (AI), Deep Learning (DL), Computer Vision (CV), Healthcare, Smart systems.

Introduction

Artificial intelligence (AI) is the study of creating or programming computer learning models by imitating human intelligence [1]. The use of AI is increasing in direct proportion to developing technology. AI methods are also used in the field of health, which contains different types of data. Healthcare is in a new era where abundant biomedical data plays an increasingly important role [2]. The use of artificial intelligence in healthcare has the potential to offer significant benefits, such as improved diagnosis and diagnostic accuracy, increased speed and efficiency, enhanced predictive care, and personalized treatment. However, there are also several challenges that need to be addressed. These include concerns about data security and privacy, limitations related to training data and generalization, legal regulations and responsibilities, ethical considerations, and the transparency and understandability of the algorithms. It is important to recognize both the potential benefits and the associated risks and to work on solutions to effectively address these challenges.

Deep learning approaches, one of the AI-based methods, are frequently used in AI applications in health. Among these methods, convolutional neural networks (CNNs), stacked autoencoders (SAEs), and recurrent neural networks (RNNs) are widely preferred. CNNs are specialized artificial neural networks that contain at least one convolution layer [3] They are end-to-end methods that perform feature extraction and classification systems together. On the other hand, SAEs are another neural network approach. This method tries to convert input data into an output similar to the input [4] RNN, another deep learning approach examined in this article, performs processing in the next step using the output calculated in the previous step [5].

AI helps provide solutions to many different issues in the field of healthcare. In this review, we will focus on AI applications in health, specifically medical image analysis, drug discovery and development, and remote patient monitoring. Under the title of medical image analysis, the focus is on studies related to breast cancer, brain cancer, heart diseases, lung cancer, eye diseases, and skin cancer.

The paper's main contributions are as follows:

Popular AI methods frequently used in the field of health

Classification of health problems solved using deep learning methods.

Related Work

This review aims to identify and analyze the applications of well-known deep learning algorithms in healthcare systems. We conducted a literature search to gather relevant and upto-date information. We utilized the Web of Science search engine to identify relevant studies published from 2020 onwards in journals indexed in the Science Citation Index (SCI) and Science Citation Index Expanded (SCIE) databases. Our search strategy included a combination of keywords: "deep learning," "healthcare systems," "medical image analysis," and "health applications in deep learning." We focused on articles with a success rate of 90% or more to ensure the inclusion of impactful research. From the selected articles, we extracted information on the specific deep learning algorithms used, the healthcare application domain (e.g., medical image analysis, drug discovery and development, etc.), and the reported outcomes or findings.

Deep Learning Models

Deep learning is a mechanism that mimics the human learning strategy and thus can perform complex tasks in computer systems. This system, which is based on artificial neural networks (ANNs) learning from a large amount of data, has many more layers than ANNs [6] It gets its name "deep" due to the multiple layers in neural networks. ANNs consist of connected neurons, similar to how the human brain works. Deep learning models work to train the connections between these neurons. An example of ANN and deep neural networks (DNNs) architecture is presented in Figure 1. Deep learning methods have been successfully used in various application areas such as image recognition, natural language processing, big data, autonomous vehicles, medical image processing, voice processing, robotics, financial analysis, and energy efficiency [7] Three of the most popular and frequently used deep learning models in healthcare are presented in detail in the subsections. These methods are CNNs, SAEs, and RNNs.

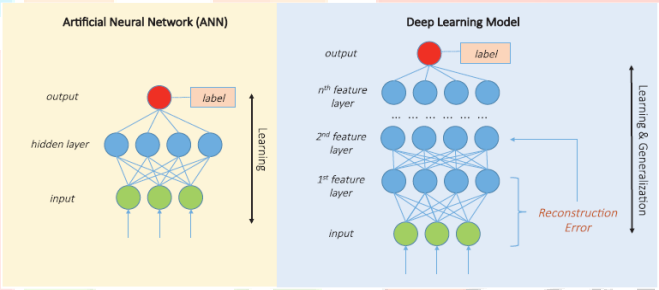

Figure 1: ANNs and Deep Learning Model Architectures

Convolutional Neural Networks: Convolutional Neural Networks are a type of artificial neural network that uses at least one convolutional layer to process information. CNNs work similarly to how the human brain processes vision, using small, moving filters to analyze visual information [3] CNNs utilize the convolution operator, which works by sliding a filter over the image and calculating a combination of pixels at each filter location to learn features of images. This allows the filter to highlight certain image features [3] CNNs use a classification layer to classify images based on extracted features, predicting the class to which the image belongs. An example of CNN architecture8 is presented in Figure 2. CNNs are used in healthcare sectors such as medical imaging, disease diagnosis, neurological disease diagnosis, drug development, health records analysis, health monitoring devices, and radiology.

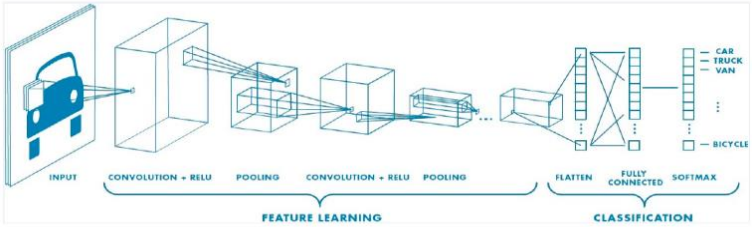

Figure 2: Convolutional Neural Networks

Stacked Autoencoders: An autoencoder is a type of neural network that attempts to convert input data into an output similar to the input.4 Stacked autoencoders consist of a series of autoencoders connected together. SAE was proposed by Hinton and Salakhutdinov in 2006 [4]. This deep learning method is designed for dimensionality reduction and feature extraction. SAEs are used in various applications, including diagnosis,

treatment, research, image analysis, natural language processing, and data analysis. An example of SAE architecture is shown in Figure 3.

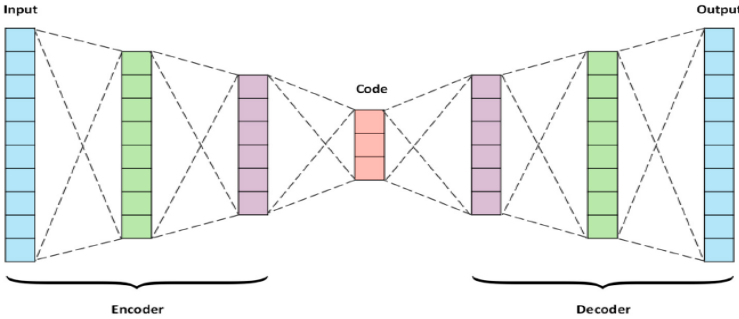

Figure 3: Stacked Autoencoders

Recurrent Neural Networks: Recurrent Neural Networks, which perform processing in the next step using the output calculated in the previous step, was proposed by Williams and Zipser in 1989 [5]. Unlike traditional neural networks that use input data only once, RNNs can process data in a series of steps. RNNs are particularly useful for applications where the output depends on previous calculations, such as machine translation, natural language processing, and speech recognition [9].

RNNs share the same weights across all steps. This algorithm has the ability to memorize sequential events and model time dependence [9]. An example of RNN architecture [10] is presented in Figure 4. The differences between the CNNs, SAEs, and RNNs, which are introduced as deep learning methods in this review, are presented in Table 1.

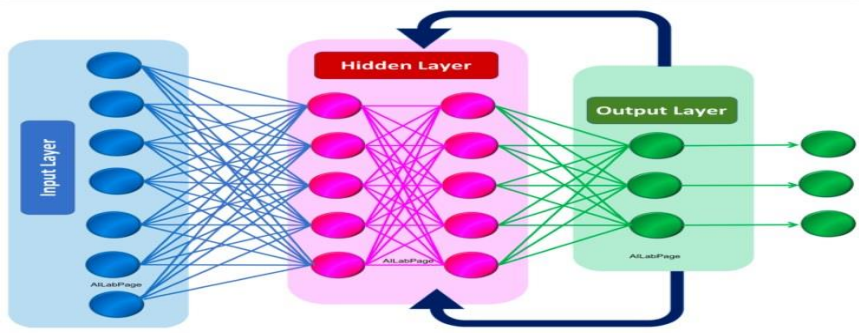

Figure 4: Recurrent Neural Networks

Table 1. The differences between popular deep learning techniques

Feature	Convolutional neural networks (CNNs)	Stacked autoencoders (SAEs)	Recurrent neural networks (RNNs)
Task	Speech recognition Image recognition Natural language processing	Anomaly detection Unsupervised learning Dimensionality reduction	Natural language processing Speech recognition
Data	Spatial or temporal	Unlabeled	Sequential
Strength	Feature extraction Pattern recognition	Efficient data representation	Long-range dependencies
Weaknesses	Not well-suited for unstructured data	Requires large amounts of labeled data	Sensitive to long time delays

Deep Learning and Computer Vision Applications

A. Medical Image Analysis:

One of the most well-known and important uses of deep learning and computer vision in healthcare is medical picture analysis. With the number of medical imaging tools like MRI, CT scans, and X-rays growing, it is more important than ever to be able to look at these images quickly and correctly. When combined with computer vision methods, deep learning algorithms have shown to be very good at automating and improving medical picture analysis, which leads to better evaluations and choices about how to treat patients.

A study in Nature Medicine found that deep learning algorithms could spot skin cancer with a 94.5% success rate by looking at dermoscopy pictures. Human doctors, on the other hand, were only 86.6% accurate, which shows the promise of these tools in dermatology.

Deep learning and computer vision algorithms let doctors and nurses get useful information from medical pictures, which helps them find and diagnose different diseases. These technologies can help find tumors, sores, abnormalities, and other health problems. This can lead to faster treatment and better results for patients.

When used together in medical picture analysis, deep learning, and computer vision have a lot of promise to improve health results. As study and development in this field continue to move forward, people can expect medical picture analysis to become even more accurate, efficient, and innovative. This will allow for early diagnosis, customized treatment plans, and better patient care.

B. Early Disease Detection:

Finding disease early is important for successful care and better patient results. Deep learning and computer vision methods have shown that they have a lot of promise to help find diseases like cancer, heart disease, and brain illnesses early on. These technologies use the power of data analysis and pattern recognition to find small changes in medical data. This lets doctors intervene and help patients as soon as possible.

Researchers have shown that deep learning systems are good at finding the early signs of diseases. For example, an NCBI study showed that deep learning models could correctly identify the start of Alzheimer's disease up to six years before it was diagnosed clinically, with an AUC of 0.88. This shows how deep learning systems can look at complicated medical data, like brain scans, and find minor patterns that are linked to the development of disease.

Deep learning and computer vision have been used in the area of medicine to find early-stage cancer and precancerous tumors. For example, a study in the journal Nature Medicine showed that a deep learning system was more accurate than doctors' at finding breast cancer in scans. Similar improvements have been made in finding lung, skin, and prostate cancers, which shows that these tools can help find cancers early on.

C. Surgical Assistance:

Deep learning and computer vision technologies are changing the way surgery is done by helping in real-time and making surgery more precise. These apps help doctors see important parts of the body, plan treatments and do complicated procedures more accurately and quickly.

Robot-assisted surgery is a popular type of surgical help. It uses deep learning algorithms and computer vision techniques to let robots do surgical tasks while being guided by doctors. These tools can look at pictures in real-time and give doctors input, which helps them handle instruments more precisely and makes sure the surgery goes as well as possible.

Deep learning algorithms have also been used to separate and analyze MRI or ultrasound pictures taken during surgery. This helps doctors find the edges of the tumor, find their way around complicated internal structures, and make sure the tumor is completely removed while causing as little damage as possible to healthy tissues.

Researchers have found that using deep learning and computer vision to help with surgery could be a good idea. A study in the magazine Nature showed that a deep learning system could find lymph node metastases in breast cancer patients better than a person could. This helps doctors make better decisions during surgery. Also, these technologies have been used in virtual reality (VR) surgery training, which lets doctors practice complicated procedures in a virtual world that looks and feels real. This improves surgery skills, cuts down on mistakes, and makes patients safer.

D. Disease Diagnosis:

For effective treatment planning and patient care, a disease must be diagnosed correctly and on time. Deep learning and computer vision methods have shown that they have a lot of promise to help doctors diagnose diseases by looking at medical data and finding trends and outliers.

Deep learning techniques have been used with X-rays, MRI scans, and CT scans, among others, to help doctors. These programs can look at a lot of image data and help doctors find abnormalities, tumors, and other signs of illness. For example, a study that was released in the journal Nature Medicine showed that a deep learning system could find and label skin cancer as well as doctors.

Deep learning models have also been made to identify illnesses like diabetic retinopathy from pictures of the retina and lung diseases from chest X-rays.

Deep learning is also used to help doctors figure by figuring out how to read medical data and clinical notes. These programs can pull useful information from patient data, lab results, and clinical accounts to help doctors diagnose diseases and predict what will happen. Deep learning models can help find disease risk factors and come up with personalized treatment plans by looking at big datasets and finding connections.

E. Drug Discovery:

Finding new drugs is a complicated and time-consuming process that requires a lot of study and testing. Deep learning and computer vision have become strong tools for speeding up drug development. They help with different parts of the process, from finding the right target to finding the best lead.

Deep learning algorithms can look at a lot of biological data, like genetic data, protein structures, and chemical interactions, to find possible drug targets and predict how well drug compounds will work. By learning from known drug-target interactions, these models can suggest new candidate molecules and predict how well they will bind. This helps researchers choose potential drug candidates to study further.

Computer vision is also used to find new drugs, especially in the processing of data from high-throughput screening (HTS). HTS is a way to find possible hits by trying big libraries of chemicals against disease targets. Computer vision programs can look at the pictures made by HTS to find and describe the interactions between chemicals and targets. This helps find good options for new drugs.

Using deep learning and computer vision to find new drugs has shown to be a good idea. For example, a study in the magazine Nature showed how deep learning models could be used to predict how medicine molecules would work in the body. These models were very good at guessing how chemicals would work on specific targets, which could cut down on the time and money needed for early-stage drug screening.

By using the power of deep learning and computer vision, the field of drug development will be able to speed up research, get better at finding targets, and optimize leads more quickly. These tools could change the way new drugs get to the market, which would be good for people all over the world.

F. Predictive Analytics:

Deep learning and computer vision are useful in healthcare when they are used to do predictive analytics. Deep learning algorithms can help predict disease results, find high-risk patients, and make the best treatment plans by analyzing large amounts of data, such as electronic health records, medical pictures, and genetic data.

Deep learning models can use complicated patterns and connections in the data to predict how likely it is that a disease will get worse, send a patient back to the hospital, or cause other problems. For example, researchers have made deep learning systems that can identify the risk of cardiovascular events like heart attacks or strokes by analyzing a patient's medical history, lifestyle factors, and diagnostic test results. By figuring out which patients are at high risk, healthcare workers can act quickly, take preventive steps, and improve the health of their patients.

Deep learning can do more than just predict how a disease will turn out. It can also be used to improve treatment plans by making them more specific to each patient. Deep learning models can help find the best medicines for each patient by looking at their data, such as their genetic information and how they respond to treatments. This method, called "precision medicine," has a lot of potential to help tailor treatments to each patient, improve the success rate of treatments, and reduce unwanted side effects.

G. Virtual Assistants:

Deep learning and computer vision could be used to power virtual helpers that could change how doctors and nurses deal with patient data, make routine chores easier, and improve patient care.

Natural Language Processing (NLP) methods and deep learning make it possible for virtual helpers to understand and answer spoken or written questions. This makes it easy for healthcare workers to find information quickly and easily. These virtual helpers can get patient information, test reports, and treatment standards. This saves healthcare workers important time and makes them more productive.

Medical pictures and diagnostic tests can also be easier to understand with the help of computer vision features that are built into virtual helpers. Virtual helpers can help radiologists, pathologists, and other experts make decisions by looking at pictures and pulling out useful information. For instance, deep learning models can look at medical pictures like MRI scans or tissue slides to find problems or help doctors figure out what's wrong.

Virtual helpers could be used in healthcare processes to make them more efficient, lower the amount of work that needs to be done, and improve patient care. By using deep learning and computer vision technologies, virtual helpers can become useful tools in the healthcare environment, helping doctors and nurses and making things better for patients.

H. Disease Monitoring:

Deep learning and computer vision could change the way that doctors keep track of diseases. By analyzing patient data and keeping an eye on vital signs, these technologies can help catch the development of disease early, allowing doctors to act quickly and improve the patient's health.

Deep learning systems can keep track of a patient's heart rate, blood pressure, glucose levels, and breathing habits by using personal devices and sensors.

By looking at this real-time data, these computers can spot differences and trends that could mean a disease is starting or getting worse.

For example, deep learning models can look at constant glucose tracking data or electrocardiograms from people with long-term conditions like diabetes or heart disease to find changes or problems that need medical care.

I. Radiology Automation:

Deep learning and computer vision uses are very helpful in the area of radiology. Radiology jobs, such as analyzing and interpreting images, could be done automatically with these technologies. This would make assessments faster and more accurate.

Deep learning models can look at medical pictures like X-rays, CT scans, and MRIs to help doctors find problems and make correct conclusions. For example, deep learning systems can look at CT scans to find worrisome lumps or tumors in lung cancer screening, which helps find cancer early.

Deep learning can also help triage and prioritize imaging studies, making sure that pressing cases get help right away.

Deep learning can improve the speed of imaging processes, reduce diagnostic mistakes, and improve patient care by automating jobs that need to be done over and over again and take a lot of time.

J. Mental Health Diagnosis:

Deep learning and computer vision are now being employed to assist in determining the underlying issues affecting an individual's mental state. By looking at patterns of behavior and facial movements, these tools can help find and diagnose mental health problems early on.

Deep learning models can look at data from different places, like electronic health records, talks with patients, and even social media, to find trends that point to mental health problems.

These tools can aid doctors in assessing mental health conditions such as depression, anxiety, or schizophrenia in their patients and initiating early intervention. Through the utilization of deep learning and computer vision, mental health professionals can enhance their diagnostic capabilities and formulate personalized treatment strategies to facilitate improved patient outcomes.

Even though deep learning and computer vision show promise in diagnosing mental health problems, they should always be used in combination with traditional clinical tests and under the guidance of trained healthcare professionals. These tools can help with diagnosing mental health problems, but they shouldn't take the place of human knowledge and care.

K. Elderly Care:

The needs of an aging population are different from those of a younger population, and deep learning and computer vision have become useful tools for meeting those needs. The main goals of these apps are to improve the quality of life for seniors, keep an eye on their health, and give them personalized care.

Detecting and stopping falls is an important use of this technology. When paired with camera systems and sensors, deep learning algorithms can look at how people walk and move to see if they are likely to fall. Alerts can be sent to medical professionals in real-time, so they can help right away and avoid accidents.

Computer vision technology can also be used to keep an eye on what older people do every day to make sure they are safe and healthy. By using cameras and image recognition algorithms, it's possible to spot outliers or changes from normal trends.

Deep learning systems can also look at data from smart devices to track vital signs, sleep habits, and how well older people take their medications. This information can help doctors keep track of the health of older people and spot any possible health problems early.

L. Skin Cancer Detection:

For skin cancer treatment to work, it needs to be found early. Deep learning and computer vision are shown to be useful tools in this area. These tools help doctors find skin cancer quickly and accurately, which helps them make good choices.

Deep learning models can look at pictures of skin tumors and moles and use big data sets to learn patterns that show whether a condition is cancerous or not. By matching pictures to these learned patterns, the models can very accurately spot possible signs of skin cancer. This technology helps doctors make quick and accurate diagnoses, which improves the health of their patients.

Also, computer vision techniques can be built into Smartphone apps, giving people the ability to check skin blemishes on their own. The camera on the device is used by these apps to take pictures, which are then analyzed by deep learning models. Users get feedback right away, which encourages them to get a professional opinion when they need to.

It's important to remember that even though deep learning and computer vision technologies show promise in areas like caring for the old and finding skin cancer, they should always be used in combination with professional medical advice and knowledge. These technologies can help and support healthcare professionals in giving personalized and effective care, but they shouldn't take the place of clinical evaluation and human judgment.

M. Rehabilitation Therapy:

Deep learning and computer vision are making big changes in the area of physical treatment, which helps people get better after accidents, surgeries, or diseases that make them weak.

Deep learning algorithms can look at how people move by using motion-tracking monitors and cameras. They can then give real-time feedback to patients doing recovery routines. With this technology, therapy programs can be made to fit each person's progress, allowing for the best possible healing results.

When virtual reality (VR) systems are mixed with deep learning and computer vision, they can make settings for recovery therapy that are engaging and dynamic. These systems keep track of the patient's moves and give them visual and audible cues to help them do their exercises. This keeps them interested and motivated.

By using these tools, healthcare professionals can make physical treatment more effective, speed up healing, and improve patients' general health and quality of life.

N. Health Monitoring Wearables:

In the past few years, health-tracking tools have become very popular. The mix of deep learning and computer vision has made them better at tracking and studying different health factors. With sensors and cameras, these devices, like Smartphones and fitness bands, can collect data in real-time and give people and healthcare workers useful information.

Deep learning systems can look at the data that trackers send, like heart rate, sleep patterns, physical activity, and more, to provide personalized health tracking. This software can find outliers and possible health risks by learning patterns and trends from a large amount of data.

For example, if one's heart rate isn't normal or if they don't sleep at the same time every night, that could be a sign of a health problem. By letting people and healthcare professionals know about these changes, health issues can be avoided or fixed quickly.

Also, gadgets with built-in computer vision technology can let people check important signs like their heart rate and blood oxygen levels without touching them. This makes it easy for people to keep track of their health at all times and gives them a fuller picture of their health.

O. Medical Research:

Deep learning and computer vision are changing how medical research is done by giving experts better tools for examining data, processing pictures, and finding trends. Researchers can use these tools to find out more about diseases and how to treat them, learn new things, and make discoveries faster.

Advanced deep learning systems possess the capacity to analyze an extensive array of medical imaging, such as X-rays, MRIs, and CT scans. This facilitates medical professionals in accurately diagnosing conditions and strategizing appropriate treatment plans. Through extensive training on copious data, these sophisticated software systems can learn to identify minor anomalies or nascent signs of illness that may potentially elude human detection. This not only enhances the precision of diagnostic tests, but also expedites their execution, leading to efficient and effective medical care.

Medical research leverages computer vision techniques to interpret complex imaging, often proving difficult to comprehend for the human eye. For instance, deep learning models can scrutinize minuscule cellular images, determine their morphology, segregate various cell types, and identify anomalies. This allows scientists to gain a profound understanding of cellular functions, disease propagation mechanisms, and pharmacological interactions.

Deep learning systems can also adeptly navigate vast datasets from genomics and proteomics, thereby identifying patterns, signaling factors, and facilitating the development of personalized medicine. These sophisticated tools can efficiently process a considerable quantum of genomic data, assisting researchers in discerning genetic variations associated with diseases, prognosticating patient outcomes, and formulating tailored therapeutic interventions.

The synergistic application of deep learning and computer vision in medical research serves to expedite discovery rates, streamline data examination, and aid researchers in making informed decisions. The potential of these sophisticated tools is vast, enabling individuals to unearth innovative methods for disease treatment and prevention, as well as facilitating a deeper understanding of disease etiology and progression.

Conclusion

In conclusion, the integration of deep learning and computer vision in healthcare is transforming the industry, paving the way for more precise interpretations, tailored therapeutics, and improved patient care. These technologies stand to revolutionize healthcare practices by providing valuable insights, enhancing treatment accuracy, facilitating early disease detection, and streamlining healthcare processes.

Deep learning and computer vision collaborate to address an array of challenges within the healthcare sector, such as interpreting medical imagery, managing remote patient care, innovating new pharmaceuticals, and analyzing genomic data. By harnessing the power of these advanced tools, healthcare professionals can make well-informed decisions, refine processes, and deliver superior outcomes to patients.

As we cast our gaze towards the future, it is evident that deep learning and computer vision will persist in significantly influencing the healthcare landscape. Embracing these technological advancements enables

improved patient care, facilitates more effective health system operations, and ignites novel medical discoveries with potential global impact.

Deep learning is an emerging powerful technique with the potential to revolutionize the healthcare industry. In recent years, DL has provided effective solutions for discovering and developing drugs, optimizing clinical workflows, improving remote patient monitoring, and analyzing medical images. This paper has focused on the healthcare challenges addressed using DL with promising results, including analyzing medical images with high accuracy and creating personalized treatment plans for individual patients.

This paper may also focus on researchers can develop and integrate efficient technologies to meet the hardware requirements. Improving the DL models is necessary to build more effective systems. Therefore, creating well-defined general architectures that work with different types of health data is essential to solving complex problems in healthcare systems. Additionally, implementing DL models in terms of Explainable Artificial Intelligence (xAI) can help in describing an AI model, its expected impact, and potential biases.

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