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Challenges and Prospects of Implementing CNNs in Healthcare Diagnostics

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Abstract:

Healthcare is closely related to human life, and it is one of the most important research fields in contemporary science. Healthcare is everywhere in human life. There is no doubt that when people have a disease, timely treatment is required. This article discusses a kind of Artificial intelligence which is the deep learning called Convolutional neural networks in healthcare. Doctors use Convolutional Neural Networks (CNNs) in disease prediction and detection like some kinds of common disease and cancer. CNNs reached a pretty great performance in healthcare. It has high efficiency and accuracy. This article shows common diseases such as pneumonia, heart disease and diabetes also this article demonstrates cancer such as lung cancer, skin cancer and prostate cancer. As results, those different disease prediction applications have shown CNN is a powerful and useful tool for healthcare. However Artificial intelligence still has lots of big challenges which include explanation, interactivity, adaption, privacy and so on. In the future, AI in healthcare is still bright even if there are so many difficulties. With continuous investigations, the explanation of algorithms is going to become clear, transfer ability would be better so that could save a lot of money and labors. It is expected to bring to more robust, safe, and widely applicable medical diagnostic tools.

Keywords: Convolutional neural networks; disease prediction; healthcare.

1. Introduction

Healthcare is closely related to human life, and it is one of the most important research fields in contemporary science. Healthcare is everywhere in human life. There is no doubt that when people have a disease, timely treatment is required. However, the scarce availability of human experts and the fatigue and rough estimate procedures involved with them limit the effectiveness of image understanding performed by skilled medical professionals [1]. This means that the diagnosis is inefficient and has low accuracy, so it will threaten the life and health of the patient. In order to improve diagnostic efficiency and accuracy and reduce patient mortality, the application of artificial intelligence can be considered to improve

diagnostic performance due to their excellent performance in other domains.

Machine learning, particularly for the deep learning, has achieved great advancements in the last decade. Notably, the Convolutional Neural Network dominates with the best results on varying image classification tasks [2]. CNN is kind of deep learning and CNN has very good performance at graphic detection and classification. It is very good at learning the local and global structures from image data. General image objects like handwritten numbers or human faces have obvious local and global structures, hence simple local features such as edges and curves can be combined to become more complex features such as corners and shapes and eventually the objects. Recently, CNN has also been incorporated into medical imaging analysis, such as the knee cartilage segmentation [3].Shankar et al. implemented the forecasting algorithm based on the real-life patient data. They established a convolutional neural network model for prediction using structured and unstructured data. Finally, the model performance can achieve between 85 and 88% in terms of the accuracy metric. Gao et al. used 49 CEDM applications to support the images which were combined again for making progress in diagnosing breast cancer. Ultimately, this model achieved over 85% accuracy in diagnosis [4]. For instance, Marques et al. proposed using CNN algorithm to detect COVID-19. Firstly, they used classifications of two kinds of figures: one was patient who got COVID-19 and the other was normal people. By training the model, as a result, it had achieved over 96% accuracy. The binary classification got a very fantastic consequence, 99.64% [5]. For example, Acharya et al. have used CNN in detecting EEG graphs. In their experiment, they used thirteen layers to detect algorithm performance was great which got 88.67% accuracy [6]. The motivation of the review is to make a summary for convolutional neural networks in healthcare and clear how convolutional neural networks work and the performance.

2. Method

2.1 Introduction of the Convolutional Neural Network

Generally, convolutional neural networks are composed of three types of layers: Convolutional Layer, Pooling Layer and Fully Connected Layer. Each layer has its own responsibility. Convolutional Layer is for extracting local features from the input image using convolution operations. The pooling layer down-samples the feature map produced by the convolutional layer, reducing its dimensions and computational complexity while preserving important features. The most common types are maximum pooling and average pooling. Maximum pooling chooses the biggest value from each particular windows in the last layer and average pooling calculates mean for each particular windows as output. The fully connected layer integrates features extracted by previous layers and uses them for the final classification or regression task. Each neuron in this layer is connected to all neurons in the previous layer. To train a CNN model, there is a lot of data for classification. By large scale data set, the algorithm is going to reach higher accuracy, performance improve as well.

2.2 Common Disease Prediction

2.2.1 Pneumonia prediction

Rahman et al. provided an in-depth analysis of pneumonia detection using four pre-trained convolutional neural networks: AlexNet, ResNet18, DenseNet201, and SqueezeNet. These models were fine-tuned with a dataset of 5,247 chest X-ray images, with resolutions ranging from 400p to 2000p, to classify images into normal, bacterial, or viral categories. The study's approach offers potential for faster pneumonia diagnosis by radiologists and can enhance rapid screening at airports. Generally, CNNs perform better with larger datasets, but transfer learning proves effective in scenarios with limited data [7].

2.2.2 Heart disease prediction

Mehmood et al. introduces CardioHelp, a method for estimating the likelihood of cardiovascular disease using convolutional neural networks. The approach focuses on modeling temporal data to predict heart failure at its earliest stage. They developed a heart disease dataset and evaluated CardioHelp against leading methods, demonstrating promising performance [8].

2.2.3 Diabetes prediction

Diabetes is a chronic condition resulting from the pancreas's inadequate insulin utilization. Early detection can significantly improve patient outcomes. Unlike traditional analytical methods, deep learning eliminates the need for manual feature extraction. To illustrate this advantage, Parul et al. developed a real-time monitoring hybrid deep learning model for detecting and predicting Type 2 diabetes mellitus using the publicly accessible PIMA Indian diabetes database. This study makes four key contributions: first, it compares various deep learning models; second, based on the results, it proposes a combined CNN-Bi-LSTM model for Type 2 diabetes detection and prediction [9].

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2.3 Cancer Prediction

2.3.1 Lung cancer prediction

Alakwaa et al. presents a Computer-aided Diagnosis (CAD) system designed for the classification of lung cancer in Computed Tomography (CT) scans with unmarked nodules, utilizing a dataset from the 2017 Kaggle Data Science Bowl. The initial segmentation of lung tissue from the CT scans was accomplished through thresholding, which was found to be one of the more effective methods for lung segmentation. The initial strategy involved feeding the segmented CT scans directly into 3D Convolutional Neural Networks for classification, but this approach proved insufficient. Instead, the authors employed a modified U-Net, trained on the LUNA16 dataset (which includes CT scans with labeled nodules), to first identify potential nodule candidates within the Kaggle CT scans. Although the U-Net produced numerous false positives, the regions containing the most likely nodule candidates, as identified by the U-Net, were subsequently processed by 3D CNNs to classify the CT scans as either positive or negative for lung cancer. This CAD system surpasses existing systems in the literature, which typically require multiple training and testing phases with extensive labeled data. In contrast, the proposed system operates in three primary stages (segmentation, nodule candidate detection, and malignancy classification), enabling more efficient training and detection while offering broader applicability to other cancers [10].

2.3.2 Skin cancer prediction

Zhang et al. applies an advanced version of the Whale Optimization Algorithm to refine a CNN. The proposed method's performance is evaluated by comparing it with other approaches on two separate datasets: the Dermquest and DermIS Digital Database. Dermquest is an online resource designed for dermatologists and healthcare professionals in the field related to skin cancer, offering a comprehensive collection of more than 22,000 clinical images. These images have been meticulously reviewed and approved by leading international editorial boards [11].

2.3.3 Prostate cancer prediction

Duran-Lopez et al. presents an innovative computer-aided diagnosis system leveraging Deep Learning techniques for prostate cancer prediction. The system processes whole-slide histology images by initially sampling patches and applying several preprocessing methods, including a distinct patch-scoring technique that discards irrelevant tissue areas. The processed patches are subsequently analyzed using a specially designed Convolutional Neural Network, which produces a heatmap indicating areas of malignancy. The study also examines the role of stain normalization in reducing color inconsistencies between various scanning devices [12].

3. Discussion

3.1 Challenges for AI in Disease Prediction

3.1.1 Poor explain-ability "black box"

AI can only produce results, but it is difficult to explain its operating rules. So, when the AI algorithm produces wrong results, it is difficult for researchers to make adjustments and improvements. Moreover, when using AI to predict results, it is difficult for doctors and patients to trust the prediction results due to poor interpretability.

3.1.2 Generalization ability

The data distribution of patients in one specific region is different from that in another region. For example, different ages and different genders will cause different data distributions. Therefore, it is difficult to apply a model to other places. Different hospitals will need to have their own independent models, which greatly increases the cost, and the amount of data used to train the model is not enough.

3.1.3 Privacy

Many patients are reluctant to disclose their privacy, and it is essential to respect and protect patient privacy. This is especially crucial for patients with significant social status, where preventing data leakage, such as for national leaders and professional athletes, is imperative.

3.2 Future Prospects

3.2.1 Expert system

Interpretable models are SHAP, LIME et al. Garreau and Mardaoui show that with a large number of examples, LIME explanations converge to a limit. This analysis links LIME to integrated gradients, revealing that LIME explanations are akin to the sum of integrated gradients over LIME's superpixels [13].

3.2.2 Transfer learning

Transfer learning enables one model to apply algorithms algorithm to another different scenario. Don't start training from scratch, so this reduces the time to train the model. Because most use prior model algorithms, only a small adjustment and amount of training.

3.2.3 Federated learning

Federated learning Is a kind of model training method based on the premise of protecting data privacy. It does

not need to concentrate on central server training, but uses multiple devices and servers for training. In this process, the data never leaves the device, greatly reducing the risk of data leakage.

4. Conclusion

From this article, convolutional neural networks play a great role in healthcare, and it has achieved a significantly advanced development especially in disease prediction. Convolutional neural networks have great performance. Healthcare uses convolutional neural network to detect figures, make classification and get diagnosis result. From common diseases to cancer, convolutional neural networks have shown great potential to improve diagnostic accuracy and efficiency. However Artificial intelligence still has lots of big challenges which include explanation, interactivity, adaptation, privacy and so on. Solving these problems is quite important to Artificial intelligence using in healthcare field. In the future, AI in healthcare is still bright even if there are so many difficulties. With continuous investigations, the explanation of algorithms is going to become clear, transfer ability will be better so that could save a lot of money and labors. It is expected to bring more robust, safe, and widely applicable medical diagnostic tools.

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