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Deep Learning in Macular Disease Diagnosis: A Technical Review

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ABSTRACT: The era of medical big data requires robust and high-speed framework for recognizing diseases and its progression. Deep Learning has renovated the area of health care like radiology, cardiology and ophthalmology. The prospects of DL systems in screening macular diseases such as Age-Related Macular Degeneration, Macular Edema, Diabetic Retinopathy, Glaucoma, Choroid Neo-vascularization etc. is highly effective. Automated detection of these retinal diseases can be employed through different imaging modalities like fundus photography, Optical coherence Tomography (OCT). OCT, a non-invasive technique gains attention by easing the task of distinguishing retinal disorders. This paper outlines the perspective of deep learning algorithms for diagnosing ocular diseases using OCT images.

KEYWORDS: Deep Learning, OCT, Retinal diseases, AMD, Glaucoma, Diabetic Retinopathy

I. INTRODUCTION

Deep Learning is the subdivision of Artificial intelligence which had been evolved in 2000[4].The ability of deep learning network is to automatically train low level representations and integrate them to high level representations[2].DL algorithms generate features which are challenging for human interpretation. Hence it is known as “black box”[4]. Thus, DL model utilizes multiple processing layers and it mimics the human neural system for decision making.DL can provide more accurate results by adjusting weights. The advent of mathematical models and accessibility of big data leads DL systems to be applicable in numerous industries. Additionally,it can be widely used in face recognition, object recognition and Natural language processing[5]. It also reforms health care industry from drug discovery to disease diagnosing.

Globally,2.2 billion people are affected by vision impairment. Cataracts and glaucoma are the leading cause of blindness. Besides, several eye diseases like Age related macular degeneration (AMD), diabetic retinopathy (DR), Macular Edema (ME), Drusen, Macular holes, Vitreous traction, Branch retinal vein Occlusion (BRVO), Choroid NeoVascularization (CNV), geographic atrophy are in evolved[3].

In case of retinal diagnosis model aids doctors by automated monitoring, progression and identification of eye disease. There are several modalities like fundus photography, Optical Coherence Tomography, Scanning Laser Ophthalmoscopy (SLO)are being applicable for screening macular disorder[10]. Among these,OCT is highly efficient and emerging modality. It is a non-invasive technique which can exhibit pathological changes in the cross sectional retinal layers.OCT is reliable to diagnose the disorder in earlier stages for patients in which the symptoms are not seen. OCT tool is commercialized nowadays by incorporating deep learning algorithms. Evidently,OCT with DL algorithms can accurately characterize Macular diseases.

Conventional methods of diagnosing technique may lead to higher erroneous rate and time consuming.Employing DL in ophthalmology improves accuracy and reliability. It simplifies the task of ophthalmologists. The motivation of the work is to emphasis technical perspectives of deep learning in retinal screening using OCT images.

The paper is organized as follows, Section II explains related work, Section III comprises of methodology and Section IV describes conclusion.

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II. RELATED WORK

Justin et.al [2] discussed about the deep learning applications in analysis of medical images. The paper explains about the the different deep learning architectures. It describes the role of DL in different process of image analysis like classification, localization, detection, segmentation and registration.It results that DL algorithms is efficient for image recognition.

Wei Lu et al [4] describes about the applications of Artificial intelligence in Ophthalmology. The paper focuses on the major diseases such as Diabetic Retinopathy, Glaucoma, Age Related Macular Degeneration and Cataract. It concludes that AI system revolutionize the existing diagnostic pattern.

Daniel et al [1]reviewed about the clinical and technical perspectives of deep learning in ophthalmology. The paper examines fundus imaging and OCT imaging technique in retinal disease diagnosis. The paper also describes about the future directions of deep learning algorithm in retinal diseases.

III. METHODOLOGY

3. Deep Learning

The robust DL model comprises of 2 components 1.DL architecture 2.Datasets This section describes about two prominent architecture of DL system such as 1.Convolutional Neural Network(CNN) 2.Recurrnt Neural Network(RNN).

3.1 Convolutional Neural Network(CNN)

CNN was developed in the year 1990.It is the most efficient algorithm which can accomplish complicated tasks.CNN is composed of two parts feature extraction part and classification part. Convolution layer, Rectified Linear Unit(RELU) layer and pooling layer[2] defines the first one and the latter one is defined by fully connected layers.
The convolutional layer performs two functions.One function consists of input pixel values of image.The second function represents filter. The product between the two functions provide output.The process is repeated for whole image and the feature extraction map is constructed. Filtering takes place in this map. The low level features are integrated into high level features. The ReLu Layer focuses mainly to speed up calculations.It also helps to avoid the gradient values tends to reach zero. The Pooling layer is mainly responsible for reducing parameters and image size.
The last layer is fully connected layer. This layer is mainly responsible for classification.It takes the input of previous layers and classify them.It is composed of activated features which helps to predict the appropriate class. The Architecture of CNN is shown in Fig.1

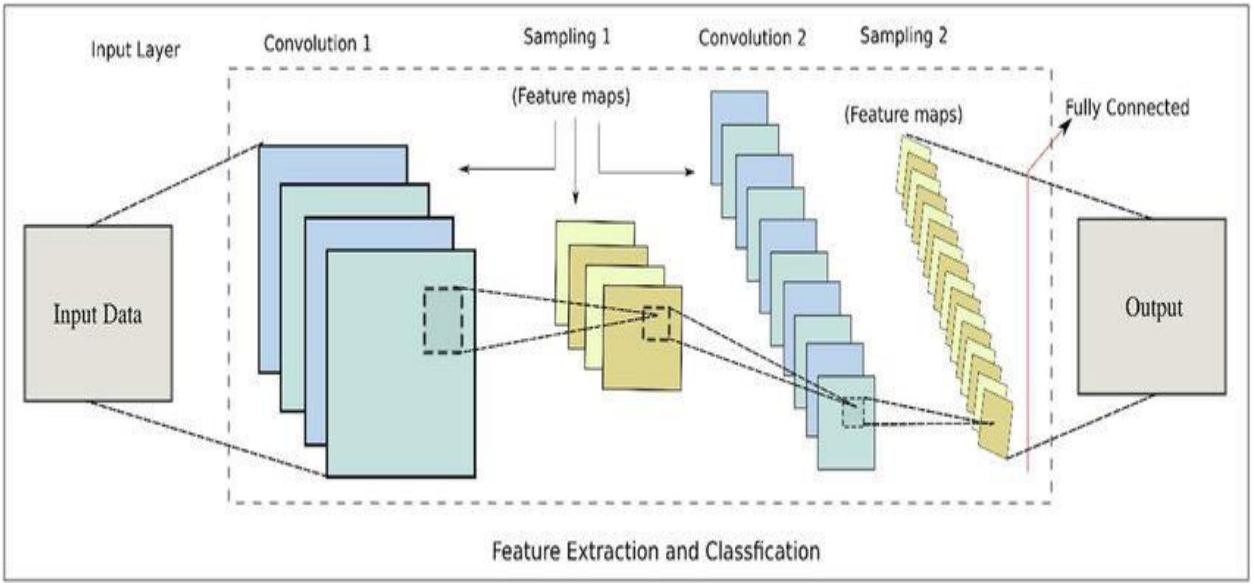

Fig 1.Architecture of Convolutional Neural Network

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3.2 Recurrent Neural Network(RNN)

Recurrent neural networks (RNN) are constructed to analyze sequence of data.RNN network has a memory which is able to remember the previous data for further prediction. Hence the output of previous layer is fed as input to current layer. The weights and bias is common for all hidden layers. The architecture consists of input layer,hidden layer and output layer. The predicted output is compared with the actual output

If there is no match,then the error is generated and backpropagated.There are some other RNN architectures are developed such as Long Short Term Memory(LSTM) and Gated Recurrent Units(GRU) to solve convergence problem[2].The applications of RNN are Image Captioning, Sentiment Classification and Language Translation. The architecture of RNN is demonstrated in Fig 2.

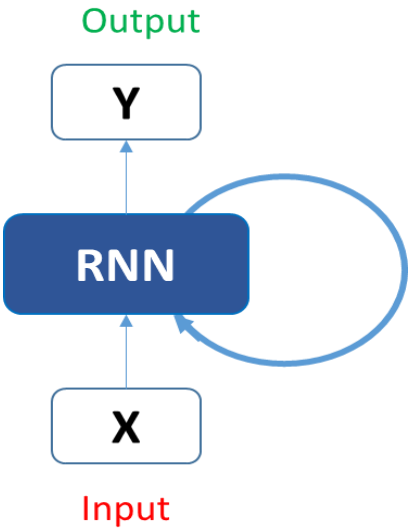

Fig 2. Architecture of Recurrent Neural Network

IV. DEEP LEARNING IN RETINAL DISEASES

4.1 DL in AMD:

Age related Macular Degeneration is one of the important cause of visual impairment.It occurs due to macular damage correlated with drusen existence.Drusen is located between Retinal Pigment Epithelium(RPE) Layer and the Bruch Membrane.AMD is generally classified into intermediate stage(Drusen) and advanced stage(Choroid Neo-vascularization).Untreated AMD results in central vision loss[6].DL algorithms aims to identifying lesions in macular region and classifies whether it relates to AMD related or not.AMD patients are identified by anti-vascular endothelial growth factors(VEGF) in some areas.By automatically characterizing the progression level and analysis, DL model can classify the AMD datasets effectively. Some recent research works are also based on DL algorithms. Treder et.al[7] proposed a DL model to identify AMD using SD-OCT images.SimilarlyLee.et al[8], discuss about the macular fluid segmentation in OCT images using deep learning.

4.2 DL in glaucoma

Glaucoma is the second cause of visual impairment.Glaucoma is assessed using structural changes in Optic Nerve Head(ONH),Retinal Nerve Fibre Layer(RNFL) and neuroretinal rim width[10].DL algorithms achieve its reliability in segmenting Optic Nerve Head(ONH) to calculate cup to disc ratio.Recent trends reveals that CNN acts as a reliable algorithm to identify changes in Optic Nerve Head including RNFL assessment.So far,few works had been released with glaucoma detection in OCT images using deep learning.Recently,Bruch membrane is used as a considerable parameter to measure minimum rim width for glaucoma diagnosis.[1]

4.3 DL in Diabetic Retinopathy

Diabetic retinopathy(DR) is a chronic disease mainly affects one third of diabetic patients.Untreated disease leads to irreversible vision loss.The major causes for DR are presence of ,microaneurosyms, exudates and cotton wool spots[5].Most DR screenings are applied through fundus images.DL algorithms plays a significant role in diagnosing

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DR.CNN architecture provides optimal results in detecting the presence of lesions.ELTanbolyet.al.[9] proposed a DL technique to detect DR using OCT images.

V. CONCLUSIONS

Studies regarding Deep Learning algorithms and macular diseases,reveals that DL models work efficiently in diagnosing ophthalmology diseases.Though many drawbacks are involved in DL models,it provides reliable results and thus easing the fundamental work of macular screening.These DL models can be employed in all stages of macular analysis.It plays the major role in analyzing large volumes of OCT images.

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