Need of use of Machine Learning Techniques for Recognition and Classification of Ocular Diseases

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***Abstract*—Although ophthalmic problems are often not life-threatening, their progression over time may have a significant impact on the patient's quality of life. The purpose of this opinion paper is to assess the need of use of machine learning techniques for classification and recognition of ocular diseases. This paper uses the meta-analyses techniques to present opinion about the research topic. The paper reviews different publications in 2018. In 2018, 44 publications focus on diabetic retinopathy, 30 publications focus on glaucoma, while 25 publications focus on macular degeneration. On the other hand, in 2019, this ratio is the same, but there were 4 publications on cataract and 6 publications on retinopathy of prematurity. Methodology includes data collection, pre-processing, segmentation, and testing with various data ratios for detection and classification. Applications for AI, ML, and DL are undoubtedly evolving quickly. These technologies promise to be a particularly important advance in the field of health care applications, even though they have not yet been sufficiently developed to be used in a clinical context If health care organizations and ophthalmologists use these innovations widely, the medical profession and ophthalmic community will gain a lot.**

***Keywords*—Ocular, ML, AI, DL, imaging, ophthalmologist**

INTRODUCTION

Many eye disorders that lead to blindness such as diabetic retinopathy (DR) and glaucomamay be prevented or postponed when they are identified and treated in the early stages. For the early identification of diseases and the care of patients, new sources of information are now accessible because of recent advancements in diagnostic technologies, imaging, and genomics. Utilizing innovative techniques, such as machine learning, it is necessary to manage the quantity of multimodal data needed to support clinical judgments. As a therapeutic decision-support tool, deep learning has improved in the biological sciences by improving the high specificity of illness screening and treatment. This could increase the objectivity of clinical decisions. When analysing highly dimensional, very complex medical data, machine learning algorithms may make use of multimodal data, previous knowledge, and noise reduction [1]. In light of this, the research topic needs to be assessed because eye disorders get worse with time.

Physical examinations are conducted using ophthalmological instruments, and a diagnosis is made after a careful analysis of the results. Any machine-based solution should thus include observations, symptoms, and test-result data all at once when making predictions. The use of a standard description for clinical data and test results in medicine may also contribute to success. The first step in this way is the use of electronic health records. A lot of benefits, including easy retrieval and timely data interchange among various medical practitioners, may come from keeping patient data as digital data. The use of standardized taxonomies further improves the standard, accuracy, and consistency of patient data collecting [2]. According to this, physical examination of eye using ML will be very effective and accurate with minimum incision.

MACHINE LEARNING (ML)

Machine learning methods are designed to conveniently uncover complex behaviour in a particular dataset, enabling interpretation or forecast in fresh datasets. The detection of homogeneous subgroups within the input dataset is made possible by machine learning techniques. Machine learning approaches enable the construction of a classifier, or regression function, predicting the membership of upcoming cases when a grouping or classification label is provided for each example. Therefore, all potential sources of bias can be eliminated or reduced in order to guarantee that learning algorithms operate correctly on a given data.

Clinicians often try to integrate the findings from multiple testing and imaging technologies in order to diagnose and monitor illness. Machine learning methods are proven to be very effective and practical tools for assisting in illness judgment. Clinical visual sciences have used machine learning approaches to more effectively integrate multimodal data and enhance the testing and imaging equipment now utilized for illness diagnosis, prognosis, and monitoring. Several commercial diagnostic equipment now includes machine learning algorithms to quickly diagnose damaged eyes. For example, GDx by Carl Zeiss Meditec, Inc. is one of the tools which identifies glaucomatous eyes using NN algorithms [3]. Accordingly, these examination tools can lay the foundation for quick imaging and assessment of the eye disorder. The figure below illustrates the open source deep learning libraries

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used in ophalmology.

Open source deep learning libraries					
Python	C++	R	Java	JavaScript	MATLAB
TensorFlow	TensorFlow	MXNet	TensorFlow	TensorFlow	MXNet
Pytorch	MXNet	H2O	MXNet	MXNet	ConvNet
MXNet	Caffe	Darch	H2O	ConvNet	CXXNET
H2O	Torch	DLib	DeepLearning4J		
Caffe	Eblearn	DeepNet	Encog		
Keras	PaddlePaddle				
Chainer	DLib				
Theano	DSSTNE				

Figure 1: Open source deep learning libraries

Before objective prediction models for clinical vision sciences can be created, a few issues must first be resolved. The selection of the training sample is one of the main issues with prediction models for eye diseases. For the diagnosis and prognosis of illnesses in patients, predictive models should be developed. The current prediction models, however, often rely on a set of trainingthat consists of one patient's eye, with the selected eye being either healthy or ill. Additionally, it's likely that both of the eyes suffer different illnesses than what was taken into consideration when the models were being trained when applying the prediction models to the actual population. A glaucoma detection model, for instance, may not be able to identify a patient's ill eyes if they have diabetic retinopathy since the procedure was only trained to detect non-glaucoma from glaucoma patients [4]. This is very useful because diabetic patients can be segregated in advance to any surgical procedures.The classification technique may be used to evaluate the severity of an illness and potentially serve as a prediction tool given the likelihood of progression [15].

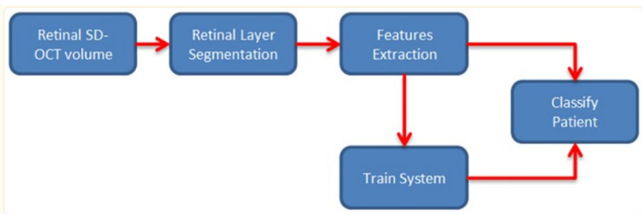

Figure 2: The block diagram of the proposed methodology in [15]

So, before using a machine learning approach, pre-processing the data is important. It is well known that most data include some inherent noise, which might bias the results of deep learning. Depending on the study source, imaging technique, device being utilized, and device parameters, this noise will change. The noise is seen as a purposeful mistake when utilizing technology that is readily available in commerce. By establishing many collections and averaging them, the user may increase the data integrity and decrease noise [5]. By gathering primary information using the same methods, under similar circumstances, and with the same equipment, the user may further reduce the impact of other causes of bias. These problems may be resolved, and unbiased estimation techniques might be developed. By assessing patients based on the sum of all important risk factors and multisensory data, these predictive models will also enable the selection of people who are most likely to benefit from treatment and the evaluation of the cumulative effect of the many adverse outcomes. Stratified and tailored medicine will improve significantly as a result of these models serving as a useful decision-making tool for controlling illness care and prognosis [6]. Hence, it is seen that ML is viable and convenient if applied to ophthalmology departments.

This demonstrates that practically all current research is disease-based, and consequently, algorithms developed or used were assessed for specific eye diseases. As a result, there isn't a single available solution. This is mostly due to inconsistent medical data collection, a serious problem that has limited the implementation of extensive automated solutions. When utilizing machine learning algorithms to assess data gathered by various professionals, inconsistencies brought on by different expression styles and vocabularies for sickness description and diagnosis present a serious difficulty [7].

Controlled terminologies have been created in order to improve communication across healthcare organizations and information systems and to eliminate any misunderstanding that may have resulted from using different medical language to express the same problems. In order to categorize similar items, these terminologies act as medical word equivalents for a related notion. The foundation for important abilities like evidence-based practice, prospective clinical trials, and retrospective data analysis is laid here [8]. A few examples of accessible standards in medical terminology include the Medical Entities Dictionary, Clinical Terms, and the Systematized Nomenclature of Medicine. The prediction accuracy is higher when using tree algorithms for classification.

This is because data may be organized hierarchically, and utilizing a step-by-step examination of pruned trees, the decision tree and random forest algorithms were able to anticipate more accurately. Additionally, compared to other algorithms, tree algorithms have reduced error rates[9]. Given that there are so many hidden layers involved, the neural network approach could also be effective.

In contrast to other medical specialties, ophthalmology is best suited for the implementation of AI, ML, and DL-assisted mechanized treatment and detection due to the frequent use of ocular images, which provides software programs with a plethora of data. Optometrists, retina specialists, and trained human graders will soon be replaced by autonomous robotic applications of AI, ML, and DL for the treatment and detection of DR, AMD, myopia, and other eye diseases.

Numerous publications investigating automated AI, ML, and DL implications in eye illness diagnosis have been issued in recent years. The majority of these research focus on DR, AMD, and glaucoma, the three diseases that cause complete impairment most often worldwide. Recent studies have shown the usefulness of AI, ML, and DL approaches as a screening tool for recognizing and diagnosing a variety of eye problems in ophthalmic health care settings. Patients in remote areas without access to medical personnel, resources, or infrastructure may benefit greatly from these initiatives. These studies have shown that automated image processing using high precision AI, ML, and DL systems can identify and diagnosing a range of retina issues [10].

METHODOLOGY

The methodology comprises of detection and classification across four primary phases: data collection, data acquisition, training model, and testing model. Since that the data used in this approach is not in real-time, it may be gathered and utilised in both the learning and evaluation processes. For 10k fold validation, the data may be split in many ways, including 80% and 20%, 60% and 40%, or 50% and 50%.

Pre-processing and segmentation come first in the image processing procedure. For image recognition, just a small section of the image is processed as opposed to the complete image to reduce the load on the processing machine. Some common segmentation techniques are addressed in this research, out of a large variety of options.

The photos are scaled down and turned to grayscale to lower the total data size. File names are used to identify the photos inside a folder structure. Input photos may be scaled down in size using a MATLAB application. The size of the pictures, the size of the filters employed, and the number of filters used in the convolutional layer are all factors taken into account in this analysis. This system takes pixels as its input. To get to the output category, the pixels are first transformed into edges, then into corners and contours, and last into object components. Accuracy, precision, recall, and F1 score will all be used to determine how well the system performs. The figure below illustrates a block diagram of the proposed methodology.

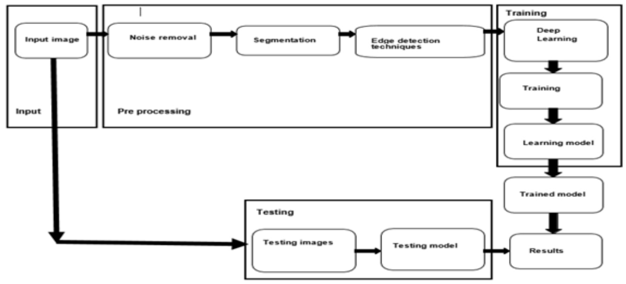

Figure 3: Block diagram of proposed methodology.

DISCUSSION

A major cause of loss of vision is AMD, a chronic macular disease. The signs of this awful and fatal condition include drusen, retinal changes, choroidal vascularity, haemorrhaging, exudation, and sometimes geographic degeneration. Predictions state that drusen will use AI, ML, and DL algorithms to provide unique suggestions for AMD. These systems can predict the development of drusen behind the retina in AMD. Systems of AI, ML, and DL provide automatic recognition of drusen, fluid, and spatial shrinkage concerning AMD tumours using fundus images and spectral-domain OCT, enhancing AMD diagnosis and treatment (SD-OCT).
The slow death of photoreceptors and the irreversible loss of axons from the visual cortex are two characteristics of glaucoma, the second most common cause of visual loss. Early identification and use of glaucoma medications are essential to lowering avoidable blindness. Examining the optic head and retinal nerve fibre network surrounding the optic disc is necessary for a precise diagnosis of hypertension. The application of AI, ML, and DL is thought to dramatically revolutionize early glaucoma screening, diagnosis, and classification processes. By finding and evaluating new risk factors, they may also detect the onset, progression, and treatment of glaucoma [11]. However, there isn't a clear gold standard for the procedures used to assess the presence and severity of glaucoma today. More accurate sickness definitions should be used in future study in order to construct and improve the current methodology and data inputs for AI, ML, and DL analysis, as well as to improve information gathering techniques from learned discoveries. Recent studies serve as the foundation for the most effective automated glaucoma diagnostic and grading systems. There have been several AI, ML, and DL algorithms employed. Recent studies on the diagnosis of glaucoma have shown that ML, DL, and AI have excellent sensitivity, specificity, and accuracy [12].

For both diagnosis and treatment in many specialties, a precise and rapid clinical picture assessment is crucial. However, clinical health care operations heavily rely on the reproducibility, validity, accuracy, precision, dependability, sensitivity, and specificity of clinical pictures. Computer vision algorithms are necessary for processing biological pictures; hence their development is essential. In several ophthalmological settings, retina experts often analyse retinal imaging. Due to its varying interpretation, repeatability, and interobserver agreement fluctuation, such assessment is subjective and time-consuming. In scientific settings, DL has emerged as a significant class of ML models during the last ten years. Deep learning has been used to improve statistical analysis, pattern recognition, and signal processing. Additionally, DCNN has made image processing and segmentation simpler. Clinical practice will undoubtedly be impacted by these findings, which will favorably reflect imaging technology. The main element of AI technology is machine learning (ML), which consists of mathematical algorithms and models produced by many input experiences. AIcan successfully process ophthalmological images by primarily using images of the fundus. Additionally, there is a good chance that it will acquire accuracy on par with that of clinical specialists. For instance, it has been shown that an automated machine learning system that identified and quantified reticular pseudodrusen using multimodal data performed just as well as human graders. The use of AI, ML, and DL algorithms to automate retinal imaging applications has therefore been shown in several publications in recent years. The graphs below shows the number of publications related to the eye diseases in 2018 and 2019.

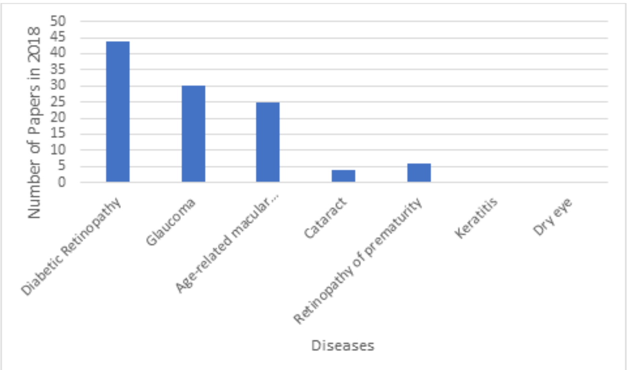

Figure 3: Number of publications in 2018

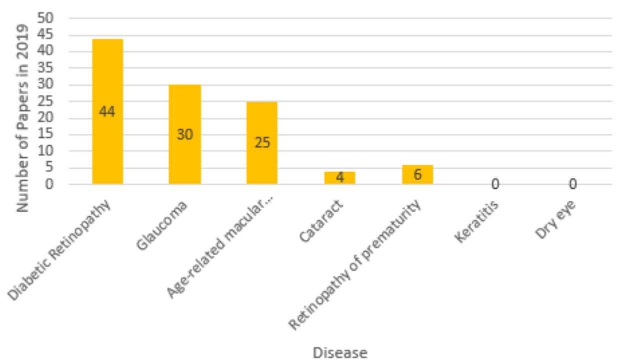

Figure 4: Number of publications in 2019

It is undeniable how far medicine has come since the invention of AI, ML, and DL. ML, DL, CML, language processing, automation, logic, general intelligence, intelligent agents, automated education, and scheduling are just a few of the many goals of AI. It also aims to use logic and common sense. As the global population ages—a development that is occurring everywhere—more people might develop eye disorders. It is commonly acknowledged that early detection and treatment of eye conditions are crucial for preserving eyesight and improving quality of life [13].

CONCLUSION

Conventional techniques of eye diagnostics are insufficient since there aren't enough ophthalmologists, retina specialists, graders, or cutting-edge eye technologies. Since traditional diagnostic techniques rely on the expertise and specialized knowledge of medical experts, there is also a considerable risk of misdiagnosis and unnecessary loss of medical data. In light of this, widespread acceptance and use of AI, ML, and DL techniques in optometry has the potential to improve treatment results. Further research is required to comprehend the reliance of algorithms on AI, ML, and DL and assess their suitability for diagnosing DR, DME, AMD, myopia, and other ocular illnesses[14].Automated retinal imaging technology could make it easier for people to get medical care and health inspections, perhaps lowering the prevalence of avoidable blindness worldwide.

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