Using AI for Detection, Prediction and Classification of Retinal Detachment

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Abstract. The current state of machine learning (ML) and deep learning (DL) algorithms used to detect, classify and predict the onset of retinal detachment (RD) were examined in this scoping review. This severe eye condition can cause vision loss if left untreated. By analyzing the medical imaging modalities such as fundus photography, AI could help to detect peripheral detachment at an earlier stage. We have searched five databases: PubMed, Google Scholar, ScienceDirect, Scopus, and IEEE. Two reviewers independently carried out the selection of the studies and their data extractions. 32 studies fulfilled our eligibility criteria from the 666 references collected. In particular, based on the performance metrics employed in these studies, this scoping review provides a general overview of emerging trends and practices concerning using ML and DL algorithms for detecting, classifying, and predicting RD.

Keywords. Retina, Retinal Detachment, convolutional neural networks, machine learning, deep learning.

1. Introduction

Retinal detachment (RD) may lead to permanent vision loss if left untreated. That is because the eye's retina, a thin layer of tissue stretching into the back of the eye, shifts out of its normal position and disturbs the flow of nutrients and oxygen [1]. Due to its potential for improvement in diagnostic accuracy and efficiency, as well as improving patient outcomes, the use of artificial intelligence (AI) has gained increased attention over recent years concerning detecting RD [2]. The results obtained with AI algorithms, such as Machine Learning (ML) and Deep Learning (DL) techniques, indicate promise in accurately identifying focal detachment from medical images, including optical coherence tomography scans and fundus photographs [3]. However, there are several problems associated with the application of AI for the detection of retina detachments that include the need to have vast quantities of high-quality data, the lack of comprehensive medical image annotations, and the non-standardized acquisition of medical images [3]. The use of AI for detecting and classifying RDs has been studied in several past studies. Nevertheless, a comprehensive understanding of the present state of research is urgently needed, given the prevalence and seriousness of retinoid detachments and their potential for significant vision loss and possibly blindness. To our knowledge, this is the first scoping review explicitly focused on RD, which will draw

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valuable data from today's literature. Therefore, this scoping review aims at determining and analyzing existing literature on the use of artificial intelligence, particularly ML and DL algorithms, to detect and classify RDs with a particular focus on identifying challenges and limitations in using these techniques. This scoping review will inform future research and clinical practice on RD detection and management by giving a comprehensive overview of the current situation in this area.

2. Methods

This scoping review was carried out in line with the Joanna Briggs Institute's guidelines [4]. We searched Five databases: PubMed, Google Scholar, ScienceDirect, Scopus, and IEEE. While selecting studies, 3 steps were taken: the removal of duplicate studies discovered in 893 retrieved studies, analysis of title and abstract data and finally view their full content, refer to Appendix A2 for the steps. Then, we compiled the data into an Excel spreadsheet and synthesized it with a narrative approach. As a result, simplified text and tables have been presented for all the documents included.

3. Results

3.1. Search Results

A total of 32 studies were included out of the 666 retrieved studies. The included studies focused on three main use cases for artificial intelligence in RD. These cases were the detection of the RD from medical scans, classification of the ophthalmologic disease the patient is suffering from, and the prediction of early onset of RD complications. Eleven studies addressed the detection of RD. Nineteen studies focused instead on the prognosis / classification of the ophthalmologic disease that the patient is having through the support of artificial intelligence. Two studies attempted to predict the onset of RD. All of this information is summarized in Table 1 below. Refer to Appendix B2 – Table 3 For Study Characteristics details.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Number of Studies</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Model purpose</strong></td>
<td><strong>Detection: 11</strong></td>
</tr>
<tr>
<td></td>
<td>Machine learning: 3</td>
</tr>
<tr>
<td></td>
<td>ML &amp; DL: 1</td>
</tr>
<tr>
<td><strong>AI method</strong></td>
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<tr>
<td></td>
<td>SVM: 1</td>
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<tr>
<td></td>
<td>AI Combination: 1</td>
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<td></td>
<td>Image Thresholding: 1</td>
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<tr>
<td></td>
<td>Custom method: 1</td>
</tr>
</tbody>
</table>

Table 1. Summarization of the studies with its key characteristics and models used.

CNN: Convolutional Neural Network. SVM: Support vector machine. QDA: Quadratic Discriminant Analysis

2 https://github.com/Hesham-hz1703584/Appendix.git.
3.2. Characteristics of Studies

3.2.1. The nature of studies included

Out of these 32 included studies 6.25% (n=2) of the studies were published in 2017, 16% (n=5) in 2018, 6.25% (n=2) in 2019, 12.5% (n=4) in 2020, 22% (n=7) in 2021, 28% (n=9) in 2022, and 9% (n=3) in 2023, there were no studies published before 2017 all of them were excluded based on the chosen criteria. The highest number of studies were published from China (n=13), followed by India (n=8) and the rest were below 4 studies per country.

Figure 1. Publication by Country

3.2.2. Models used

Twenty-three of the studies used deep learning techniques in their work to analyze the RD; namely, CNN was used in twenty-two of the papers with different CNN learning architectures being used except for one paper that used novel method called Dimension Reduced Deep Learning. Five of the papers used machine learning techniques in their work. While four papers used a combination of both machine learning and deep learning techniques. Deep Convolutional Neural Networks papers mostly used the Residual network (ResNet) architecture with twelve of the papers incorporating Resnet either as a separate architecture or as part of the bigger model. Refer to Appendix 2 – Citations, for the paper’s information.

3.2.3. Types of images used

Among the selected papers, optical coherence tomography (OCT) images are the most commonly used retinal image type, with twelve papers employing them. Two of these papers utilized publicly available datasets, such as the RETOUCH dataset for OCT images. For more information on the datasets, please see Appendix B – Table 2. Color Fundus Images are the second most frequently used image type in the reviewed papers, with six of the seven papers employing public datasets like Pathological Myopia (PALM), RIADD, Retinal Image Bank, Kaggle, DrishtiGS, Jan Odstrcilik et al, Cataract Image Dataset, and the Automated Retinal Image Analysis (ARIA) database.

3 https://github.com/Hesham-hz1703584/Appendix.git.
4. Discussion

The studies show promising results in detecting RD, classifying ophthalmologic diseases, and predicting complications using deep learning and machine learning techniques on retinal images, primarily optical coherence tomography (OCT) and color fundus images, even some of it shows that the usage of artificial intelligence in medical images could potentially compensate for the presence of an ophthalmologist due to the high-performance metric results received. However, further research and testing are needed to determine if AI can be fully substituted for ophthalmologists in detecting and treating RD. Furthermore, the studies discussed could be more extensive in scope. Some studies have used smaller sample sizes or been based on personal datasets, which may not accurately represent the variety of patients and cases of retinopathy detachment. Furthermore, the study may have been conducted using various imaging methods and techniques with which direct comparisons to its results would not be possible. Therefore, the results need to be verified, and it is necessary to carry out more research to ensure that AI Based systems can accurately and reliably provide diagnoses and forecasts.

5. Conclusion

In this scoping review, thirty-two studies focused on using AI to detect RD based on Three primary types: detection, prediction, and classification. In 23 studies, Deep Learning Techniques were applied, with CNN being the most commonly used technique. Twelve studies used OCT tomography images as image type, while the second most frequently used type of image is color fundus images, with six studies using public databases. In general, the potential for AI to detect and classify RD could lead to better patient outcomes and lower healthcare costs. Given that most of the studies have focused on detecting and classifying ophthalmologic diseases, further research into predicting RD complications should be undertaken at a relatively early stage which is addressed in only two studies. Furthermore, besides CNNs, further research should be undertaken to investigate using additional AI algorithms, such as reinforcement learning and evolutionary algorithms, which may increase performance. Finally, it would be necessary for future clinical trials to include data from different patient groups and public datasets in order to ensure that the AI model developed is generalizable.

References


