Artificial Intelligence-based on Automatic Detection of Diabetic Eye Diseases

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Abstract

Diagnosing eye diseases, especially those linked to diabetes, poses significant challenges for ophthalmologists in developing countries like Africa, where access to advanced technologies is limited. However, the advent of artificial intelligence (AI), including machine learning and deep learning models, is simplifying the detection and analysis of these conditions. Although current prediction systems can identify disorders such as glaucoma, cataracts, and diabetic retinopathy, their accuracy can vary. Manual diagnosis by ophthalmologists remains slow, expensive, and error-prone, yet some continue to rely on this method. This paper underscores the pivotal role of AI systems in early detection of diabetes-related eye disorders in Africa, potentially enhancing access to ocular healthcare and alleviating the burden on healthcare professionals.

Keywords : Artificial Intelligence, Machine Learning, Deep Learning, Diabetic Retinopathy, Glaucoma, Cataracts, Healthcare access

Introduction

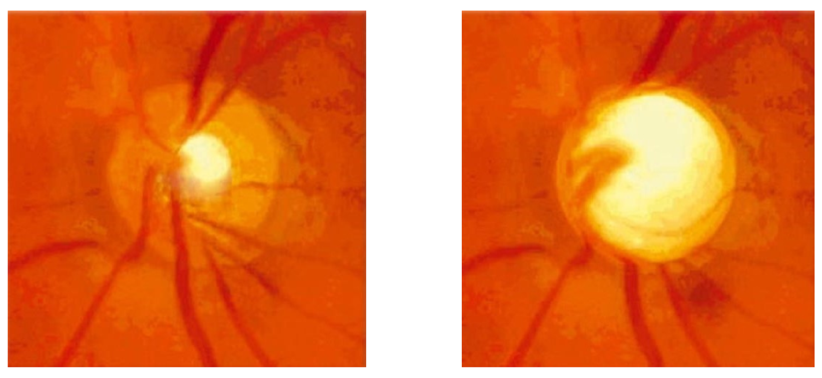
Early detection of a disease greatly facilitates its treatment. Diabetes, characterized by elevated blood glucose levels due to insufficient insulin production or utilization, comprises several types: type 1, type 2, gestational, and specific causes. Type 1 primarily affects young individuals and requires insulin injections. Type 2, the most prevalent form, impedes effective insulin use and is influenced by obesity, a sedentary lifestyle, and diet, with increased risk if there are family histories of diabetes. Gestational diabetes occurs during pregnancy, increasing the risk of complications. Diabetes due to specific causes results from identifiable factors. Currently, 537 million adults are affected by diabetes, posing a major public health challenge.
Often asymptomatic, diabetes can affect the retina and lead to severe complications.

This block highlights the **most severe diabetic eye diseases** that can result from asymptomatic diabetes:

- Glaucoma
- Cataracts
- Diabetic retinopathy

If these complications are not detected and treated in time, they can lead to vision loss.

- Glaucoma



(a) Normal Eye (b) Glaucomatous

Figure 1. Normal Eye vs Glaucomatous fundus

It characterized by increased intraocular pressure, damages the optic nerve and manifests in various forms, each requiring tailored diagnostic and therapeutic strategies.

- Cataract

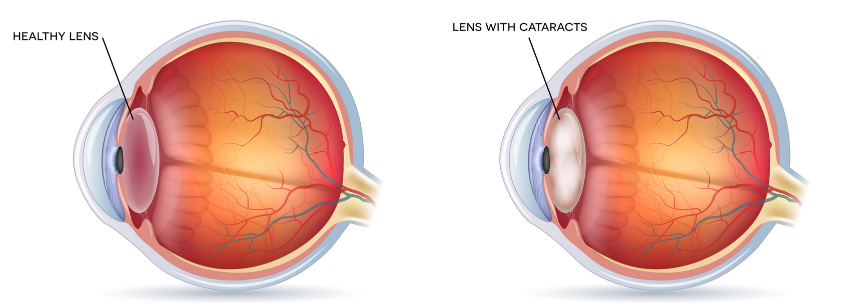


Figure 2. Normal eye and eye with cataract

It's an opacification of the lens, resulting in vision impairment.

- Diabetic retinopathy

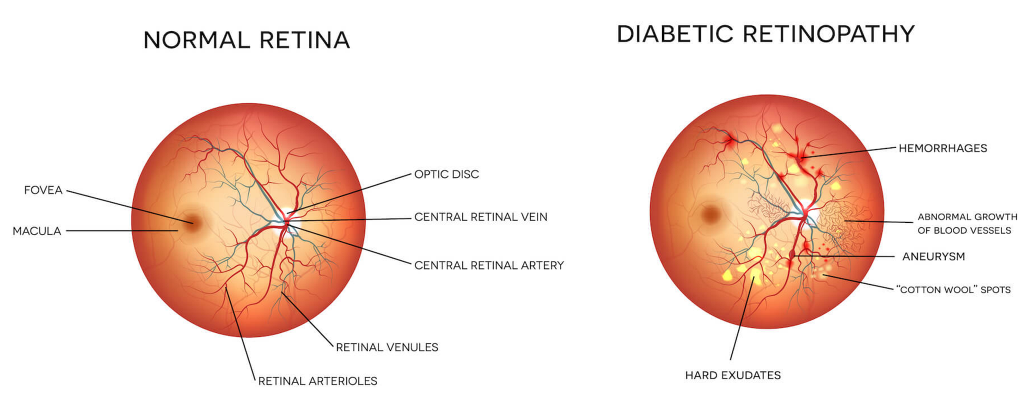


Figure 3. Normal retina and diabetic retinopathy

Diabetic retinopathy is a complication of diabetes that causes swelling of the blood vessels in the retina and leakage of fluids and blood. Diabetic retinopathy, as shown in Fig. 4, has four severity stages: proliferative retinopathy, light non-proliferative retinopathy, moderate non-proliferative retinopathy, and severe non-proliferative retinopathy.
Light non-proliferative diabetic retinopathy is an early form of retinopathy.

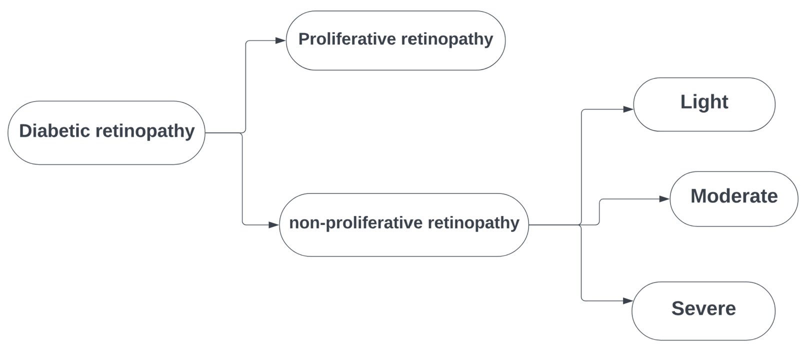


Figure 4. Normal retina and diabetic retinopathy

Impact of diabeties in Africa

In Africa, the prevalence of diabetes is increasing compared to previous years. This increase can be attributed to :

- Nutritional transition

- Rapid urbanization

- Genetic predisposition

- Access to health care

It is crucial to implement effective strategies to meet these growing challenges, in order to improve diabetes management and promote public health in Africa.

AI in the detection of diabetic retinopathy

To tackle the dangers associated with diabetes, researchers and practitioners around the world have been using approaches based on artificial intelligence (Machine Learning and Deep Learning). Among them, we have:

- Machine Learning approach

Pal et al. [1] utilized four machine learning algorithms (Naive Bayes, Decision Tree, K Nearest Neighbors, and Support Vector Machine) to predict the onset of diabetic retinopathy. The datasets were obtained from the Irvine Machine Learning Repository, containing features extracted from the Messidor dataset. The results showed that SVM had the best accuracy, closely followed by KNN.

Sidibe et al. [2] proposed a semi-supervised method for detecting anomalies in OCT volumes. Their approach, based on Gaussian mixture models, enables the classification of OCT volumes and identification of abnormal B-scans within each volume.During testing on 32 OCT volumes, their method achieved a sensitivity of 93% and a specificity of 80%.

- Deep Learning approach

Hongyang Jiang et al. [3] proposed a deep learning model based on eye tracking to detect diabetic retinopathy early. They utilized eye movements of ophthalmologists recorded during diagnosis using eye tracking, which improved the precision and interpretability of the model. However, collecting eye tracking data for a large number of patients can be costly, and generalizing the model to other populations or diseases remains a challenge. The interpretability of the model also remains an area for further investigation.

Li et al. [4] introduced a new attention-based deep learning architecture for simultaneously evaluating diabetic retinopathy (DR) and diabetic macular edema (DME).

AI challenges in ophthalmology

In Africa, and particularly in *Senegal*, the integration of artificial intelligence (AI) in the field of ophthalmology faces several challenges:

- limited access to healthcare and medical technologies
- diversity of populations and socio-economic environments
- raising awareness and training healthcare professionals in the use and interpretation of AI technologies in ophthalmology

Conclusion

Artificial intelligence in the detection of diabetic eye disorders offers major advantages:

- Improving early detection
- Precise segmentation of anatomical structures
- Clinical decision support.

As perspectives we propose:This opens up new prospects for the proactive management of ophthalmology patients' health via software such as Orthanc.

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