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# Proposal for the Development of an Easily Accessible System for the Early Detection of Diabetic Retinopathy for Non-Experts

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***Abstract*—Diabetic retinopathy is the most common condition among patients with diabetes mellitus and the main cause of vision loss. This is because DR can evolve for years without its carrier detecting it. However, in a DR exam, image capture is a manual process that can take a long time. Advances in deep learning algorithms have made it possible to learn the most predictive features of DR directly from fundus images obtained from patients with diabetes. These images are used to train deep learning models that can identify patterns of DR in new patients. In turn, existing models have been shown to perform as well as or better than a specialist in the area. The present study reviews the state of the art of models used for DR detection and establishes a possible theoretical proposal for the creation of an imaging system to obtain fundus captures. In addition, the use of existing deep learning models to process the images and determine whether the patient may have DR.**

***Index Terms*—Diabetic retinopathy, eye ailment detection, automatic retinopathy detection.**

## I. Introduction

Diabetic retinopathy (DR) is the most common condition among patients with diabetes mellitus and the leading cause of vision loss. [1–3]. Moderate and severe vision impairment attributable to DR increased from 1.3% to 1.9% between 1990 and 2010 [1,4]. It was estimated that in 2019, 9.3% of the global population suffers from diabetes. In a study published in the American Academy of Ophthalmology, where 59 population-based studies published up to March 2020 were collected from PubMed, Medline, Web of Science and Scopus, the prevalence of DR was 6.17% in adults around the world [5,6]. This is because DR is a disease that can give signs of symptoms or vision problems [7]. In addition, factors such as age, smoking and hypertension aggravate the complications by accelerating vision loss [2,8,9].

In retinal examination, medical use devices such as an ophthalmoscope witha 20 diopter lens or a fundus camera. Because of the image quality and the permanence of the data to be stored, fundus cameras are commonly employed by ophthalmologists for the detection of DR. However, capturing images is a manual process that can take a long time. Not to mention, it requires a certainlevel of expertise to capture the image. On the other hand, fundus cameras are ostentatious as well as large, which makes them difficult to transport and theircost makes them unaffordable for every health clinic to purchase.

Advances in deep learning algorithms have made it possible to learn the most predictive features of DR directly from fundus images obtained from patients with diabetes. These images are used to train artificial intelligence models that can identify signs of DR in new patients [10,11].

A review of the state of the art of existing works that employ deep learning algorithms to issue DR diagnoses is carried out. Based on the information found, a possible theoretical proposal is established where existing models could be used to process the fundus images captured from a patient, by means of an imaging system that performs the image captures and emits the result of the diagnosis obtained.

## II. Relevant Work

Diabetic retinopathy (DR) is the most common condition in patients with diabetes, the loss of vision is caused by damage to the blood vessels of the retina. This condition does not present initial symptoms until advanced symptoms develop, which may include blurred vision, spots or dark strands floating in the eye.

### *A. Diabetes*

Type I diabetes: Insulin is a hormone that controls the level of sugar or glucose in the human body. When suffering from type I diabetes, the patient becomes dependent on insulin and requires injections to supply the body. Otherwise, a rise in blood sugar occurs causing health complications [12].

Type II diabetes: The patient is not insulin dependent. The body produces enough insulin, but does not use the insulin for energy conversion. Since it does not produce enough energy, the body produces even more insulin, which causes a rise in blood sugar level [12].

Increased blood sugar over a prolonged period of time in patients with diabetes can develop diabetic retinopathy. The damage caused by high blood sugar levels to the blood vessels in the tissue found in the back of the eye can lead to vision loss.

### *B. Deep Learning Models*

Recent technological development has enabled the design of deep learning-based models, allowing automated detection of DR using image processing algorithms.

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TABLE I
ARTICLES ON DEEP LEARNING MODELS FOR DR DIAGNOSTICS

| No | Name | Propose | Limitations |
|---|---|---|---|
| 01 | Deep neural networks to predict diabetic retinopathy [13] | Deep neural network model using Grey Wolf Optimization algorithm [14]. | Requires large datasets to exhibit high performance. |
| 02 | A Deep Learning Ensemble Approach for Diabetic Retinopathy Detection [15] | Clustering of models to increase the performance of the 5-stage diabetic retinopathy classifier. | It is a metamodel, the result depends directly on the training that was presented in each model individually and on the data sets used. |
| 03 | An artificial intelligence-based deep learning algorithm for the diagnosis of diabetic neuropathy using corneal confocal microscopy: a development and validation study [16]. | Diagnosis of diabetic neuropathy by corneal confocal microscopy. | Requires images obtained from the confocal microscope. |

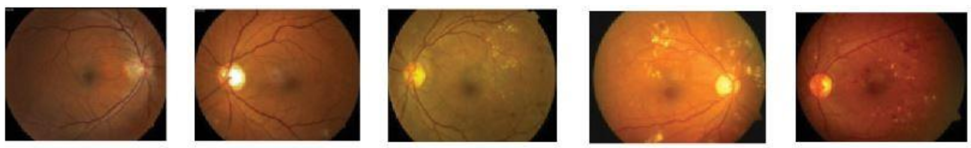


Fig. 1. Examples of fundus images of the different types of RD [15,17,18]

TABLE II
ARTICLES ON DEEP LEARNING MODELS FOR DR DIAGNOSTICS

| No | Name | Propose | Limitations |
|---|---|---|---|
| 04 | Development and Validation of a Deep Learning System for Diabetic Retinopathy and Related Eye Diseases Using Retinal Images from Multiethnic Populations with Diabetes [19] | Evaluation of diabetic retinopathy and related eye diseases in Singapore data sets. | Requires further research to evaluate application in health care settings and assess its usefulness. |
| 05 | Pivotal trial of an autonomous AI-based diagnostic system for detection of diabetic retinopathy in primary care offices [21] | Generate and study the output of an FDA cleared standalone AI diagnostic system. | Requires a physician or specialist to capture the patient's eye images. |
| 06 | Performance of a Deep-Learning Algorithm vs Manual Grading for Detecting Diabetic Retinopathy in India [20] | Detect diabetic retinopathy in India where there is a population with high rates of diabetes. | More research is needed to evaluate the application in healthcare settings to assess its usefulness and to verify its behavior in diverse economic environments. |

Each model contains its own approach and processing that it applies to the images, such as solving for non-uniform illumination, to subsequently detect signs of DR and indicate a diagnosis.

Table 1 and 2 shows articles whose approach or proposal is the analysis of images for the detection of eye conditions related to DR.

The development of models may arise from the need to generate new methods as alternatives that can serve as a basis for the detection or confirmation of a diagnosis given by a specialist. Each article may employ a different approach when studying a specific type of Diabetic Retinopathy (normal, mild, moderate, severe and proliferative), the different types can be seen in Figure 2.2 [15,17,18]. This leads to the development of deep learning models capable of determining whether a user may have diabetic retinopathy. Similarly, the diversity of DR articles using deep learning models report promising results, demonstrating performance equal to or superior to a retina specialist or clinical staff [19,20].

### C. *Image Systems*

For a retinal examination, optical devices such as an ophthalmoscope (direct and indirect) and a lens of different diopters (15, 20, 28, 30, 40) commonly used is the 20 diopter lens. In addition, a fundus camera can be used. With these instruments the medical staff or the ophthalmologist can perform an examination of the eye, using a clockwise observation technique to visualize all sectors of the retina. Also, different light filters can be used according to the type of observation to be performed: white color is used for the usual observation; green color is used to evaluate the layer of fibers and blood vessels; yellow color is used to protect the maculae and avoid photophobia (sensitivity to light). Thus, the process is a manual one that requires time and expertise to perform the retinal examination.

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TABLE III
ARTICLES FOR DR DETECTION BY MEANS OF SMARTPHONES

| No | Name | Propose | Limitations |
|---|---|---|---|
| 01 | Automatic Identification of Referral-Warranted Diabetic Retinopathy Using Deep Learning on Mobile Phone Images [22]. | Detecting diabetic retinopathy in low-resolution images acquired by a smarthphone with an indirect ophthalmoscope lens adapter. | The confidence interval of the result is proportional to the quality of the input image. |
| 02 | Comparison of smartphone-based retinal imaging systems for diabetic retinopathy detection using deep learning [7]. | They employ existing tools for fundus imaging using iPhone 5-7. subsequently applying a deep learning model to detect DR. | The compatibility of the tools is limited to iPhone 5-7 devices. The resulting field of view of retinal images affects the results obtained. |

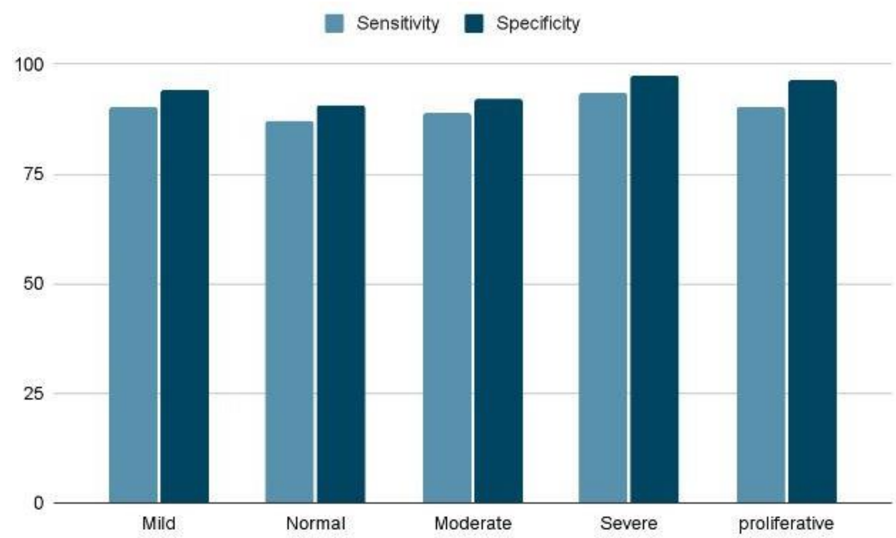


Fig. 2. Results in the detection of different types of DR: Sensitivity and specificity

Optical devices used for fundus screening can be challenging to transport, not to mention the fact that their cost is a constraint for low-income clinics. Therefore, as the number of people with diabetes increases, there is an opportunity to develop portable and affordable tools to diagnose DR. One of the accessible portable systems are smartphones, which can be used as a tool to use deep learning models to determine whether a patient has DR.

Table 3 shows articles whose focus or proposal is image analysis by means of smartphones for DR detection.

Technological development has allowed the inclusion of smartphones in the health area, since they have become capable of executing artificial intelligence algorithms, allowing the patient's condition to be read by means of external sensors and determining whether the patient has a medical condition.

Mobile devices for DR detection face complications in capturing fundus images. Such as, brightness, lens smudging, focus and low quality images. These factors may cause a reasonable doubt in the result of the diagnosis obtained [22]. To cover existing complications, the use of tools can be helpful in improving the success rate of capturing a patient's fundus image. On the other hand, the compatibility of the tool will be linked to the smart mobile device to which it was directed, giving a restriction to people who do not have in their possession a similar device.

### *D. Deep Learning Performance*

The deep learning models in Table 1 and 2 indicate a performance higher on average than the articles consulted at 0.90 in sensitivity and higher on average at

0.94 in specificity. The performance presented can be seen in Figure 2 according to the specific type of diabetic retinopathy (normal, mild, moderate, severe and proliferative) indicated in the articles in Table 1 and 2.

To achieve the values shown in Figure 2. A large set of images of patients with diabetic retinopathy is required depending on the approach to be used to build the respective models. If it is the normal type for example. To obtain an index of 0.83 sensitivity and 0.87 specificity 1698 and for validation 2137 fundus images were used respectively [16].

A common element among the articles reviewed was that they require expert ophthalmologists, clinicians, or specialists in the field to evaluate the data sets used to train and validate the efficiency of a model. In addition, extended periods of time are required to train and validate, denoting difficulty in achieving the rates presented by the articles addressed for Table 1 and 2.

In this way, already trained models with high performance can be used and applied. In addition, new tools can be applied for use in clinical settings or by the general public.

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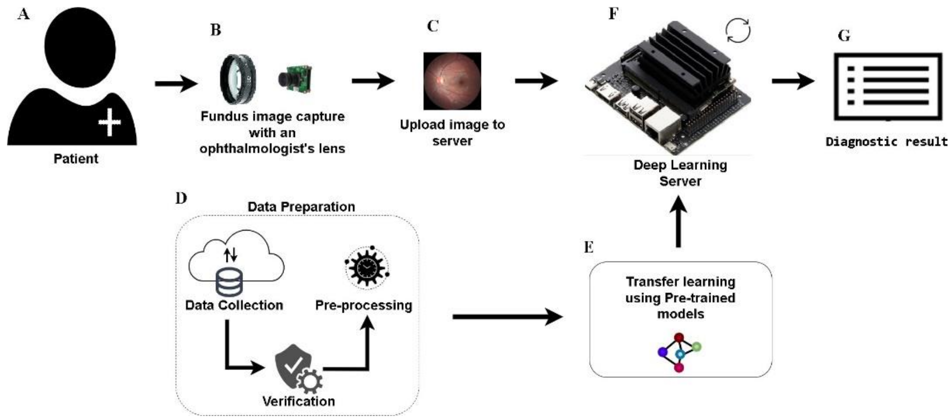


Fig. 3. Proposed system architecture

## III. Design of the Possible Proposed System

To enable more people to have access to a DR diagnostic test, the development of portable devices that can indicate to the patient whether he or she has a condition or signs of DR without the need for a specialist is of vital importance. In addition, the patient can be told whether or not they need to go to a clinic for medical care based on their diagnostic result.

It is proposed to create a tool that uses deep learning models to diagnose DR using fundus images. The images will be captured by a camera module using a 20 diopter ophthalmoscope lens. By means of the captured images of the patient the model will give a result and determine whether or not DR is present.

### *A. Patient*

Person who suffers from eye discomfort, blurred vision problems, spots or dark strands floating in the sight[1, 2, 7]. Also, for people who want to have a preventive diagnosis of RD.

### *B. Image Capture*

In a controlled environment to keep the pupil dilated and by means of a 20 diopter lens, the fundus image can be captured. When the pupil is dilated, the fundus image can be captured by visualizing the blood vessels and the tissue they are looking for, to later look for any damage or signs of vision loss.

### *C. Upload Images to Server*

The captured images are downloaded to a server that will contain the deep learning models that will be used to read the images and determine a diagnosis.

The proposal contemplates the use of a nvidia jetson nano developer kit. its use was proposed since it is often used in the development of artificial intelligence algorithms, neural networks or deep learning models.

### *D. Data Preparation*

There are a variety of retinal image datasets used to develop and compare deep learning systems to diagnose DR. In addition, part of these public-use image collections and models are located in the Kaggle scientific data platform.

In this, the models and image sets needed to train and validate the model to be employed in this proposal will be retrieved.

### *E. Pre-Trained Models and Deep Learning Server*

In this way, the models to be used are trained with a wide set of data, classifying the different types of diabetic retinopathy (normal, mild, moderate, severe and proliferative). In this way, the trained models to be used are obtained.

With the images captured from the patient's fundus the trained model is used, the respective models will apply a preprocessing to the images cleaning the possible noise, to later classify the images and obtain a result.

### *F. Diagnosis Result*

With the result obtained, the respective diagnosis is indicated to the patient. In addition, this allows the general public without experience to apply the test using the proposed tool and, if necessary, be referred to a specialist for specialized treatment.

## IV. Limitations

This proposal has several limitations. Firstly, access to models that are validated and verified according to the identification and detection of DR by means of images of varying quality, and secondly, access to models that are validated and verified according to the identification and detection of DR by means of images of varying quality. Secondly, making use of the model and trying to replicate the results published by the model. This can be a challenge when dealing with the versions of the tools used to build the model, presenting incompatibilities at software level or that the hardware is limited by not corresponding to the physical characteristics required to cover the demand resulting from the processing of the software, which concludes as a problem in its use.

## V. Conclusions

This paper presents a comparison between deep learning models developed to detect diabetic retinopathy. The diagnosis of retinal diseases caused by diabetes is relevant to

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prevent vision loss. There are people who do not undergo regular screening because of the lack of specialized screening equipment or the availability of specialists in clinical settings. In addition, the cost of having clinical vision examinations can be an impediment. Thus, difficult access to specialized clinical care means that widely available automated screening and diagnosis may prove to be an opportunity to prevent eye disease in patients.

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