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# Predicting Diabetic Retinopathy using Deep Learning

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***Abstract:*** **Research works done so far are majorly focused on the risk factors which include diabetic retinopathy (DR); however, it is still unclear up to what extent the risk factors are associated with diabetic retinopathy. We use early prevention procedures considering diabetic retinopathy during the most high-risk group with better detected DR-related risk factors. Machine learning, a recent advancement during state-of-the-art technology, plays a critical and crucial role during image processing applications such as biomedical, satellite image processing & Artificial Intelligence applications includes object identification & recognition, among others. The goal of this study is to look towards a deep-learning system to predict the probability of diabetic retinopathy developing within two years among people with diabetes. Using colour fundus pictures, deep-learning algorithms predict the development regarding diabetic retinopathy and the diabetic systems were independent which were more informative to the existing risk variables. The proposed works aims to develop and validate the deep learning system towards the prediction of progression regarding diabetic retinopathy of diabetic individuals to receive tele-retinal diabetic retinopathy screening during a primary care environment.**

***Index Terms:*** **Diabetic Retinopathy, Deep learning, Color fundus photographs, Screening.**

## I. Introduction

There may exist billions of people who suffer from vision impairment, and certain issues may yet exist unsolved. Diabetic retinopathy is also often known as diabetic eye disease which develops when diabetes damages the retina. It's a systematic condition that affects up to 80% of the diabetic patient's eye who have been considered as 20 or above years. Inspite of these alarming statistics, research suggests that not less than 90% of the new case might exist and can be avoided if the eyes were treated, monitored properly and by keenly observing the changes. This is the sample images of the different stages of diabetic retinopathy in Figure 1. Diabetic retinopathy was more likely observed towards developing those who had diabetes considering a long time. Previous research has primarily concentrated on reducing one key risk factor like glucose levels; there are some more studies that investigate other risk factors that consider Diabetic Retinopathy [1]. Diabetes mellitus causes diabetic retinopathy, a micro vascular condition. It determines through a patient's history regarding their diabetes problems [2].

Diabetic retinopathy is a highly specific vascular consequence regarding both type 1 and type 2 diabetes provides a clear correlation between prevalence and diabetes duration.

Diabetic Retinopathy (DR), on other hand, can be frequently undiscovered until it has progressed towards point where it is endangering one's eyesight. Due to low adherence and access towards retina screening visits, current state regarding DR screening during real world, based on assessments regarding color fundus photographs (CFPs) through a retina specialist otherwise a trained grader, leaves a large proportion regarding the patients who have not been diagnosed and thus receiving medical help too late [3,4]. Given the pandemic magnitude regarding diabetes community, in-person expert exams exist unfeasible and unsustainable [5, 7]. Regardless, early detection & prevention regarding DR progression exist critical towards reducing rising threat regarding Diabetic retinopathy.

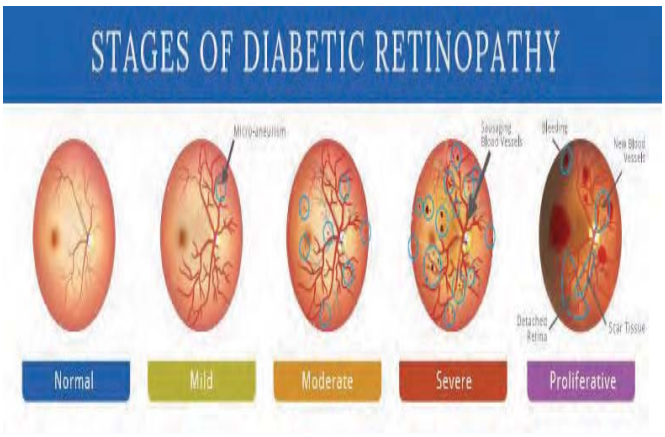


Figure 1. Sample images of the retina

Diabetes is caused when pancreas fails to produce enough insulin or otherwise the body is unable to process it. Vision loss can be avoided if they are detected early.

There exist two forms of diabetic retinopathy: non-proliferative & proliferative. Non proliferative stage is the first stage of diabetic retinopathy detection. Patients with diabetes should consult a doctor and proper clinical tests should be done to discover the disease in the early stage and to stop vision loss or eye related problems. Treatment

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regarding the vision-threatening retinopathy prevents 98 percent of the visual loss caused through diabetic retinopathy.

With the advancements in numerous technologies such as Internet of Things, big data, cloud computing, artificial intelligence, and DL. Deep learning has become increasingly important during the categorization approaches. The various stages of diabetic retinopathy can be classified in table 1.

Retinal examination can be identified during several phases: such as observing color change in the image. Traditional classification strategy and DL processes are the two machine learning procedures considering solving diabetic retinopathy, because it is built on convolutional neural networks, we gain superior accuracy, classification results, & prediction regarding human retina features.

TABLE I.
STAGES REGARDING DIABETIC RETINOPATHY

| S.NO | DESCRIPTION | STAGE OF DR |
|---|---|---|
| 1 | Small areas of balloon – in the retina's tiny blood vessels called micro aneurysms may leak fluid into the retina | Mild NPR |
| 2 | Blood vessels that nourish retina may swell and damaged, so it is not able to transport blood | Moderate NPDR |
| 3 | Many more blood vessels are blocked, for the supply of blood to the blood vessels. | Sever NPDR |
| 4 | Advance stage, growth factors secrete by the retina trigger the proliferation of new blood vessels, which grow along the surface of the retina | PDR |

There can be repeatedly no symptoms during the early stages of diabetic retinopathy. Changes in the vision can be observed as, difficulty of reading, seeing distant things, and other signs people may or may not notice. These modifications may appear and disappear.

***Causes:*** When you have immoderate sugar within the blood, tiny blood vessels that nourish your retina gets closed, cutting off your retina's blood supply. As a result, these eyes make a conscious attempt to produce new blood vessel. These blood vessels, on the other hand, do not form properly and are prone to leaking.

## II. RESEARCH MATERIAL

### *A. Motivation Towards This Paper*

Several factors influence the annual screening by considering the global population affected through diabetes. Among them lower risk groups can exist and safely screened less frequently than with high risk groups.

### *B. Dataset*

As we know that dataset is a collection of different and useful information about various things, persons etc. considering an example of a patient's statistics or data, it stores their information about the age, gender, state, religion, language etc. But basically, DR Dataset contains data in the form of images.

Some of the existing datasets are STARE, DRIVE, Messidor-2, Messidor, CHASE-DB 1, FAZ (Foveal Avascular Zone), ARIA, DR2, DR1, DRiDB.
Some of the accessibility regarding to the diabetic dataset is given in table 2.

Some of the private datasets:

1. *HUPM dataset:* It contains about 250 fundus images among them 200 images were labeled as diabetic retinopathy and 50 were labeled as normal images. This dataset abides used during works [3].

2. *SNDRSP dataset:* Singapore National DR Screening Program collected a count regarding 1, 97,085 fundus images. This dataset is used during [4] for research related towards eye diseases.

3. *JMU dataset:* This dataset contains 9939 digital fundus images. These images were recorded through a RGB camera regarding 45o FOV. This dataset is one of the private datasets used in [5].

Some of the public datasets:

1. *Kaggle dataset:* It is a well-known dataset for the use of retinal images to find the diabetic retinopathy. It mainly contains 88,702 retinal images in which 35,126 images are used for training and 53,576 for testing. Gulshan et al. [6] it uses the dataset to identify the diabetic retinopathy.

2. *DIARETDB1dataset:* It is also one of the datasets considered for diabetic retinopathy identification. There can be 89 retinal pictures in the total dataset. Among them five pictures were classified like normal &84 image were likely to classify as diabetic retinopathy. Bui et al. [7] used dataset used to detect cotton wool of diabetic retinopathy study.

3. *Messidor-2:* It contains fundus images which were captured using a camera at 45 degrees FOV. It contains about 1784 digital fundus

TABLE II.
ACCESSIBILITY OF DIABETIC RETINOPATHY DATASETS

| S.NO | NAME OF DATASET | STATUS | |
|---|---|---|---|
| | | AVAILABLE | NOT-AVAILABLE |
| 1 | Kaggle | YES | |
| 2 | E-Ophtha | YES | |
| 3 | ROC | YES | |
| 4 | DIABETD B1 | | |
| 5 | DIABETD B0 | YES | |
| 6 | STARE | YES | |
| 7 | DRIVE | YES | |
| 8 | Messidor -2 | YES | |
| 9 | Messidor | YES | |
| 10 | CHASE_D B1 | YES | |
| 11 | FAZ | YES | |
| 12 | ARIA | YES | |
| 13 | DR2 | YES | |
| 14 | DR1 | YES | |
| 15 | DRiDB | YES | |
| 16 | HUMP, Cadiz, Spain | | YES |
| 17 | KMCM, India | | YES |
| 18 | LECHCR India | | YES |
| 19 | SNDRSP | | YES |
| 20 | JMU | | YES |
| 21 | CLEAPTRA | | YES |
| 22 | Moorfields Eye Hospital | | YES |
| 23 | TMUMH | | YES |

### *A. Procedure*

The basic procedure or the flow of the system is shown in the Figure 2 shows the flow of the model.

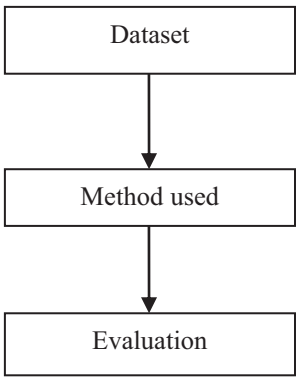


Figure 2. Basic components of the system

### *B. Performance regarding DL approaches:*

Deep learning gives high performance in the areas of image processing and to find out diabetic retinopathy using the images of fundus camera. The performance regarding the traditional and Deep learning approaches can be shown in the table 3.

TABLE III.
PERFORMANCE REGARDING TRADITIONAL & DL APPROACHES

| TECHNIQUE | RESEARCH STUDY | DATASET | ACCURACY |
|---|---|---|---|
| Deep learning | CNN | DIARTDB1 | 98.50% |
| Traditional | Morphological operations | DIARTDB1 | 97.75% |
| Deep learning | ANN | DIARTDB1 | 96 |
| Traditional | Random forest Classifier | DIARTDB1 | 93.58% |
| Deep learning | Random forest Classifier | DIARTDB1 | 98% |
| Traditional | Fuzzy Technique | DIARTDB1 | 93% |

## III. RELATED WORKS

### *A) IDF diabetes atlas: global estimates considering prevalence regarding diabetes considering 2015 & 2040.*

To develop present estimates regarding the diabetes of national, regional, & global impact considering from 2015 to 2040. A systematic literature analysis was carried out towards discovering the statistics sources on diabetes prevalence since research conducted between 1990 and 2015. Estimates considering the countries lacking data a can be modeled using extrapolation from similar countries among accessible data, utilizing an analytic hierarchy procedure for choosing most applicable research or method by considering each country. Smoothed age-specific estimates were generated using logistic regression models were applied for UN population estimates. Diabetes prevalence, diabetes-related fatalities, and diabetes-related health spending are more towards climb around world, among significant social, economic, & health-system.

Diabetes prevalence during adults aged 20–79 years were estimated 8.8% during 2015 and is expected to rise 10.4% through 2040. Diabetes' high incidence during the adults has significant social, economic, and developmental consequences. Governments are under increasing pressure towards establishing policies to reduce the risk factors among the type 2 diabetes and gestational diabetes. To guarantee all persons living with diabetes have proper access to the treatment. IDF continues to act like an advocate considering persons having diabetes through educating not only individuals but also governments keep their efforts done in the direction of the prevention and managing condition.

### *B) Screening intervals considering diabetic retinopathy & implications considering care.*

To examine the lower-risk population that could exist and can be evaluated by sight-threatening diabetic retinopathy (DR) are less frequently screened than once a year. Patients with no signs of diabetic retinopathy in neither of the eyes are considered at low risk within 2 years

CVR Journal of Science and Technology, Volume 22, June 2022
DOI: 10.32377/cvrjst2212

irrespective of the methods used. Figure 3 shows the variation of DR in the left and right images.

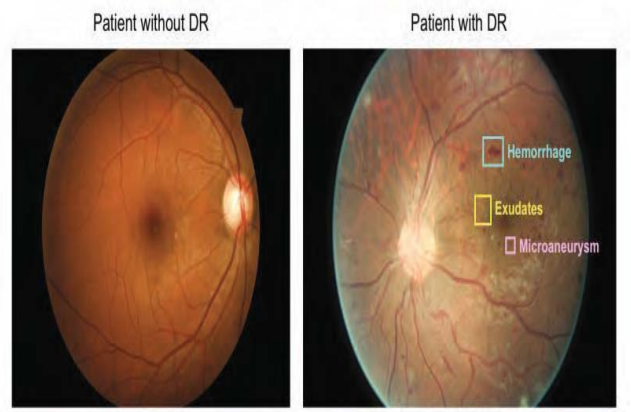


Figure 3. Example regarding fovea-centered color fundus photographs (CFPs) regarding a patient without DR (left) & a patient among signs regarding DR (right)

The goal of the study abides towards how well these central retinal fields predicted DR progression when compared towards peripheral retinal fields (F3, F4, F5, F6, & F7). The peripheral retinal fields (F3, F4, F5, F6, & F7) were discovered to be the most useful predictors as they include in the portions of the retina away from both the fovea and the optic nerve. Our result is supported by performance comparisons of models trained exclusively on central fields (F1 & F2) against models trained on all seven retinal fields.

### *C) Diabetic retinopathy and diabetic macular edoema disease severity measures proposed for international clinical use.*

To improve the communication and treatment coordination among diabetic physicians we create a global agreement on clinical disease severity categorization techniques for diabetic retinopathy and diabetic macular edoema. Clinical diabetic retinopathy disease severity scales were developed.

A group of 31 people representing comprehensive ophthalmology, retina subspecialties, endocrinology, and epidemiology from 16 different countries. The group accepted the first clinical categorization system based on publications like the Early Treatment Diabetic Retinopathy Study and the Wisconsin Epidemiologic Study on Diabetic Retinopathy. By e-mail, each participant evaluated it and the responses were categorized using a custom Delphi system. Separate systems for diabetic retinopathy and macular edoema were developed at a subsequent meeting. Members of the group then reevaluated them, and a modified Delphi procedure was used to determine degrees of the agreement once more. Several classification schemes have been agreed upon. Three levels of low risk, a fourth level of severe non-proliferative retinopathy and a fifth level of proliferative retinopathy make up a five-stage disease severity classification for diabetic retinopathy. There are two forms of diabetic macular edoema: apparently present and apparently lacking. Macular edoema can be classified as a function of its distance from the central macula if the screener's abilities and equipment allow them to make an informed decision.

There appears to be a definite requirement because diabetic retinopathy and diabetic macular edoema are classified using evidence-based clinical categorization systems that are worldwide comparable. Diabetic retinopathy and macular edoema are to be appropriately classified using the recommended clinical categorization systems. These technologies exist expected to exist beneficial during increasing both diabetes screening & communication & discussion among those who care considering these patients.

### *D) Two-year incidence of retinal intervention within individuals with modest otherwise non-diabetic retinopathy who were screened by telemedicine.*

*Importance*: Most diabetic patients have little or nil retinopathy on initial inspection. Following these people long-term, outcome could help us to learn more about how it provides check out.

*Objective:* Finding how many people with mild retinopathy or no signs of retinopathy will need retinal action to improve within two years of their initial retinal examination.

*Designs, settings, & participant:* Patients who had low or otherwise no retinopathy on fundus photographs after being examined for diabetic retinopathy through a telemedicine programme at Kaiser Permanente Southern California was included within this retrospective cohort research.

*Exposure:* Retinal treatments were conducted within two years of screening.

*Main outcome & measures: during* 2012, patients with minimal or no retinopathy on first screening images had their medical records CPT code for intravitreal injections, retinal lasers, and pars plana vitrectomy have been reviewed. When patients were recognized as having received these procedures within two years regarding their retinal evaluation, their medical records were manually evaluated for further description.

Fundus photographs of regular checkup has taken for 1, 16,134 patients were taken and their (mean [SD] age, 58 [12.8] years; 54,582 [47.0 percent] female; 46,453 [40.0 percent] male). Out of these people 79,445, including 69,634 people show no signs of retinopathy and 9,811 people show some or little signs of retinopathy within two years of checkup.

The discovery to put forward for the patient with mild or no signs of the baseline retinopathy are unlikely to receive retinal therapies within two years after undergoing a retinal examination. Because most people are not likely to have vision-loss conditions if they have necessary treatment. It indicates that the recommended checkup intervals for the risk-free individuals to be reasonable if it does not result in a worse condition within the subsequent years.

## IV. Proposed Method

Now a day's machine learning, deep learning has become an emerging hot research topic for image processing [12] and highly efficient [13]. We mainly focus on convolution neural networks for the process of image classification. CNN mainly consists of an input layer, hidden layer, and an output layer. Here the hidden layer plays a prominent role as the hidden layers increase the complexity of the system or

CVR Journal of Science and Technology, Volume 22, June 2022
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model also increases. It has some components like convolution layer, activation layer pooling layer or sub-sampling layer, fully connected layer and finally the loss layer. The main basic flow of any model is shown below (Figure 4).

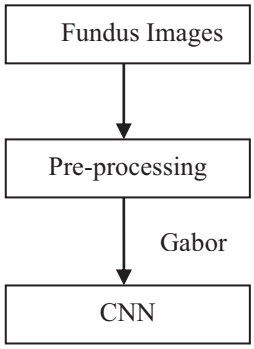


Figure 4. Proposed method

## V. Risk Factors of Diabetic Retinopathy

Long-term diabetes is the key risk variable assessed during a pooled analysis of the population-based research throughout world [8]. High hemoglobin A1C (HbA1C) levels and high blood pressure were also found towards the existing risk factors during this study [9]. According to UKPDS, incidence regarding diabetic retinopathy is closely linked towards the length ofT2D and a lower HbA1c level to reduce the chance in developing DR during these patients [10]. During clinical practice, it has been noted that certain individuals among long-term managed HbA1c levels still have a risk regarding diabetic retinopathy during T2D [11]. Most relevant risk factor is identified through every piece of empirical research diabetes duration. High fasting glucose, high postprandial glucose and high HbA1C are the symptoms of poor glycemic control. All three provides information on distinct aspects of diabetes and should be considered.

## VI. Stastical Analysis

To compare prognostication using a deep-learning system so that utilising risk variables, we can develop a set to train univariable and multivariable logistic regression models then to tested them on validation sets. We looked at the calibration to make sure that the deep-learning algorithm wasn't overconfident on the development set. Each dataset contained its own set of risk variables, and each experiment includes the patients who had risk factor statistics. Within the internal validation sample, glycated haemoglobin, self-reported diabetic control, years with diabetes, and insulin were the risk factors. Diabetes control was assessed as poor, fair, moderate, outstanding, or otherwise exceptional.

*Performance evaluation metrics:* evaluation metrics also plays a vital role during classification. Identification regarding the stage of diabetic retinopathy using a fundus camera should exist pre-processing like median filtering, average filtering & also adjustment regarding contrast during image [14].

The outcome regarding the statistics used during the medical treatment was mainly of two types. One becomes class among the disease and the second one becomes towards class without disease. So, the correctness regarding the disease exists correctly estimated through specificity, sensitivity measures respectively.

## VII. Discussion

We have developed a deep-learning algorithm for predicting the onset of diabetic retinopathy within two years which we tested using datasets that included an internal validation set of images from predominantly Hispanic patients in the United States, as well as an external validation set of images from Thailand. Deep-learning system performed well on both datasets and during isolation & risk.

Deep learning accepts color fundus pictures towards predict advancement on Early Treatment Diabetic Retinopathy Study scale through two or more levels.

## VIII. Conclusions

The determination of clinical relevance will be accepted by the patient-level examination preferably within prospective settings. Findings show that a deep-learning system may be built to improving diabetic risk categorization.

Here, we developed a systematic DL process considering detecting phases regarding retinopathy during diabetic patients. A clear view regarding the collection of datasets is also included. Choosing a performance metrics plays a vital role during outcome. Designing such system will give more information and identification to different stages of diabetic retinopathy. Although there exist various approaches towards detect, but DL models gives us more accuracy and providing future directions to the researchers. It mainly focuses on betterment of the patient life with minimum cost.

## IX. Future Direction and Challenges

We can also apply feature optimization algorithms to this work. So, in the next paper we are planning to apply genetic algorithm or Gabor feature algorithm to optimize image statistics to get better prediction accuracy [15].

It is necessary to build an effective DL – based procedure which should have consumed less time and less expensive. Performance regarding the present model (deep learning) exists improved through using a cascade regarding dynamic sized frameworks. As a result, cost regarding training considering individual models to reduce and they will be able to work independently.

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