Automated Identification of Diabetic Retinopathy Using Deep Learning

Beatrice Bisighini - Nicola Farella

Imágenes Biomédicas Avanzadas II – Ingeniería Biomédica – ETSI de Telecomunicación – Universidad Politécnica de Madrid

Introduction

- Diabetes affects more than **415 million** people worldwide, or 1 in every 11 adults.

Diabetic Retinopathy (DR) is a vasculopathy that affects the fine vessels in the eye that is caused by diabetes.

- **40-45% of diabetic patents** are likely to develop DR at some point of their life.
- Vision lost to diabetic retinopathy is sometimes irreversible. However, early detection and treatment can **reduce the risk by 95 %.**

Traditional Diagnosis

Visual assessment of the fundus by direct examination and by evaluation of colour photographs: [2]

- Changes to blood vessels;
- Leaking blood vessels or warning signs of leaky blood vessels, such as fatty deposits;
- Swelling of the macula;
- Changes in the lens;
- Damage to nerve tissue.

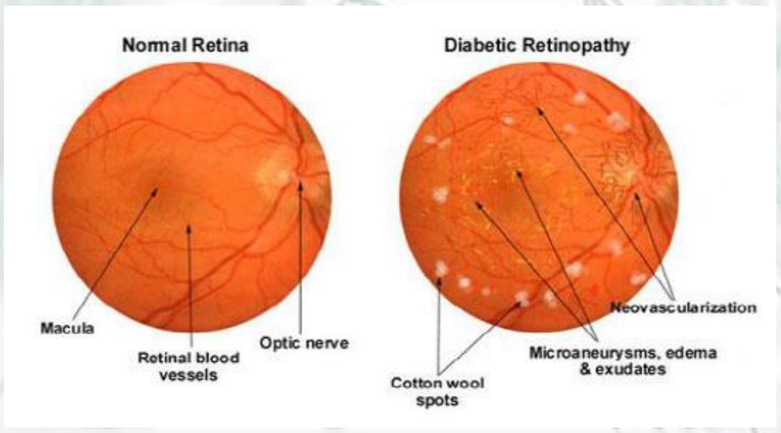

Figure 1. A comparison of a normal retina and diabetic retinopathy [5]

Given the large number of diabetes patients globally, this process is **expensive** and **time consuming.**

A solution to these limitations is the use of automated tools for RD diagnosis. In first place, such a tool could alleviate the workloads of trained specialists, allowing untrained technicians to screen and process many patients objectively, without dependence on clinicians.

Previous Methods Limitations

- Small data-set (500 images);
- Homogeneous images;
- Manual feature extraction.

Materials and Methods

Fundus Image Dataset

75 137 colour fundus images (different colours) obtained with varying camera models from patients of different ethnicities, amalgamated from many clinical settings.

Each image was associated with a diagnostic label of 0 or 1 referring to no retinopathy or DR of any severity, respectively, determined by a panel of medical specialists.

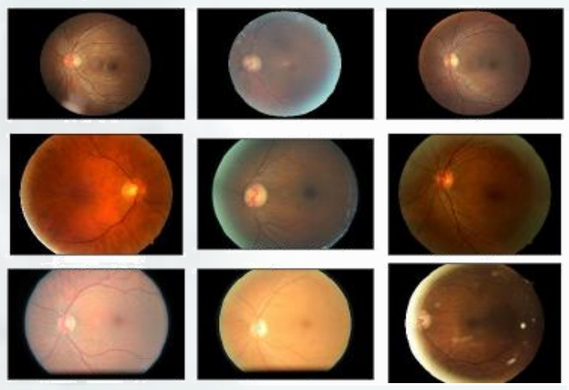

Figure 2. Typical DataSet [5]

Preprocessing

- Pixel values scaling [0,1];
- Downsizing to 512x512 pixels.

Data-set augmentation

To improve generalisation properties:

- Random orientation;
- Random brightness and contrast adjustments.

Deep Feature Learning

The principle of **deep residual learning** was used to develop a custom convolutional network, learning discriminative features for DR detection.

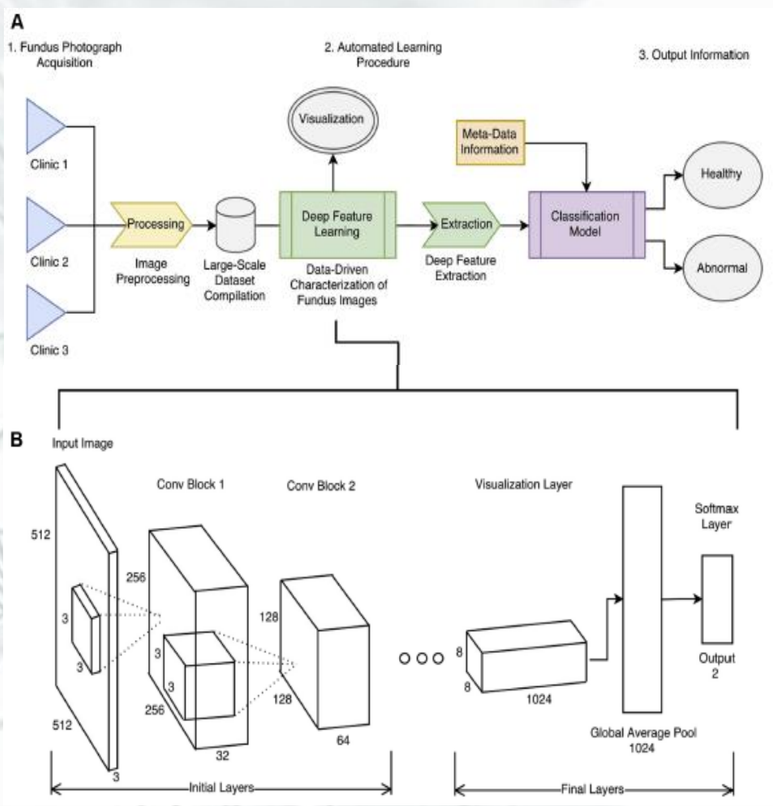

Figure 3. Abstraction of the proposed algorithmic pipeline. A, Integration of the algorithm in a real diagnostic workflow. B, Abstraction of the deep neural network.

Results

The model was tested model using 5-fold stratified cross-validation on the local data set of 75 137 images (subsequently, using two independent and different datasets).

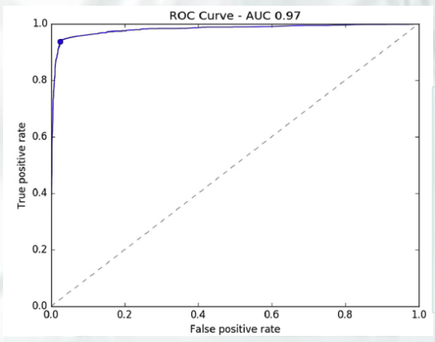

Fig. 4. ROC curve.

AUC = 0.97
sensitivity = 94%
Specificity = 98%

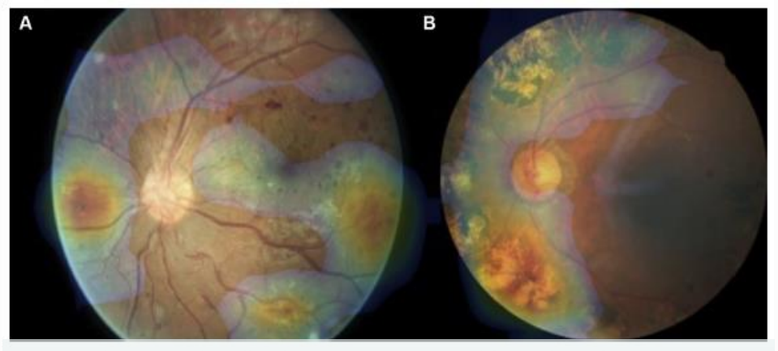

Figure 5. Visualization maps generated from deep features.

Extra

A novel and different AI disease-staging system is proposed for grading diabetic retinopathy that involves a retinal area not typically visualized on fundoscopy and another AI that directly suggests treatments and determines prognoses. [4]

Modified Davis grading.

Grading	
SDR	Microaneurysm, retinal hemorrhage, hard exudate, retinal edema, and more than 3 small soft exudates
PPDR	Soft exudate, varicose veins, intraretinal microvascular abnormality, and non-perfusion area over one disc area
PDR	Neovascularization, pre-retinal hemorrhage, vitreous hemorrhage, fibrovascular proliferative membrane, and tractional retinal detachment

SDR, simple diabetic retinopathy; PPDR, pre-proliferative diabetic retinopathy; PDR, proliferative diabetic retinopathy.

Figure. 6. Modified Davis gradient.

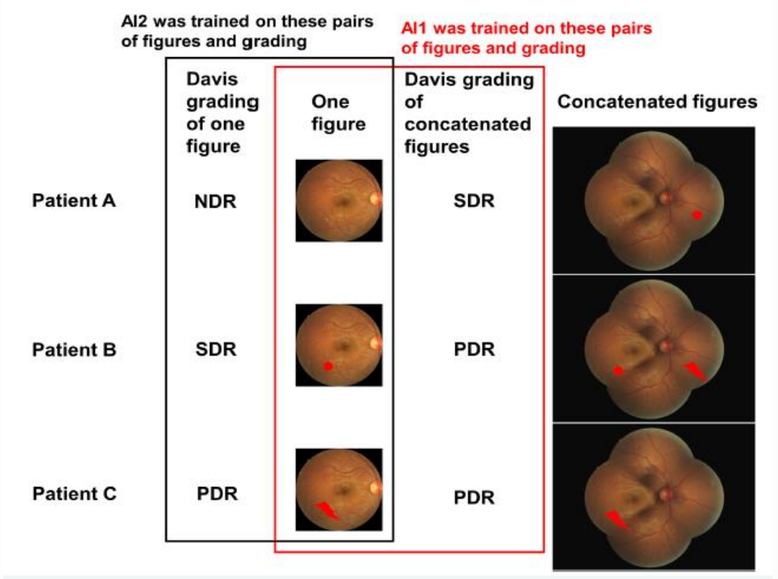

Figure 7. Two training methods

FDA-approval

"The U.S. Food and Drug Administration today permitted marketing of the first medical device to use artificial intelligence to detect greater than a mild level of the eye disease diabetic retinopathy in adults who have diabetes."
From FDA website April 11, 2018 [3]

Bibliography

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