Using An Ensemble Convolutional Neural Network to Detect Diabetic Retinopathy in Rural Areas in India

Zain Hussain*[1], Dominic Ng*[2], Hazem Yousef[3], Su Young[1], Peter Cackett[1]
[1]University of Edinburgh [2]University of Manchester [3]NHS Greater Glasgow & Clyde *Co-first authors

Background

- Diabetic retinopathy (DR) is the leading cause of blindness among working-aged adults worldwide. In India, where diabetes is an escalating public health issue, this problem is only exacerbated (Gadkari et al., 2016).
- DR screening, which requires clinicians to examine fundus images, is time consuming and resource draining (Fig 1.). Automating detection of DR can have major implications in reducing the burden on clinicians involved in eye care (Gargeya, 2017), especially in rural areas of developing countries, where there is a lack of primary care access and training.
- Studies to-date have demonstrated the capabilities of deep learning models in effectively detecting disease (Hemanth et al., 2019), however the literature for rural settings is limited.
- Whilst deep learning models are flexible and can scale in proportion to the size of the training data, they are sensitive to specifics in the data which can lead to different predictions – this is termed having high variance.
- Ensemble learning helps reduce variance, as multiple models are trained, and the predictions from these are combined (Fig 2.).

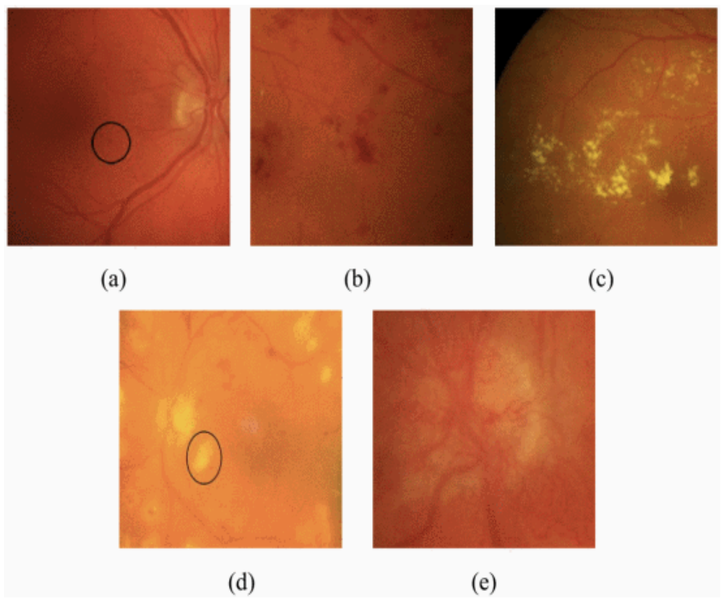

Figure 1. Typical lesions in color fundus image with DR (a) Microaneurysms; (b) hemorrhages; (c) hard exudates; (d) soft exudates; (e) neovascularisation.

Aim

- We aimed to employ an ensemble deep learning approach to detect DR automatically, regardless of stage, using rural data from a developing country.
- It is hoped that our results will inform the approaches being researched and developed for screening in such countries.

Results

- The CNNs were trained on both left and right eyes, and their predictions were then averaged to give a single probability distribution. There was also good agreement between both eyes.
- The ensemble CNN predicted with 94% accuracy (92% sensitivity and 93% specificity), whether a patient had diabetic retinopathy or not.

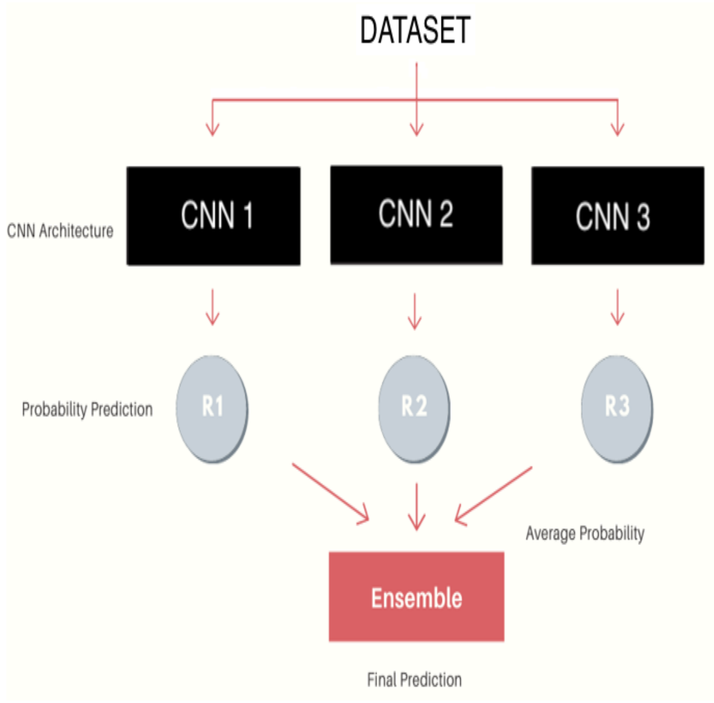

Figure 2. Ensemble Convolutional Neural Network

Methods

- The dataset used in this study was collected from a rural area in India, by the Aravind Eye Hospital, and was publicly available.
- We used 5390 fundus images of both eyes, for which the stage of DR had been diagnosed by trained clinicians. The inter-rater agreement was reported to be high.
- The patients are representative of a rural diabetic population undergoing screening. All patients had a diagnosis of diabetes.
- Images were initially pre-processed by rescaling them to 300x500 pixels and then clipping to 90% to remove boundary effects.
- Three Convolutional Neural Networks (CNNs) were trained, and combined to create an ensemble CNN.
- This is the first study to use an ensemble CNN on this dataset to detect diabetic retinopathy, regardless of stage. The cut off for DR detection was if it was referable, i.e. moderate non-proliferative retinopathy.

Conclusion

- Our findings confirm the effectiveness of an ensemble deep learning approach for accurate detection of DR and demonstrate its potential as a screening tool for DR in developing countries.
- Our results are in line with other studies (Pratt et al., 2016; Zhang et al., 2017) which have predicted DR using deep learning, which supports further exploration of their use in clinical practice.
- Our small sample size was a limitation, hence we did not detect the stage of DR and predict disease progression.
- Future research could also ensure that results are compared against other machine learning algorithms and that they are validated against another independent rural dataset in India.

Contact

Dr Zain U Hussain
Foundation Doctor (NHS Tayside)
CEP Associate Faculty Member, University of Edinburgh
Email: zain.hussain4@nhs.net

Dominic Ng
BSc (Hons), MSc
Final Year Medical Student, University of Manchester
Email: dominic.ng@student.manchester.ac.uk

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