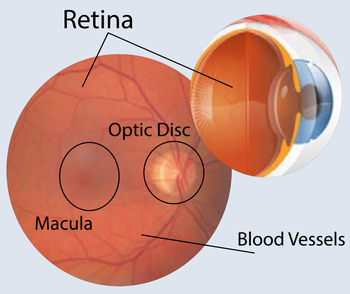
Retinal Fundus Image Analysis Project

Hanan Alghamdi, Su Wang, Lilian Tang

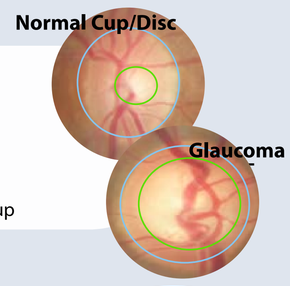
UNIVERSITY OF SURREY



In ophthalmology, retinal images are used to aid in diagnosis of several diseases. Early detection of pathological signs is critical to prevent disease progression and vision loss. Indeed, the large number of patients who need to be examined by ophthalmologists every year stresses the necessity of an automated system for disease detection. In this project a computer aided diagnosis system is to be developed to aid in the diagnosis of several diseases. Normal structure of the retina, which includes the optic disc, macula and blood vessels, should be extracted before the detection of any clinical signs. Several image processing and machine learning methods have been evaluated in this project to detect optic disc, blood vessels, dark and bright lesions.

Glaucoma

Glaucoma is the second major cause of blindness worldwide (12.3%). It may affect 79.6 million people by 2020 [1]. Retinal fundus images provide an important information for diagnose of glaucoma. Opthamologist may measure the cup to disc vertical ratio (the vertical diameter of the cup divided by the vertical diameter of disc) as this ration is higher in glaucoma cases than in normal cases.

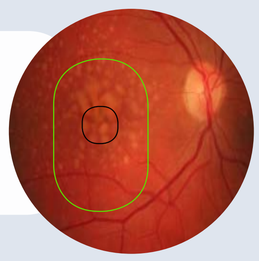


Diabetic Retinopathy

Diabetic Retinopathy is the most common complications of diabetes and is a major cause of blindness (4.8%) [1]. Pathological signs of DR consist of dark lesions including microaneurysms (MAs) and haemorrhages, as well as bright lesions such as exudates and cotton wool spots. Ophthalmologists diagnose the DR presence and severity based on the detection of these lesions.

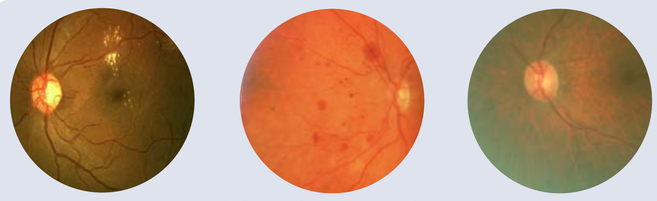
Age-related Macular Degeneration

(AMD) is a leading cause of blindness (8.7%) [1]. AMD affects the macula. The macula is the part of the retina responsible for acute vision. The presence of yellowish deposits called drusen in the macula region is a key feature to diagnosis AMD and to determine the disease severity.



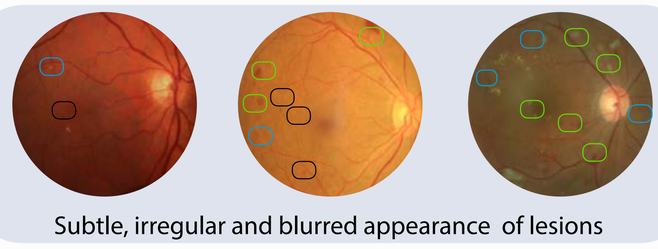
Challenges

In this project, fundus images were collected from various resources, for different populations and from several countries. Moreover, images were acquired by different experts who use variuos acquisition tools and photographing settings. In addition to this vast variety the following figures depicts more challenges in analysing the clinical signs:



Variability of the retinal images

Similarities between lesion signs and the anatomic structure of the retina

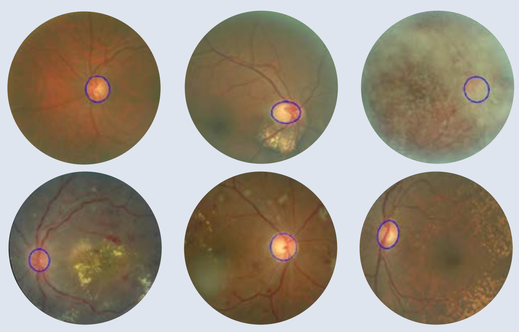


Subtle, irregular and blurred appearance of lesions

Optic Disc & Macula Detection

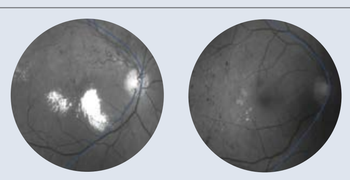
The optic disc is an important anatomic landmark to locate other retinal structures and it is essential to detect diseases such as glaucoma. In this project, optic disc has been detected by employing two different algorithms.

The first algorithm is based on the assumption that the optic disc represents one of the brightest objects in the retina and is approximately circular in form. However, as several bright objects can be detected using this assumption, this method utilizes another key feature of the optic disc; vessel density to solve the ambiguity.

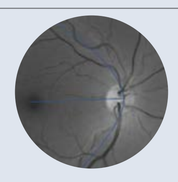


Optic Disc Detection based on color, shape, size and vessel density

The second algorithm utilizes the geometric relationship between the optic disc and the vessels. It is based on fitting a parabola with the main vessels, hence, its vertex will be localised inside the optic disc. The candidate region of macula is defined as a circular area and it is located at about 2 disc diameter temporal to the optic disc.



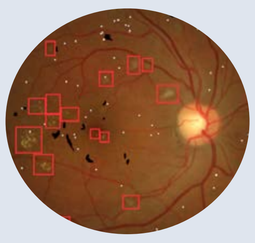
Optic Disc Detection results of the first algorithm



Localization of the Macula

Bright Lesion Detection

Currently, all bright regions are extracted and classified as lesions or non-lesions by using a multi-classifiers approach. As the optic disc should be detected first, it will be removed from the bright candidate regions.

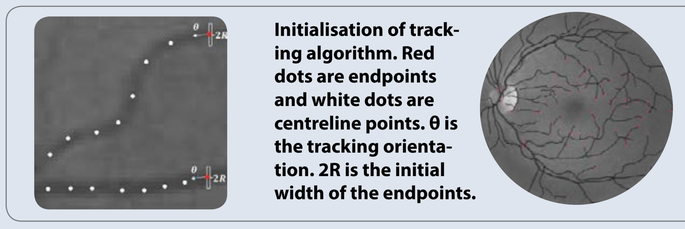


Red squares are white lesions.

Blood Vessel Detection

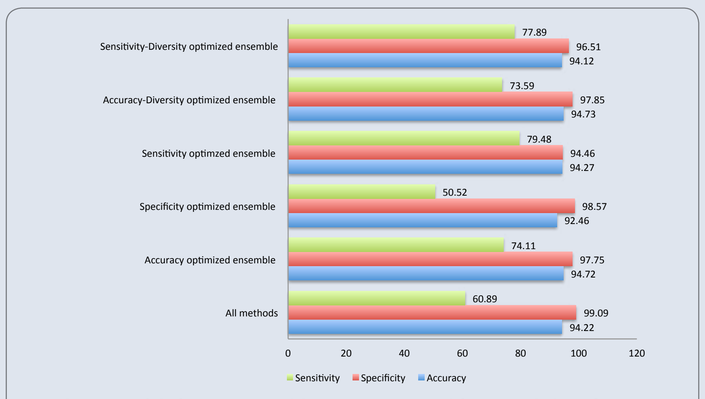
Vessels are important landmark to determine the presence of clinical signs and to help in locating optic disc and fovea. Moreover, the change of vessels indicates some changes of pathology. In this project vessels were detected by two approaches:

Blood Vessel Tracking in wich the vessel centrelines are extracted by SSA method and regarded as initial points to generate the vessel network by measuring local information. Finally, a trace-back mechanism is used to reconstruct the vessel network and tiny vessels.

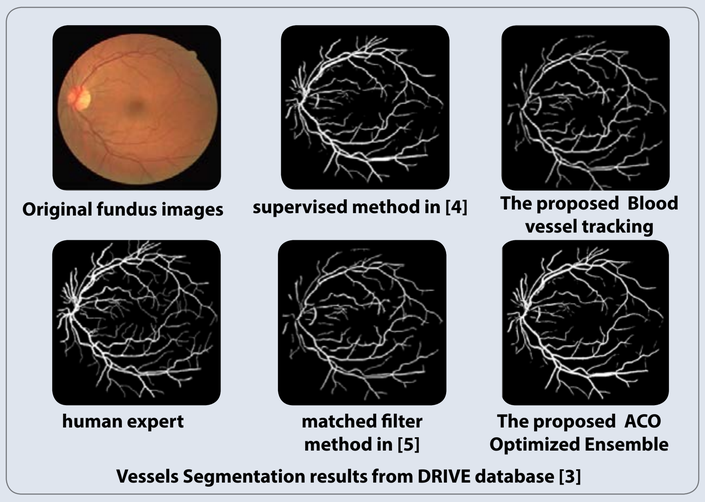


Initialisation of tracking algorithm. Red dots are endpoints and white dots are centreline points. θ is the tracking orientation. 2R is the initial width of the endpoints.

Blood Vessel Pixel Classification in which all pixels were classified as being vessel/non-vessel by Ant colony optimized ensembles. Several heuristics including diversity, sensitivity, accuracy and specificity were utilised in optimizing different ensemble structures [2].



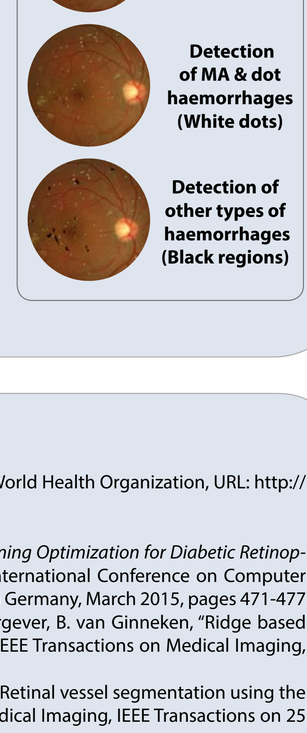
Evaluation of different ensemble structures used for vessel classification [2]



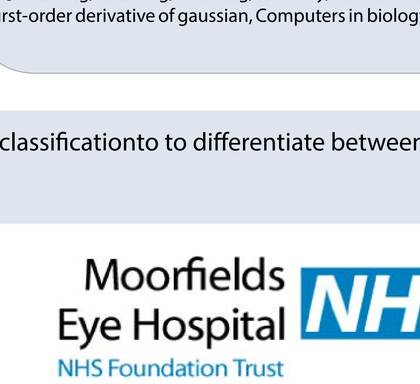
Vessels Segmentation results from DRIVE database [3]

Dark Lesion Detection

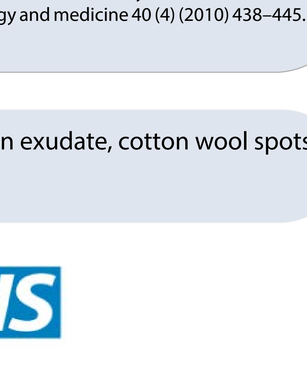
Microaneurysms and dot haemorrhages are two clinical signs which appear as circular dark lesions. Thus the cross-section profiles of these signs play an important role for an effective separation between them and other dark objects such as vessels. SSA is used to decompose each profile and reconstruct a new one that is of a slow varying trend. The reconstructed profile is weighted using the correlation coefficient between itself and an ideal Gaussian shape assuming this candidate is a true MA. Features are then extracted from the profiles for classification. The results have demonstrated the robustness of this approach when testing on large scale datasets with clinically acceptable sensitivity and specificity.



The cross-section profiles of different objects. (a) an MA, (b) a background, (c) a haemorrhage (an elongated non-MA structure), and (d) a blood vessel crossing.



Evaluation of the proposed method on different populations



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[3] J.J. Staal, M.D. Abramoff, M. Niemeijer, M.A. Viergever, B. van Ginneken, "Ridge based vessel segmentation in color images of the retina", IEEE Transactions on Medical Imaging, 2004, vol. 23, pp. 501-509.

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In the future we aim to to continue working on developing optic disc-cup ratio estimator in order to detect glaucoma and on bright lesion detection and classificationto to differentiate between exudate, cotton wool spots and drusen which appear in DR and AMD cases. We also aim to examine how these are linking to disc analysis in case of Glaucoma.

Acknowledgement

Engineering and Physical Sciences Research Council (EPSRC), UK
King Abdulaziz City for Science and Technology, Saudi Arabia,
Moorfields Eye Hospital NHS Foundation Trust, UK

EPSRC

مدينة الملك عبدالعزيز للعلوم والتقنية KACST

Moorfields Eye Hospital NHS
NHS Foundation Trust