SOFTWARE

Deep learning takes to the air

Sameer Trikha, Nicolas Jaccard and **Jay Lakhani** describe a new development offering clinical decision support for the detection of diabetic retinopathy, glaucoma and age related macular degeneration detection through the use of artificial intelligence

The demand for ophthalmic care is soaring. It is estimated that by the year 2020, a total of 415 million people worldwide will be suffering from diabetic eye disease, 76 million will have glaucoma and approximately 196 million will be suffering from age related macular degeneration.[1,2] At the same time. the supply of trained ophthalmic care professionals will not be able to keep up with this demand.[3]

SCREENING CHALLENGES

Conventional medical research studies have identified that early and prompt recognition of abnormalities through eye screening has tangible benefits and improves eye health. As a result, primary eye care providers and optometrists have become the cornerstone for this approach, in many ways acting as 'gatekeepers' for NHS Hospital Eye Services.

In spite of this, optometrists are, in certain areas, being put under undue pressure. Despite clinical training, many are being asked to see increased numbers of patients, and due to pressures in other parts of the service, are often asked to make quicker decisions. The result is clinical variability, and in the worst scenarios, clinical error. One such example was the manslaughter charge applied to an optometrist for failing to spot an abnormal optic disc in a young patient.[4]

Targeting such unwanted variation is a key objective in health care services. This is principally as a means to improve both the quality and accuracy of care at the outset.[5] Within ophthalmic care, certainly in the context of eye screening, variation should be unwarranted, as this could be potentially harmful to patients and the health services that support them. A recent report by Lord Carter assessed operational productivity, and estimated that unwarranted variation was worth £5bn in terms of overall efficiency opportunity.[5] Within the eye domain, work by Harper et al has identified considerable variation in accuracy between optometrists and ophthalmologists for vertical cup disc ratio detection (VCDR).[6] Furthermore, an inter-observer difference standard deviation of 0.19 was found between individual optometrists for VCDR, with an average agreement of 67% to 71% for other disc features.[7]

INTRODUCING AI

The current environment therefore requires change in order to provide innovative, sustainable and standardised ophthalmic care. Recent advances in computational power, coupled with the availability of medical data, has permitted the development of cutting edge artificial intelligence (AI) solutions.

Medical imaging is undergoing a revolution. Traditionally, machine vision algorithms for medical applications were carefully developed for specific tasks, for example the detection of bone fractures in X-ray imagery. This process can be extremely time intensive as it involves;

- Devising features (eg edges, texture) that suitably capture the pattern to detect such as discontinuities along a bone
- Finding a way to combine these features to answer our question: 'Is there a fracture somewhere in this X-ray image?'.

In many cases, the features and the rules used for their combination are to be re-engineered when considering a new task, such as 'Is this eye fundus image abnormal?'.

The advent of machine learning (ML) alleviated much of the pain related to the combination of identification pattern features. ML algorithms, which are very general in nature, can learn the optimal combination of features directly from the data, and thus

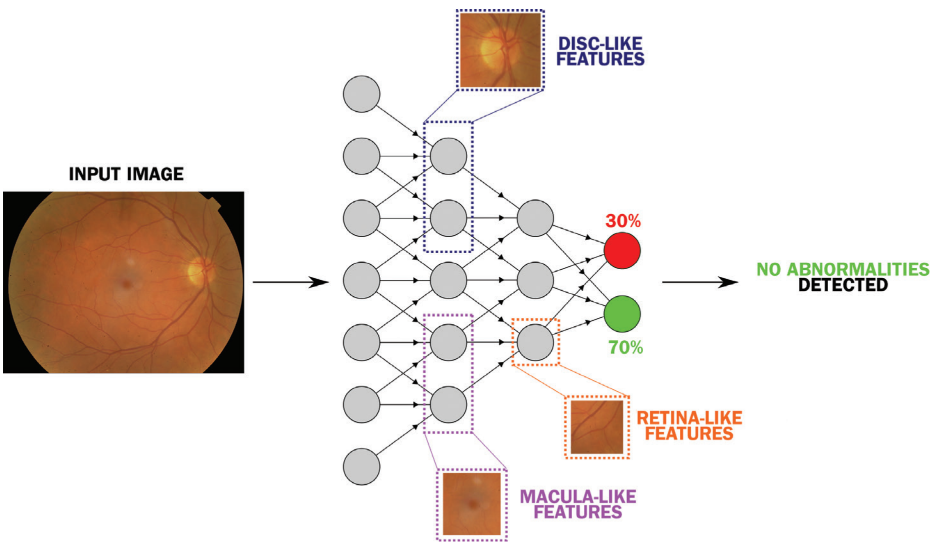

FIGURE 1 Schematic representation of an artificial neural network designed to identify anomalies in eye health

FIGURE 2 Glaucomatous discs may be detected by AI

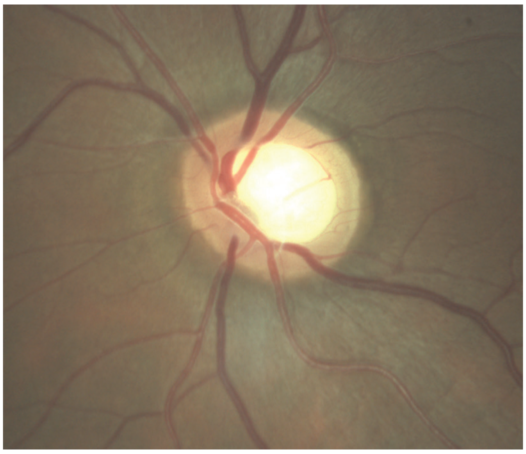

FIGURE 3 Pegasus can detect and grade diabetic retinopathy

greatly reduce the amount of work required to tackle a new task. For the better part of a decade, much of the improvements seen in medical image processing were down to new and improved features. However, the engine underpinning the current revolution in medical imaging is deep learning (DL), a modern variant of decades old artificial neural networks,[8] which allows a computer to learn both the optimal features and combinations thereof for a specific task directly from the data. DL exceeds human-level performance in many applications, including image and voice recognition.[9,10] DL, coupled with increasing computational resources and data availability, is enabling the development of robust and useful AI systems.

DEEP LEARNING FOR FUNDUS IMAGE INTERPRETATION

An artificial neural network (shown as a simplified schematic in figure 1) learns important visual features about the image (eg Disc-, Retina-, and Macula-like features) and how to best combine them to answer the question 'Is this fundus image normal?'

Visulytix (www.visulytix.com) is an AI company based in the United Kingdom which is developing AI-driven clinical decision support tools for ophthalmic care professionals. The aim is to provide high quality care, delivered in a fraction of the time, and therefore at a fraction of the cost to the healthcare provider. This will help promote a healthier population, facilitating care that can be equitably accessed. One of its products in development, Pegasus, can screen for major blinding disease groups, notably;

- glaucomatous disc morphology analysis (figure 2)
- macular pathology detection
- classification and grading of diabetic retinopathy (figure 3)

The software can automatically analyse the optic nerve in a fundus image and detect whether there is an abnormality. Clinical trials have shown Pegasus to offer superior levels of accuracy when compared to expert ophthalmologists, who have been shown to have a sensitivity of 80%.[11] Furthermore, as part of its analysis, Pegasus autonomously identifies the areas of the image it has analysed in order to reach its suggestion. This in turn allows the healthcare professional to interpret the image with greater accuracy, and the AI decision support system and professional work in synergy.

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