EYE ROBOT

Automated Diabetic Retinopathy Image Assessment

humans, robots, and ethics...



Digital imaging

1975 - The worlds first digital camera

Eastman Kodak engineer Steve Sasson.

The 8 lb camera recorded 0.01

megapixel black and white photos to a

cassette tape.



1991 - The world's first digital SLR the Kodak

Professional Digital Camera System (DCS) was a

modified Nikon F3.

It cost around \$30,000



1999 - The first fully integrated digital SLR

featured a 2.7MP sensor.

It cost around \$5,580



Luddite

noun

Derogatory: A person opposed to increased industrialisation or new technology.

Despite their modern reputation, the original Luddites were neither opposed to technology nor inept at using it...

They were concerned with issues of quality, safety & self preservation.

The camera I first used.

My favourite camera!

EQUIPMENT AND METHODS

The Canon CR3-45NM non-mydriatic retinal camera

The detection and monitoring of diabetic retinopathy by direct ophthalmoscopy in busy diabetic clinics is far from satisfactory. The large sizes of these clinics and staff shortages often make routine dilatation of the pupils with mydriatic eye drops impractical and ophthalmoscopy through undilated pupils, which is inadequate at the best of times, is often further hampered by small pupils and cataracts (Smith and Smith, 1983), both of which are common in the diabetic population. Thus, any instrument or procedure that aids the process of detection and monitoring of diabetic retinopathy is to be welcomed. The Canon CR3-45NM retinal camera is one such instrument in that it enables retinal photographs to be made without the need to use mydriatics. Our initial experience with the Canon non-mydriatic retinal cameras was gained with the CR2-45NM model tested in a busy diabetic clinic by comparing the success rate of detecting diabetic retinopathies from photographs against observations by physicians using the ophthalmoscope through undilated and dilated pupils (Ryder et al., 1984). This trial demonstrated that the use of the retinal camera was more successful

than the physician with the ophthalmo-

scope. One hundred and thirty-seven

eyes were examined and we detected 24

e- eyes with diabetic changes from the photographs, whereas the physicians un detected only two of these through undiated pupils and eight through diated pupils. Amongst the pathology missed the by the physician through undiated pupils were two eyes with large circinate excutates around the macula.

However, despite these encouraging results we were disappointed with the high failure rate for photography with the retinal camera (22 per cent). Although insurmountable factors such as cataracts and poor patient compliance contributed substantially to this, a major factor was the small size of many diabetic pupils. This was particularly a problem when photographing the second eye, the pupil of which remained constricted for a prolonged period after the flash of photography of the first eye. We have since been able to assess the newer CR3-45NM model (Figure 1) and were pleased to find that this problem seems to have been overcome. This new retinal camera is capable of taking correctly exposed and evenly illuminated photographs with a pupil size of only 4 mm as compared to 5 mm on the CR2-45NM retinal camera. The CR3-45NM camera produces a

22 mm diameter image on 35 mm film or a 66 mm diameter image on Polaroid film covering a 45° field of view.



Figure 1. The Canon CR3-45NM non-mydriatic retinal camera.

Canon have a novel method of setting up the camera for photography which enables even the inexperienced operator to obtain good photographs with minimum instruction. The instrument incorporates an infra-red television camera (Figure 2) and a suitably filtered light source for viewing the retina whist the patient is dark-adapted, thereby utilising a naturally dilated pupil. The operator view this image on a blackand-white video monitor.



Figure 2. Canon CR3-45NM retinal camora showing the top-mounted infra-red television camera and Polaroid SX-70 film back with the interposed mirror box for monitoring the retina through dark-adapted pupils on the black-and-white video monitor.

Optical alignment and the correct working distance of the retinal carnera from the subject's eye is easily achieved. First, an auxiliary lens is moved into the optical path enabling the operator to see the external eye and the retinal camera is adjusted to centre a small target circle over the image of the pupil. When the auxiliary lens is removed the operator has a view of the retina. Built into the camera's objective lens mount are two small infra-red emitting diodes which reflect off the cornea and can be seen by the operator as two circular highlights on either side of field of view. The camera is set in the opti-



Everyday automation





PLANES

Most airliners that are certified for Autoland, must perform at least one successful Autoland each 30 days in order to maintain certification. So, at least once a month, most commercial and freight large aircraft must do one.



TRAINS

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The ATO and ATC/ATP systems work together to maintain a train within its timetable.

The combined system will marginally adjust parameters such as the ratio of power to

coast when moving and station dwell time.



AUTOMOBILES

Automated (driverless) parking, park assist, lane departure and automatic breaking are all currently in use. Driverless cars, we are told, are in advanced stages of

development and will likely be available in the next few years.

Novel uses for A.I.

Market research turns to automation

Automating market research can get things done faster and cheaper, but care must be taken to safeguard quality when designing the necessary software

But it's not just about saving time

TOMATION METHODS USED IN

"If reporting is automated,

Artificial intelligence creates sci-fi trailer

Ben Hoyle Los Angeles

A trailer for a film about the moral complexity of creating artificial life is unnerving not just because of the cinematic thrills it advertises: it was itself put together by a computer. *Morgan*, directed by Sir Ridley Scott's

son Luke is a claustrophobic, occasion-

selected scenes for the trailer in the light of its newly acquired knowledge.

13

News

The result, following some human intervention from a "resident IBM film-maker", is chilling. It is notably darker in tone than the studio's previous trailers and features scenes that had not been chosen by humans for their versions.

Automated retinal image analysis

Advances since the turn of the century

- Imaging hardware
- Computational power
- Data storage

- Better understanding of disease processes
- Advances in diagnosis and treatment

Our ability to capture, process and analyse digital images of human tissue has reached an advanced stage...

What are the driving forces

- General clinical need
- Explosion in diabetes
- Maturation of organised screening programmes
- The needs of research

...

• The retina as a window on other conditions

Although computer based systems have been shown to be valuable in other conditions, one of the most successful areas is

...diabetic retinopathy

Image quality assessment

Image analysis

A growing evidence base

ldx-DR

Iowa Detection Program Image Quality ma, haem & CWS detection Sensitivity 0.97 Specificity 0.59

Abramoff MD, Folk JC, Han DP,Walker JD,Williams DF, Russell SR, et al. Automated analysis of retinal images for detection of referable diabetic retinopathy. JAMA Ophthalmol. 2013;131:351–7.

iGradingM

Aberdeen University Algorithm Image Quality ma & dot haem detection Sensitivity 0.98 Specificity 0.41

Fleming AD, Goatman KA, Philip S, Prescott GJ, Sharp PF, Olson JA. Automated grading for diabetic retinopathy: a large-scale audit using arbitration by clinical experts. Br J Ophthalmol. 2010;94:1606–10.

Retinalyze

Denmark Image Quality Red ma & haem lesion detection Sensitivity 0.97 Specificity 0.71

Larsen M, Godt J, Larsen N, Lund-Andersen H, Sjolie AK, Agardh E, et al. Automated detection of fundus photographic red lesions in diabetic retinopathy. Invest Ophthalmol Vis Sci. 2003;44:761–6.

RetmarkerDR

Coimbra University Portugal

Image Quality

Co-registration (ma detection and turnover)

Sensitivity 0.96 Specificity 0.52

Pires Dias JM, Oliveira CM, da Silva Cruz LA. Retinal image quality assessment using generic image quality indicators. Information Fusion. 2014;19:73–90.

EyeArt (EyeNUK)

Los Angeles California

Image Quality

Co-registration (ma detection and turnover)

Sensitivity 0.90

Specificity 0.63

Pires Dias JM, Oliveira CM, da Silva Cruz LA. Retinal image quality assessment using generic image quality indicators. Information Fusion. 2014;19:73–90.

Other systems?

CARA - Diagnos Quebec Canada

The TRIAD Network - University of Tennessee

Visulytix - United Kingdom

Health Technology Assessment

National Institute for Health Research

Evaluation, Trials and Studies

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News and literature	Publication date	August 2016	To receive funding alerts and other programme news, please join our mailing list.
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Chief Investigator - Mr Adnan Tufail

Co-investigators - Miss Clare Bailey (University Hospitals Bristol NHS Foundation Trust), Ms Catherine Egan (Moorfields Eye Hospital NHS Foundation Trust), Professor Christopher Owen (St George's, University of London), Dr Caroline Rudisill (London School of Economics and Political Science), Dr Alicja Rudnicka (St George's, University of London), Dr Paul Taylor (University College London)

Automated systems being used

iGrading (Medalytix)

Retmarker (Critical Health)

EyeCheck (Idx-DR)

EyeArt (EyeNUK)

HTA Report

ARVO 2016

Automated diabetic retinopathy image assessment softwares: large scale, real world evaluation of diagnostic accuracy and costeffectiveness compared to human graders.

Catherine A. Egan, Alicja Rudnicka, Christopher Owen,, Caroline Rudisill, Sebastian Salas-Vega, Paul Taylor,, Gerald Liew, Aaron Lee, Clare Bailey, John Anderson, Adnan Tufail. 20,258 consecutive patients

Results

Sensitivity point (95% CI)

	EyeArt	Retmarker	iGrading	EyeCheck
Any DR	94.7%	73.0%	na	not tested
Referable	93.8%	85.0%	na	not tested
R3	99.6%	97.9%	na	not tested

Study conclusion

"Retmarker and EyeArt achieved acceptable sensitivity

for referable retinopathy when compared with a quality-assured, real

world human grader working in a high volume clinical setting as a

reference standard and had specificity sufficient to make them cost

effective alternatives to a purely manual grading approach".

Possible methods of deployment

Primary grading filtration of negatives



60 grades

+ 10% QA

= 66 grades

40 grades x 2

+ 5% arbitration

= 82 grades



10 ROG grades

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Grand total = 158 grades



10% QA

= 6 grades

40 grades (triaged?)

10 ROG grades?

or even...

40

Grand total = 56 or 86 grades

On Screen Aid

Which will you grade quickest?





ma (lesion) count

Lesion co-ordinates

Threshold?

ma count - threshold?



more?



Automation benefits

Quicker results

reduced patient anxiety

quicker referral

Cost savings

Resources to focus on service development & continuous improvement

ma turnover

risk profiling

personalised screening interval?

Changes to job role

More focus on...

Patient safety

Patient education

Patient engagement

Hard to reach

Research, audit and continuous service improvement

Other imaging/screening tests

CPD

Technology Opinion

A world without work is coming - it could be utopia or it could be hell Ryan Avent

Robots will eventually do all our jobs, but we need to start planning to avert social collapse



Illustration by Nathalie Lees

Monday 19 September 2016 06.00 BST

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Save for later ost of us have wondered what we might do if we didn't need to work if we woke up one morning to discover we had won the lottery, say. We entertain ourselves with visions of multiple homes, trips around the world or the players we would sign after buying Arsenal. For many of us, the most tantalising aspect of such visions is the freedom it would bring: to do what one wants, when one wants and how one wants.

But imagine how that vision might change if such freedom were extended to everyone. Some day, probably not in our lifetimes but perhaps not long after, machines will be able to do most of the tasks that people can. At that point, a truly workless world should be possible. If everyone, not just the rich, had robots at their beck and call, then such powerful technology would free them from the need to submit to the realities of the market to put food on the table.

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R.M. Levenson, E.A. Krupinski, V.M. Navarro, E.A. Wasserman

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Thank you.