Computer-aided Diabetic Eye Disease Assessment: Understanding and Exploiting Retinal Fundus Features Using Online Learning through Evolutionary Programming (CAMERA)

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Collaboration

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- Nanyang Technological University
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- Diabetic eye disease (DED) is a leading cause of vision loss in Singapore and worldwide.
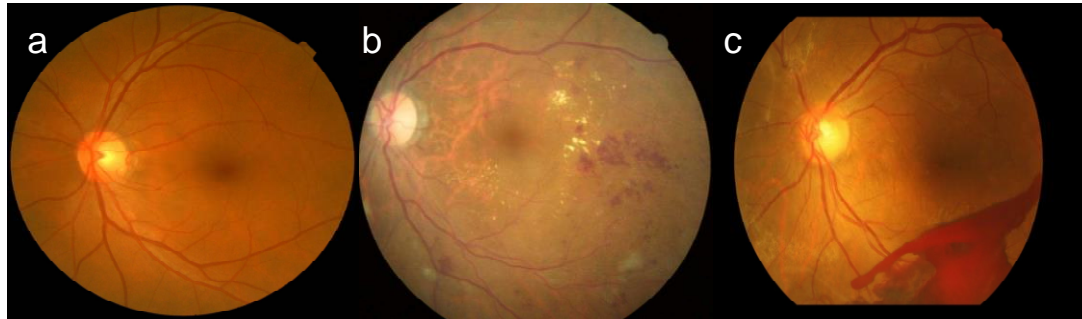

Figure 1. Examples of retinal fundus features of diabetic eye disease, showing (a) normal eyes; (b) moderate non-proliferative diabetic retinopathy with maculopathy; (c) proliferative diabetic retinopathy with pre-retinal haemorrhage.

Hypothesis

- We hypothesize that salient features (eg. haemorrhages, exudates and vascular morphology changes) in retinal fundus images with DED can be exploited in order to better distinguish them from normal eyes.
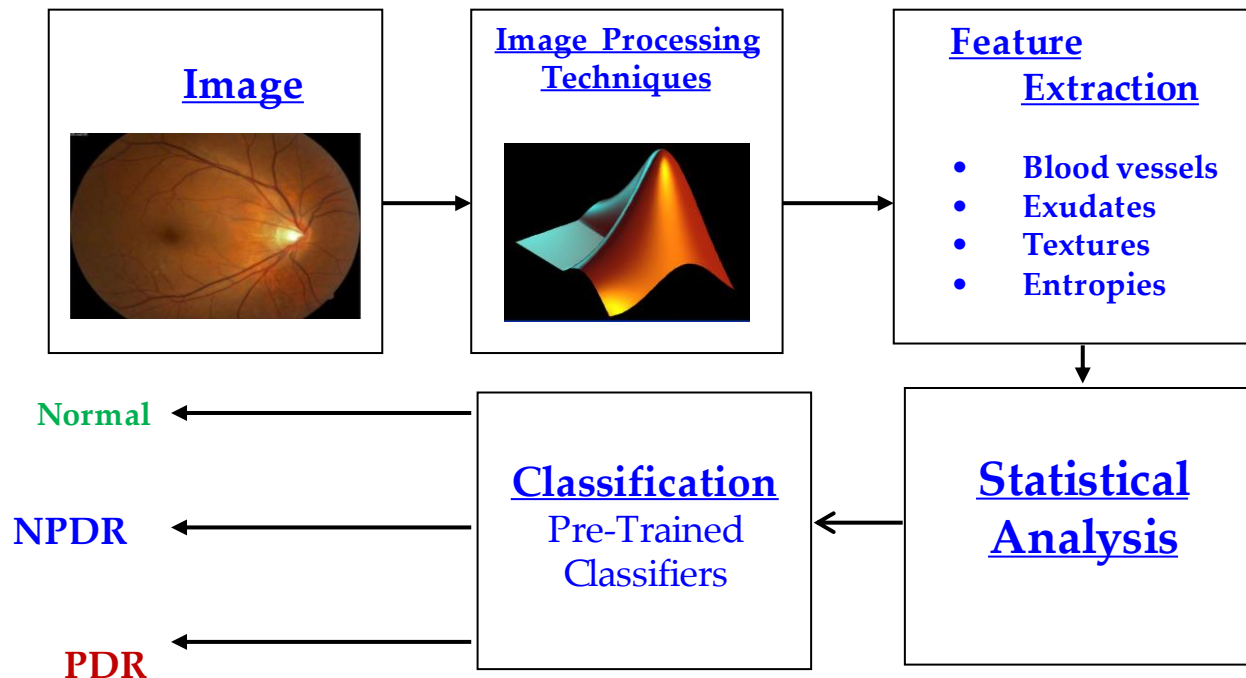
Aims

The overall objectives of the CAMERA project are:

- To establish a better understanding of the impact of diabetic eye disease on retinal fundus features.

- To explore image processing tools to differentiate images of diabetic eye disease.

- To compare the utility of computer-aided tools against human examiners.

- To explore online learning though evolutionary programming to fine-tune and improve performance of tools.

Improvement on current methodology

- **Better Tool:**
  - Average accuracy, sensitivity, and specificity of classification are less than 97%. We set out to try to improve on the performance to better these figures.

- **Bigger image sets:**
  - Many reported software performance were done on limited, small sample sizes. We set out to train and analyse the images on about 10,000 retinal fundus images collected from our electronic diabetic retinopathy screening program.

Improvement on current methodology

- **Novel methodology:**
  - Only conventional features like blood vessels, exudates, microeneurysms and haemorrhages were used in many current software algorithms. We explored how other nonlinear features (like texture) could potentially be exploited to improve the performance of these classifiers.

- **More robust classifier:**
  - More robust classifiers with evolutionary algorithms like genetic algorithms to fine-tune the spread of kernel functions can significantly improve the performance of the computer-aided system.

Improvement on current methodology

- **Single Integrated Index:**
  - To develop one single integrated index (one number) using features that can classify the different classes of DED. This may be used as an adjunct tool by the healthcare professionals to annotate the disease states.

Plan of Action

- <u>Work Package #1 (WP1): Data acquisition</u>

- <u>Work Package #2 (WP2): Software development</u>

- <u>Work Package #3 (WP3): Data analysis and mathematical modeling</u>
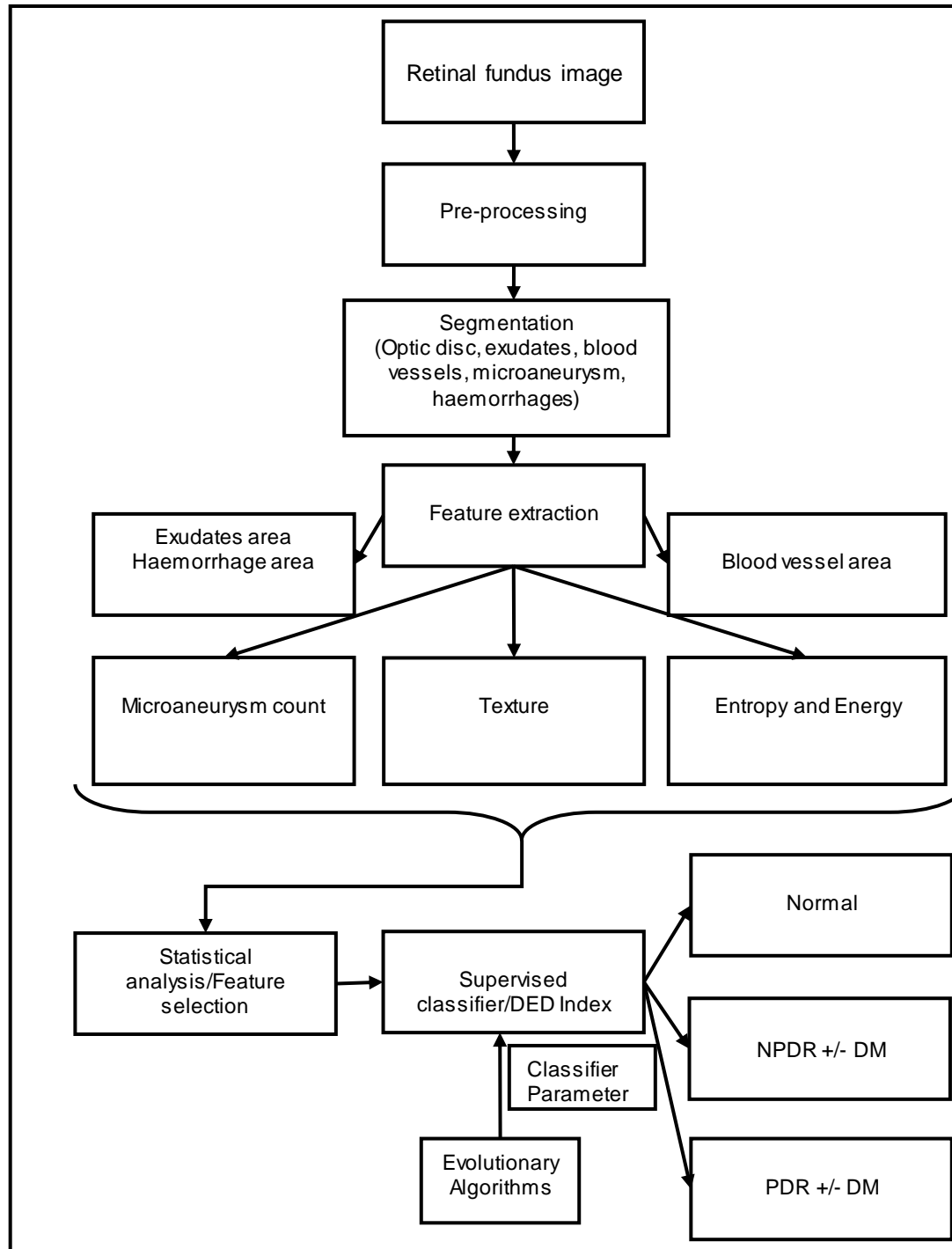
Preliminary data

- We (AL, RA, MK, EN) have developed automated classification system for normal (n=50), NPDR (n=61) and PDR (n=45) retinal images by automatically detecting the blood vessels, hard exudates, texture and entropy features.

- **The results are quite promising and our experimental results yielded an average accuracy of 96.2%, sensitivity of 100%, and specificity of 100%.**
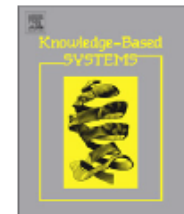
Evolutionary algorithm based classifier parameter tuning for automatic diabetic retinopathy grading: A hybrid feature extraction approach

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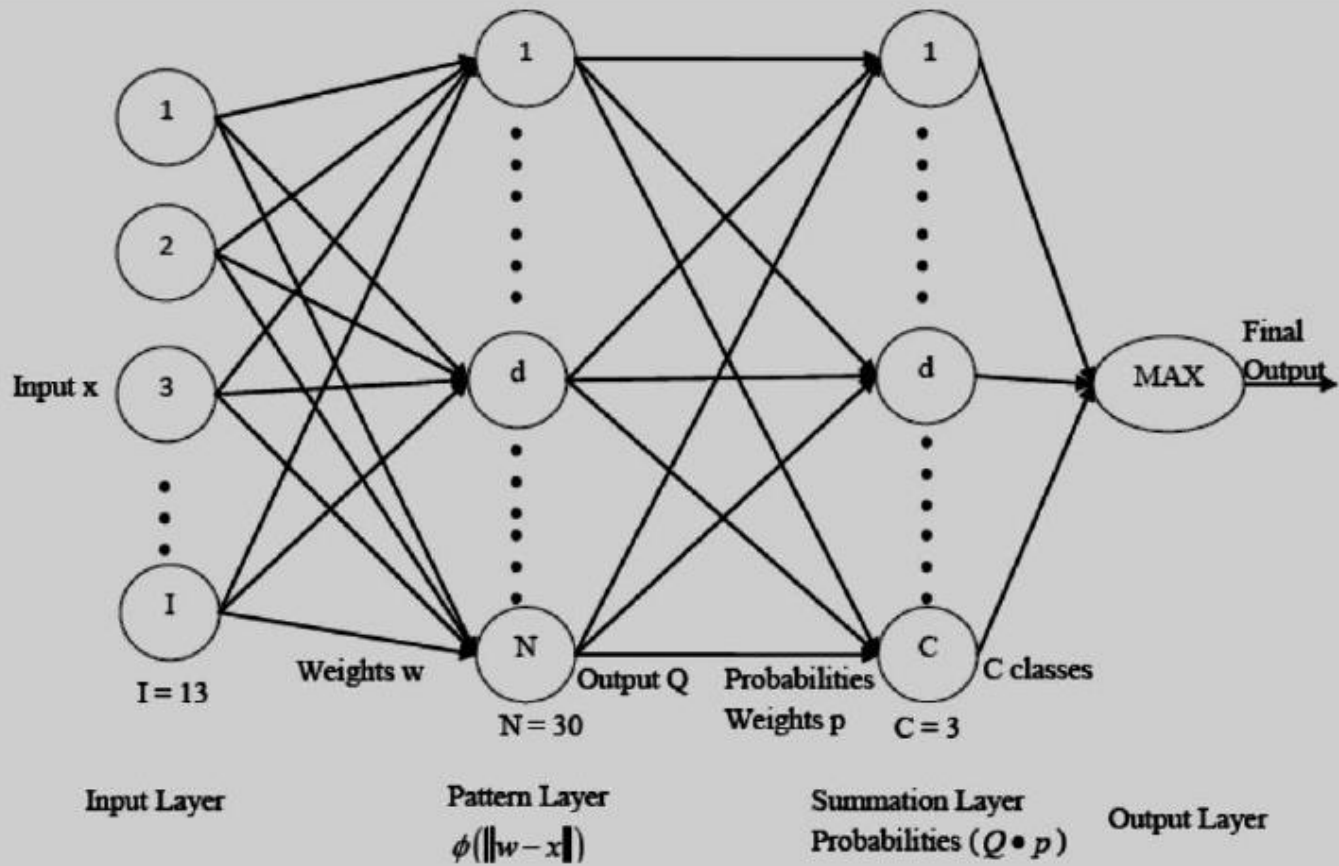
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Features	Normal (Mean ± SD)	NPDR (Mean ± SD)	PDR (Mean ± SD)	p-value
Exudates area	0±0	1015.23±1051.356	3193.867±4903.35	<0.0001
Blood vessel area	37230.56±5171.363	33545.54±5494.929	35726.16±9806.936	<0.0001
Bifurcation point count	305.4±53.2736	309.6557±77.8089	383.5778±132.9623	<0.0001
LTE9	$(3.4\pm4.19)\times10^{10}$	$(7.51\pm1.76)\times10^{09}$	$(6.97\pm3.03)\times10^{09}$	<0.0001
LTE14	$(9.75\pm7.3)\times10^{08}$	$(2.85)\times10^{09}\pm(8.6)\times10^{08}$	$(3.45\pm2)\times10^{09}$	<0.0001
Shannon Entropy	6.352±0.3416	6.0384±0.2625	6.2006±0.3758	<0.0001
Kapur Entropy	7.2509±0.2135	7.0467±0.22	7.1502±0.3298	<0.0001
Renyi Entropy	4.9749±0.4026	4.7231±0.0946	4.704±0.1554	<0.0001
LBP Entropy $_{2,8}$	2.9194±0.0996	2.8896±0.1149	2.8728±0.1157	<0.0001
LBP Entropy $_{2,16}$	3.3873±0.0723	3.3604±0.1178	3.4236±0.0953	<0.0001
LBP Energy $_{2,8}$	0.1538±0.0184	0.1595±0.0195	0.1621±0.0227	<0.0001
LBP Energy $_{2,16}$	0.1514±0.015	0.1544±0.0261	0.142±0.018	<0.0001
LBP Energy $_{2,24}$	0.203±0.0296	0.2016±0.0429	0.1754±0.0334	<0.0001

Input x

I = 13

Weights w

Output Q

N = 30

Probabilities
Weights p

C classes

C = 3

Final
Output

MAX

Input Layer

Pattern Layer
$\phi(\|w - x\|)$

Summation Layer
Probabilities $(Q \bullet p)$

Output Layer

An Integrated Diabetic Retinopathy Index for the Diagnosis of Retinopathy Using Digital Fundus Image Features

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$$DRI = \frac{\beta \times \gamma}{\alpha \times 10^9} \qquad (15)$$

Where $\alpha = LBP_{1,8}Entropy \times LBP_{1,8}Energy \times LBP_{2,16}Entropy \times LBP_{2,16}Energy \times LBP_{3,24}Entropy \times LBP_{3,24}Energy$

$\beta = Shannon\ Entropy \times Yages's\ Measure$
$\gamma = M_1 \times M_2 \times M_3 \times M_4 \times M_5 \times M_6 \times M_7$
10^9 is a constant value.

Table III. Range of diabetic retinopathy index for normal and DR dataset.

Feature	Normal	DR	p-value
DRI	3.27 ± 0.000157	2.94 ± 0.000559	<0.0001

Automated detection of optic disk in retinal fundus images using intuitionistic fuzzy histon segmentation

Muthu Rama Krishnan Mookiah[1], U Rajendra Acharya[1],
Chua Kuang Chua[1], Lim Choo Min[1], EYK Ng[2],
Milind M Mushrif[3] and Augustinus Laude[4]

Abstract

The human eye is one of the most sophisticated organs, with perfectly interrelated retina, pupil, iris cornea, lens, and optic nerve. Automatic retinal image analysis is emerging as an important screening tool for early detection of eye dis-

Application

- How will the results of this study be used?
- The algorithms developed by CAMERA can have a direct and immediate application for population based screening programs (eg. SiDRP).
- Potential for application in other eye disease screening (eg. AMD).

Application to current system

SiDRP / eDRP system

Reading Centre
NHG Eye Institute / TTSH Eye

CAMERA

Human Readers
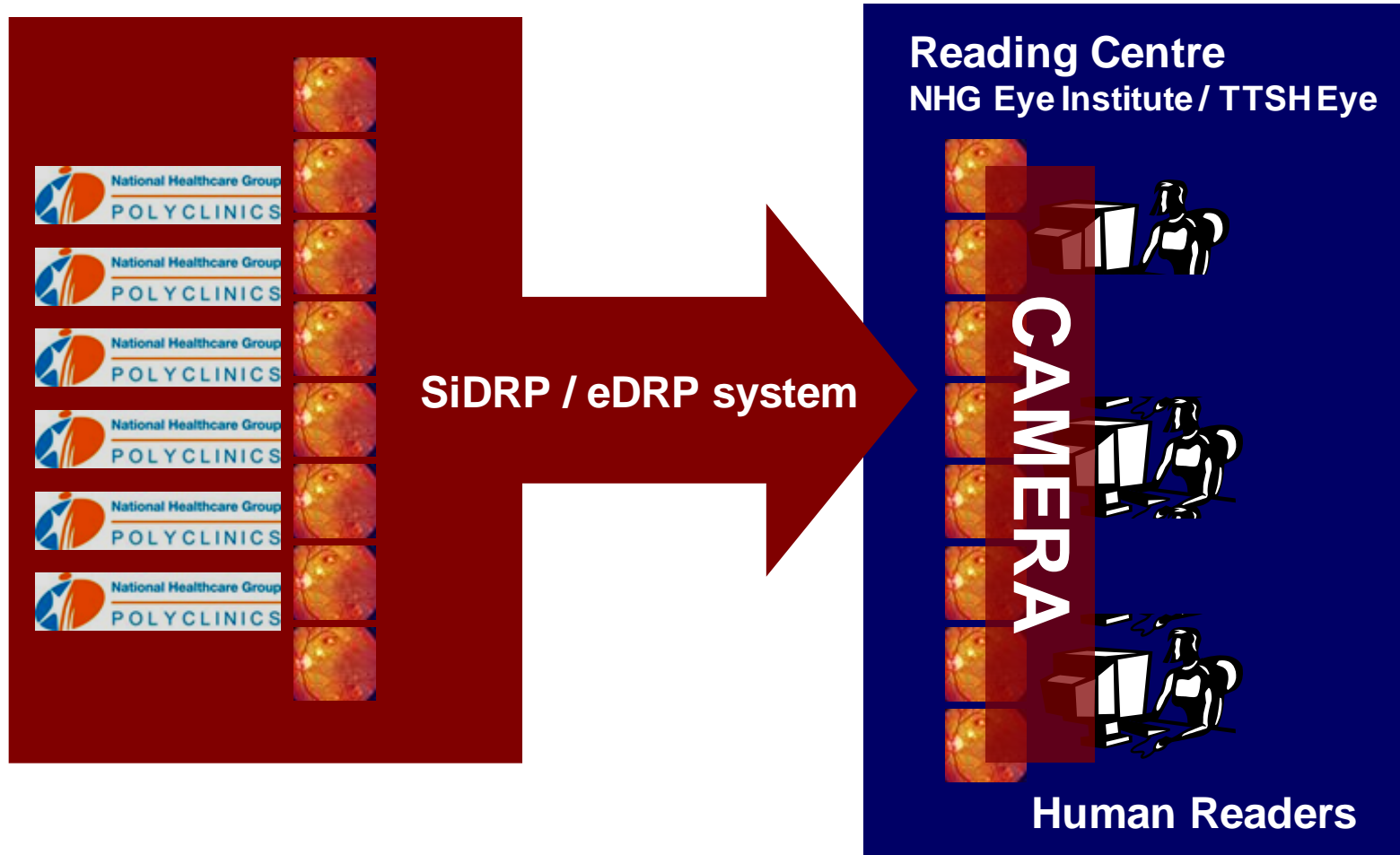
Thank you

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