DISCOVERY INNOVATION & PRACTICE
32ND ASIA-PACIFIC ACADEMY OF OPHTHALMOLOGY CONGRESS
SINGAPORE 2017
ORGANISERS: CO-SPONSOR: SUPPORTED BY: HELD IN:
1-5 MARCH 2017

Poster No.:
EX2-245

The Deep Learning Computer model in reading Diabetic Retinopathy & Normal Images

Authors: Sriram Sonty MD FACS[1,2], Visweswararao Durga MSc MBA[2]
[1] Univ of Illinois @ Chicago, Illinois [2] Midwest Eye Center @ Calumet City, Illinois

Abstract

Purpose: To study a Deep Learning model based computer solution as a supplement to the reading function of the Diabetic Retinopathy fundus images.

Methods: A dataset of 100 fundus images of both normal and Diabetic Retinopathy (from MESSIDOR dataset) have been used to see how well the model performed in a binary classification scenario in comparison to a Retina Specialist, a General Ophthalmologist and the readings provided by the MESSIDOR Group

Results: The Accuracy was '91% (with Group A – Model and MESSIDOR group)', '93% (with Group B – Model and Retina Specialist) and '92% (with Group C – Model and General Ophthalmologist)'; Precision was 94% for Group A, 90% for Group B and 88% for Group C; Sensitivity was 93% for Group A, 100% for Group B and 100 % for Group C; Specificity was 88% for Group A, 83 % for Group B and 80 % for Group C; Kappa Coefficients were 0.79 for Group A, 0.85 for Group B and 0.83 for Group C. Kappa Coefficients were 0.83 between the Retina Specialist and the MESSIDOR Group, 0.81 between the General Ophthalmologist and the MESSIDOR Group and 0.98 between the Retina Specialist and Ophthalmologist.

Conclusion: The Deep Learning Model has compared well in inferring Diabetic Retinopathy by reading the mixed (normal and retinopathy) fundus images with the Retina Specialist, the General Ophthalmologist and with the MESSIDOR Group.

Introduction

The prevalence of type II Diabetes is rapidly increasing resulting in a global public health issue[1] and diabetes has become a premier blinding disease[2]. The prevalence of diabetes was estimated at 285 million or 6.4% of adults in the world in 2010[3]. This prevalence is expected rise to 552 million by 2030[4]. According to a study by the American Diabetes Association (ADA) diabetic retinopathy (DR) has affected more than 4.4 million Americans of age 40 and older during 2005 – 2008, with almost 0.7 million (4.4% of those with diabetes) having advanced DR that could lead to severe vision loss[5] . Early detection and treatment of DR can probably decrease the risk of severe vision loss by over 90%[6]. DR is one of the consequences of diabetes and a leads to 'acquired' blindness. To minimize DR, early detection and intervention are needed. Several attempts have been made to automatically detect DR with mixed results[7] . Computer aided screening systems have recently gained importance for increasing the feasibility of DR screening and several algorithms have been developed for automated detection of lesions such as exudates, hemorrhages (HA) and micro-aneurysms(MA)[8] . In this study a model[9] (applying 'deep learning' techniques) is used and compared its performance with two ophthalmologists (a Retina Specialist and a General Ophthalmologist) and the data provided by the MESSIDOR Group[10].

Purpose

To study the effectiveness of a Deep Learning model computer solution as an automated solution to supplement to the reading function of the Diabetic Retinopathy (DR) using fundus images.

Material & Methods

A dataset of 100 fundus images of both normal and with Diabetic Retinopathy (from MESSIDOR[10] dataset) have been used to see how well the model performed in a binary classification scenario in comparison to a Retina Specialist, a General Ophthalmologist and the readings provided by the MESSIDOR group.

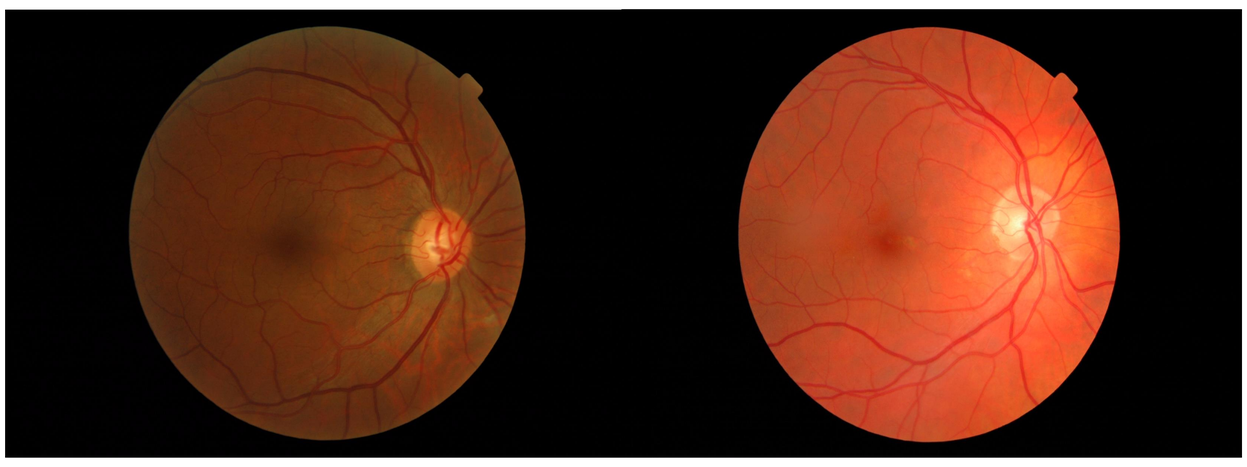

Fig 1: Fundus image of a 'normal' eye

Fig 2: Fundus image of a eye with Diabetic Retinopathy

Results

Overall, with the three Groups (the MESSIDOR Group, the Retina Specialist and the General Ophthalmologist) the Artelus Model showed highly comparable results (Table 1). The Analysis comparison between the Artelus Model and the MESSIDOR Group (Group A), the Artelus Model and Retina Specialist (Group B) and the Artelus Model and General Ophthalmologist (Group C) showed the following results:
Accuracy was 91% for Group A, 93% for Group B , 92% for Group C;
Precision was 94% for Group A, 90% for Group B, and 88% for Group C;
Sensitivity was 93% for Group A, 100 % for Group B, 100 % for Group C;
Specificity was 88 % for Group A, 83 % for Group B, 80 %for Group C; (Fig 3 and 4)
Kappa coefficient and AUROC were 0.79 and 0.89 for Group A, 0,85 and 0.91 for Group B and 0.83 and 90 for Group C. Kappa coefficient and AUROC were computed for MESSIDOR Group and the Retina Specialist to be 0.83 and 0.90, for the MESSIDOR Group and the General Ophthalmologist to be 0.81 and 0.89 and for the Retina Specialist and the General Ophthalmologist to be 0.98 and 0.99 (Figs 5 and 6).

	Messidor n Artelus	RS n Artelus	GO n Artelus	RS n GO	Messidor n RS	Messidor n GO
Accuracy	0.91	0.93	0.92	0.99	0.92	0.91
Sensitivity	0.93	1.00	1.00	0.98	0.88	0.87
Specificity	0.88	0.83	0.80	1.00	1.00	1.00
PPV (Precision)	0.94	0.90	0.88	1.00	1.00	1.00
F1 score	0.93	0.94	0.94	0.99	0.94	0.93
kappa	0.79	0.85	0.83	0.98	0.83	0.81
AUROC	0.89	0.91	0.90	0.99	0.90	0.89

Table 1: Summary of all results

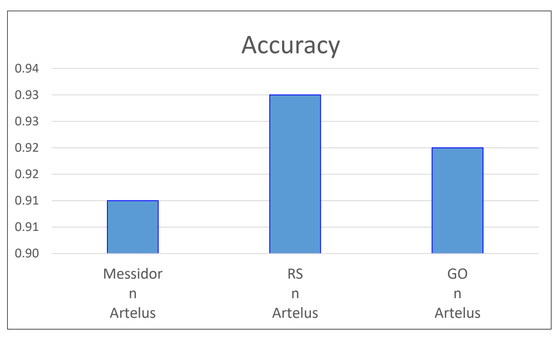

Fig 3: Accuracy

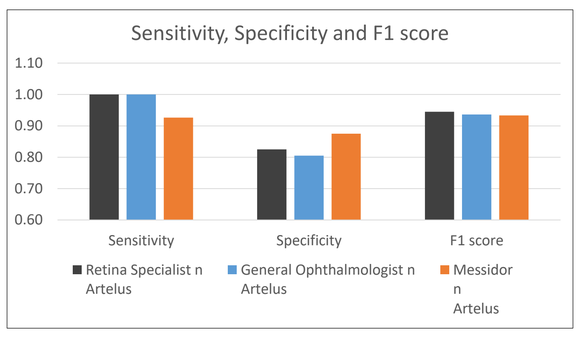

Fig 4: Sensitivity, Specificity and F1 score

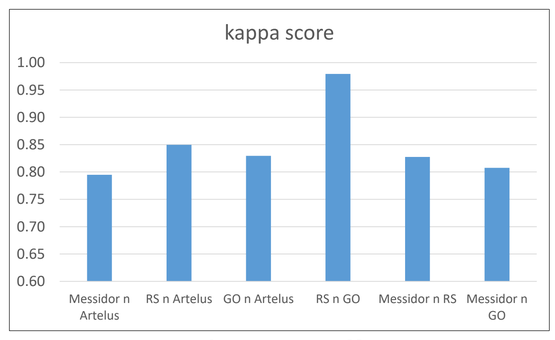

Fig 5: kappa Coefficient

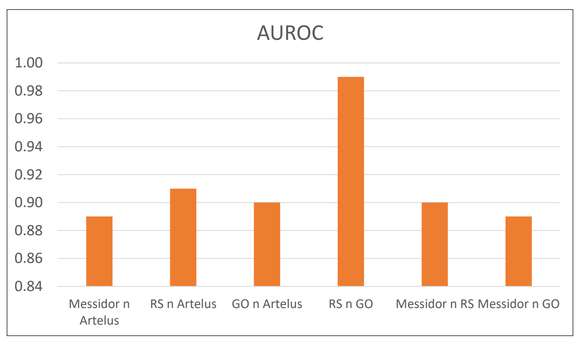

Fig 6: AUROC

Discussion

Diabetic Retinopathy (DR) is a leading cause of vision loss among diabetic patients in developed and developing countries. Early detection of occurrence of DR can greatly help in effective treatment. Since the symptoms of DR do not show up till an advanced stage, regular screening for DR is essential in diabetic patients. Due to lack of enough skilled medical professionals, this task can become tedious as the number of images to be screened becomes high with regular screening of diabetic patients. An automated DR screening system can help in early diagnosis without the need for a large number of medical professionals. To improve detection several pattern recognition techniques are being developed. These include Support Vector Machine (SVM) systems with genetic algorithms (GA) and Deep Learning models made of convolutional neural networks (CNNs) etc. Computer aided screening systems have recently gained importance for increasing the feasibility of DR screening and several algorithms have been developed for automated detection of lesions such as exudates, hemorrhages (HA) and micro-aneurysms(MA)[8].
In this study a model[9] (applying 'deep learning' techniques and convolutional neural networks) developed by **Artificial Learning Systems Inc (Artelus)** was used and its performance, in comparison with two ophthalmologists (a Retina Specialist and a General Ophthalmologist) and the data provided by MESSIDOR Group[10] was studied. The readings of the 'deep learning' based solution, in comparison, with those of the Retina Specialist, the General Ophthalmologist and the MESSIDOR Group are comparable based on the accuracy, precision, sensitivity, specificity and the kappa metrics. Further exploration is suggested to see if the performance of the 'deep learning model' based solution is acceptable. Development of such a solution and embedding the solution as a standalone service (in the Cloud) or embedded in the Fundus Cameras will be of tremendous value and minimize 'acquired blindness' due to diabetes across the Planet.

Conclusions

In this pilot study of ours, the 'Deep Learning Model' based computer solution, developed by Artelus, did identify diabetic retinopathy from fundus images well in comparison to the 'experts' (the Retina Specialist, the General Ophthalmologist and the MESSIDOR Group).

Bibliography

1. Global report on diabetes. 1. Diabetes Mellitus – epidemiology. 2. Diabetes Mellitus – prevention and control. 3. Diabetes, Gestational. 4. Chronic Disease. 5. Public Health. I. World Health Organization. ISBN 978 92 4 156525 7 (NLM classification: WK 810) 2016
2. National Institute of Health: facts about Diabetic Retinopathy disease. National Institute of Health Information, No 03-2171, 2009
3. Shaw JE, Sicree RA and Zimmet PZ : "Global estimates of the prevalence of Diabetes for 2010 and 2030" Diabetic Research and Clinical Practice Vol 87 no.1 pp 4-14, 2010
4 Whiting DR, Guariguata L, Weil C and Shaw J: "IDF Diabetes Atlas : Global estimates of the prevalence of Diabetes for 2011 and 2030." Diabetic Research and Clinical Practice Vol 94 no.3 pp. 311-321, 2011.
5. American Diabetic Association, (2011, Jan 26). Data from the 2011 national diabetes fact sheet(on line) Available : http://www.diabetes.org/diabetes -basics/diabetes-statistics
6. Garg S and Davis RM. "Diabetic retinopathy screening update." Clin. Diabetes. Vol 27, no.4, pp.140-145,2009.
7. Choi SB, Kim WJ, Yoo TK, Park JS, Chung JW, Lee YH, Kang ES Screening for prediabetes using machine learning models. Comput Math Methods Med. 2014;2014:618976. doi: 10.1155/2014/618976. Epub 2014 Jul 16
8. Roychowdhury S, Koozekanai DD and Parthi KK : DREAM : Diabetic Retinopathy Analysis Using Machine Learning: IEEE Journal of Biomedical & Health Informatics Vol.18, No.5, pp. 1717-1728 (2014)
9. **Called 'Susrutha' developed by Artificial Learning Systems Inc (Artelus)**
10. Images are from the MESSIDOR project, a research Program that was a part of the French Ministry of Research and Defence's 2004 Techno-Vision (referred to, in this paper, as MESSIDOR Group). For details, please see http://messidor.crihan.fr