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Title :The Deep Learning Model based Computer solution in reading Diabetic Retinopathy & Normal Images

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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 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 (MOP) and a General Ophthalmologist (SS)) and the data provided by the MESSIDOR Group[10].

Purpose

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

Material & Methods

A dataset of 100 fundus images of both normal and Diabetic Retinopathy (from MESSIDOR dataset[10]) 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 shows an example of the fundus image of a 'normal' eye.

Fig 2 shows an example of the fundus image of an eye with Diabetic Retinopathy.

FIG 1: a Normal eye

FIG 2: an eye with Diabetic Retinopathy

Results

Results: Overall, among the three Groups (the MESSIDOR Group, the Retina Specialist and the General Ophthalmologist) and the Model showed highly comparable results (Table 1).
The Analysis comparison between the Model and the MESSIDOR Group (Group A), the Model and Retina Specialist (Group B) and the Model and General Ophthalmologist (Group C) are:
• Accuracy was 91% for Group A, 92% for Group B , 86% for Group C
• Precision was 92.75% for Group A, 95.65% for Group B, and 85.5% for Group C (Fig 3 and Table 2)
• Sensitivity was 94% for Group A, 92.9% for Group B, 93.6% for Groups C; Specificity was 84.3% for Group A, 89.6% for Group B, 72.9%for Group C (Fig 4 and Table 3)
• Kappa coefficients were 0.79 for Group A, 0.80 for Group B and 0.69 for Group C. It was 0.69 between the Retina Specialist and the MESSIDOR Group and 0.62 between the General Ophthalmologist and the MESSIDOR Group (Fig 5 and Table 4)

	Model and MESSIDOR	Model and Retina Specialist	Model and General Ophthalmologist	MESSIDOR and Retina Specialist	MESSIDOR and General Ophthalmologist
Accuracy	[illegible]	[illegible]	[illegible]	87.00%	[illegible]
Precision	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Sensitivity	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Specificity	84.30%	89.60%	72.90%	77.00%	70.30%
kappa	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Table 1: Overall Comparison Analysis

	Model and MESSIDOR	Model and Retina Specialist	Model and General Ophthalmologist
Accuracy	91.00%	92.00%	86.00%
Precision	92.75%	95.65%	85.50%

Table 2: Accuracy and Precision Comparison

	Model and MESSIDOR	Model and Retina Specialist	Model and General Ophthalmologist
Sensitivity	94.11%	92.95%	93.60%
Specificity	84.30%	89.60%	72.90%

Table 3: Sensitivity and Specificity Comparison

	Model and MESSIDOR	Model and Retina Specialist	Model and General Ophthalmologist	MESSIDOR and Retina Specialist	MESSIDOR and General Ophthalmologist
kappa	0.79	0.80	0.69	0.69	0.62

Table 4: kappa Coefficient

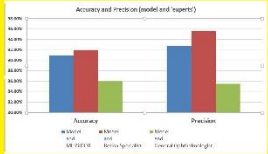

Figure 3 Accuracy and Precision

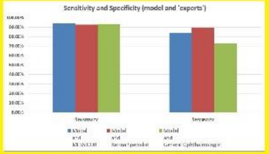

Figure 4 Sensitivity and Specificity

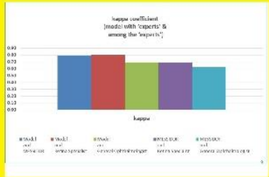

Fig 5: kappa Coefficient

Conclusion

In this pilot study of ours, the 'Deep Learning Model' based computer solution, developed by Artificial Learning Systems (ARTELUS), did identify Diabetic Retinopathy from fundus images well in comparison to the 'experts' (the Retina Specialist, the General Ophthalmologist and the MESSIDOR Group). This study showed comparably high rates of agreement with the MESSIDOR Group and the Retina Specialist. The Accuracy and Precision match well with our Retina Specialist and the MESSIDOR Group. The Specificity and Sensitivity were also closely comparable with the Retinal Specialist and the MESSIDOR Group.

Performance of the 'model' needs to be further explored and may be used as a part of an automated solution to identify Diabetic Retinopathy in a screening context. Development of such a solution and making it available as a standalone service (in the Cloud) or having it embedded in the Fundus Cameras will be of tremendous value and minimize 'acquired blindness' due to diabetes across the Planet.

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 SB1, Kim WJ2, Yoo TK3, Park JS3, Chung JW4, Lee YH5, 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