Automatic detection of diabetic retinopathy and its progression in sequential fundus images of patients with diabetes

Alexander Dietzel[1], Carolin Schanner[2], Aura Falck[2,3], Nina Hautala[2,3]

[1]Institute of Biomedical Engineering and Informatics, Technische Universität Ilmenau, Ilmenau, Germany

[2]Department of Ophthalmology, PEDEGO Research Unit, University of Oulu, Oulu, Finland

[3]Department of Ophthalmology, Oulu University Hospital, Oulu, Finland

Corresponding author:

Professor Nina Hautala

Department of Ophthalmology

University of Oulu, Oulu University Hospital and MRC Oulu

P.O.Box 21, 90029 OYS

Finland

tel. +358-8-315 3726

e-mail: nina.hautala@oulu.fi, nina.hautala@ppshp.fi

Editor,

Regular screening by fundus images is known to be effective in detecting the early signs of diabetic retinopathy (DR). Early detection and timely treatment of DR are crucial to prevent the development of sight-threatening DR and visual loss (Hautala et al. 2014). Due to global increase in the prevalence of diabetes from the current 425 million to 629 million in 2045, also the number of people with DR are estimated to triple from 2005 to 2050 (diabetesatlas.org 2018, Shah & Gardner 2016). Thus, the workload required for screening for DR will increase tremendously. Novel technological solutions and interventions might fortunately ease this challenging task in the future (Valverde C et al. 2016). We have developed an algorithm to detect early DR and its progression in the chronological follow-up fundus images in order to minimize the time consuming evaluation of the images by a trained nurse or an ophthalmologist.

Digital fundus images of 12 patients (4 female, 8 male) with either type 1 (n=10) or type 2 (n=2) diabetes were retrospectively selected from the electronic patient database of the Department of Ophthalmology in

Oulu University Hospital. Digital images were taken by Canon CF-60DSi or 6DSE fundus camera and the images were saved using DICOM standards. Red free fundus images of each eye were clinically graded for DR by an ophthalmologist, and the eyes with progression of DR were included. A 5-scale classification of DR according to Finnish Current Care Guideline for Diabetic retinopathy was used: no DR, mild non-proliferative DR, moderate non-proliferative DR, severe non-proliferative DR or proliferative DR (Summanen P et al. 2015). There were 5 cases presenting all stages of DR transition, e.g. from no DR into mild non-proliferative DR, and cases with less advancement of DR. A total of 158 grayscale fundus images of 24 eyes were included. The mean age of the patients at time of the first examination was 34±15 years, and 43±13 years at the latest examination. The number of examinations varied between 4 and 9 per eye.

For each eye, the progression map of all possible combinations of two individual fundus images were calculated (Fig. 1). First, the two images were roughly registered with help of a similarity transformation. A finer registration was implemented patchwise together with the adjustment of the contrast between them as a second step. The next step consisted of the calculation of the progression map between the two images (images E, F and G in Fig. 1). The remaining noise from the background was filtered by considering the local noise level from the two source images. The classification about a transition was based on several image analysis features.

The transition between the different grades of DR was correctly detected (true positive) in 91% of the instances, and the absence of transition (true negative) in 94%. In 6% of the cases the algorithm signaled progression without clinically detectable change of DR grade (false positive), and in 9% (false negative) the algorithm was not able to detect clinically detected progression of DR.

The results demonstrate that the algorithm developed for the detection of progression of DR in fundus images does reliably highlight changes between the images. However, evaluating the sensitivity and specificity of the current algorithm in larger set of fundus images including various stages of DR is needed. Further potential improvements can be done by detection, differentiation and highlighting clinically relevant lesions. Whether proven to be proficient, the current solution may have the potential to reduce the time, resources and costs required for the evaluation of fundus images in enormously increasing population with diabetes.

References

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Figure legend

Fig. 1. Progression maps for registered pairs of images without (E) and with transition (F, G) between stages. Each follow up image (B, C, D) is registered to the baseline image (A). All original fundus images are shown in comparable scales independent from field of view.