Synthetic Stereo Images of the Optic Disc from the CORD Dataset

Ian Coghill, *Student Member*, *IEEE-EMBS*, Kirsty C. Jordan, Matteo Menolotto, Richard A. Black, Iain A.T. Livingstone and Mario E. Giardini, *Member*, *IEEE-EMBS*

***Abstract*— Advancement of techniques for 3D reconstruction of the optic disc could lead to affordable objective detection of glaucoma. Applying computer stereo vision techniques to image pairs is particularly promising. More data, along with the stereo camera calibration parameters and ground truths required for validation, could aid development. This work presents a method to generate, using a virtual environment, synthetic stereo images of optic discs from images in the CORD database and obtain the corresponding stereo camera calibration parameters and ground truths. Our own reconstruction technique was tested using data created using this environment and quantitatively validated.**

I. Introduction

Vision loss attributed to glaucoma is the second leading cause of blindness worldwide [1]. Early detection relies mainly on identifying structural change of the optic disc, as it often precedes detectable vision loss. In practice, clinicians most often identify such change by subjectively examining stereoscopic optic disc images [2]. 3D imaging devices which can make an objective assessment, based on acquired 3D images, with higher diagnostic accuracy than general ophthalmologists [3], are prohibitively expensive for community/primary care services. A number of researchers have therefore been working on a potentially more cost-effective solution: 3D stereo reconstruction of the optic disc from stereo images [4]. The amount of data publicly available to develop reconstruction techniques, however, is scarce. Moreover, to our knowledge, no dataset contains stereo optic disc images together with the stereo camera calibration parameters and ground truths required for solid validation. Thus, this work presents a method to generate synthetic stereo images of optic discs using a virtual environment, where the corresponding stereo camera calibration parameters and ground truths are determinable. Our own reconstruction technique was tested using data created using this environment and quantitatively validated.

II. Methods

Synthetic optic disc stereo images (Fig.1) were generated by texturing a glaucomatous optic disc like 3D model (Fig.1) with a fundus image (cropped such that only the disc region remained) from the CORD dataset [5] (Fig.1) in the CAD software Rhinoceros 6 (McNeel Europe, Barcelona, Spain) and capturing images from viewpoint (or virtual camera) positions which were separated by a small distance. To obtain the calibration parameters of the virtual stereo camera, the Camera Calibration Toolbox for MATLAB® [6] was utilized on 36 stereo image pairs of a flat checkerboard held in various random orientations and positions in the field of view of both virtual cameras, constructed in Rhinoceros 6 by texturing a flat rectangular surface with a checkerboard pattern. Our own reconstruction technique was tested using this virtual environment and the rms error against the corresponding ground truth was determined.

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I. Coghill, K. C. Jordan, M. Menolotto, R. A. Black and M.E. Giardini are with the Department of Biomedical Engineering, University of Strathclyde, Glasgow G1 1XQ, UK (e-mail: ian.coghill@strath.ac.uk).

I. A.T. Livingstone is with NHS Forth Valley, Falkirk Community Hospital, Falkirk FK1 5QE, UK (email: iain.livingstone@nhs.net).

III. Results

Example synthetic stereo images are provided (Fig.1). The textured 3D reconstruction obtained using our technique in the virtual environment is provided (Fig.1) and the rms error against its ground truth was successfully determined.

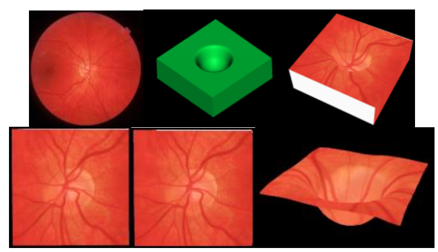

Figure 1. Top (left to right): CORD dataset image, glaucomatous like optic disc 3D model and textured 3D model. Bottom (left to right): Example right and left synthetic stereo images and textured 3D reconstruction obtained using our technique in the virtual environment.

IV. Discussion & Conclusion

The method, using the virtual environment, can be used to aid development of various computer stereo vision techniques for 3D reconstruction of the optic disc, potentially leading to more rapid development of a low-cost objective glaucoma detection solution.

References

[1] S. Kingman, "Glaucoma is second leading cause of blindness globally.," *Bull. World Health Organ.*, vol. 82, no. 11, pp. 887–888, Nov. 2004.

[2] J. A. Giaconi, S. K. Law, K. Nouri-Mahdavi, A. L. Coleman, and J. Caprioli, *Pearls of Glaucoma Management*. Springer, 2016.

[3] R. M. Vessani, R. Moritz, L. Batis, R. B. Zagui, S. Bernardoni, and R. Susanna, "Comparison of quantitative imaging devices and subjective optic nerve head assessment by general ophthalmologists to differentiate normal from glaucomatous eyes," *J. Glaucoma*, vol. 18, no. 3, pp. 253–261, Mar. 2009.

[4] M. Bansal, M. Sizintsev, J. Eledath, H. Sawhney, D. J. Pearson, and R. A. Stone, "3D optic disc reconstruction via a global fundus stereo algorithm," *Conf. Proc. Annu. Int. Conf. IEEE Eng. Med. Biol. Soc. IEEE Eng. Med. Biol. Soc. Annu. Conf.*, vol. 2013, pp. 5877–5882, 2013.

[5] *Comprehensive Ophthalmic Research database - CORD*. https://cord.bioe.strath.ac.uk last visited on 17 April 2019, DOI 10.15129/39bcd12d-0677-4cf3-a099-b763fbb7d3c4.

[6] J.-Y. Bouguet, *Camera Calibration Toolbox for Matlab®*. 2018.