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ABSTRACT

Simultaneous stereoscopic fundus photography is an important tool for classification and follow-up of glaucomatous optic neuropathy. The use of conventional film-based simultaneous stereoscopic fundus cameras is complicated and time-consuming due to film processing and sensitivity of its mechanical components. Digital simultaneous stereoscopic fundus cameras are not available in Germany, since the existing ones are lacking the EC-certificate. We realised a digital simultaneous stereophotographic fundus camera by replacing the conventional film-based analogue camera of the simultaneous stereoscopic fundus camera TOPCON TRC-SS (TOPCON CORPORATION, Tokyo, Japan) by the digital 21.10 megapixel, 36 x 24 mm *full frame* CMOS camera CANON EOS 5D, Mark II (CANON INC., Tokyo, Japan).

BACKGROUND

In clinical ophthalmology morphological findings are crucial for diagnostics, as well as follow up or accessing therapeutic success. Of particular importance is a stereoscopic view of the posterior eye segment structures such as the retinal morphology, the optic nerve head, or the retinal vessels. A monocular estimation is not appropriate for a three dimensional estimation.[1]. A stereo image is regarded the standard for assessing optic disc damage in glaucoma.[2,3]. The three dimensional morphologic finding can be accessed by the examiner with the help of binocular indirect ophthalmoscopy and the slit lamp; however, documentation for classification and follow-up purposes requires a stereoscopic picture. An exact and reproducible three dimensional documentation is necessary for clinical routine follow up as well as for a documentation in clinical studies.[4-6]. To our knowledge, a simultaneous stereoscopic fundus camera capable of digital imaging, such as NIDEK 3-Dx (NIDEK Co., Ltd., Hiroishi, Japan) is not approved in Germany due to lacking CE-certification. According to the outing of the distributors of the OCULUS Company (OCULUS, Wetzlar, Germany) the light emission of this camera is assumed to be too high, interfering thus with the certificate. Sequential stereoscopic imaging by shifting the monocular fundus camera has proven to be insufficient due to inappropriate standardization.[7,8]. The aim of this paper is to demonstrate a solution for upgrading a conventional film-based simultaneous stereoscopic camera into digital equipment.

METHODS

The conventional simultaneous stereo fundus camera TOPCON TRC-SS (TOPCON CORPORATION, Tokyo, Japan) has been transformed into a digital camera by replacing the original camera body by a digital camera (CANON EOS 5D, Mark II, CANON INC., Tokyo, Japan), as depicted in Fig. 1. The 21.10 megapixel full frame CMOS (complementary metal oxide semiconductor) sensor camera is capable of capturing both stereo-images simultaneously. The connection of the digital camera was provided by a specifically constructed adapter connecting the conventional fundus camera and the digital full format camera.

RESULTS AND DISCUSSION

To our knowledge, this is the first time that a conventional analogue simultaneous stereoscopic fundus camera has been transformed into a digital system, which is compatible with the CE prescription and can be integrated into an electronic patient data record system.

Stereoscopic fundus photography is an optimal documentation of the morphology of the posterior eye segment in follow up of glaucoma or macular diseases.[4-6,9,10]. Such findings can be collected and viewed by stereo viewers such as the screen-VU Stereoscope (Heidelberg Engineering, Inc., Heidelberg, Germany). The result of conventional stereoscopic photography approaches are classical photo slides. This approach is, although the picture quality is mostly excellent, time-consuming, since the photography film must be used up completely before development, which is usually performed externally in case of colour slides. As a consequence, an immediate observation and judgement of the photographic output is impossible. Moreover, the storage and retrieval of photographic slides is a considerable economical and spatial burden. Switching to digital photography allows circumventing the above mentioned shortcomings and is extremely attractive for the increasing number of clinics working with digital patient records as is the case of the Department and Institute for Ophthalmology, University of Tuebingen. For gaining electronic data, the classical analogue stereoscopic slides can be digitalized ex post. However, this is a considerable economical and time effort that is, unfortunately, associated with an inevitable quality loss. Therefore, an optimal solution, direct stereoscopic digital fundus photography should be obtained.

A simultaneous stereoscopic fundus camera with the possibility of digital imaging, such as NIDEK 3-Dx (NIDEK Co., Ltd., Hiroishi, Japan) has not been approved in Germany so far. The reason for this is the lacking CE-certification, since the light emission of this camera is assumed to be too high, based on the information of the distributors of the OCULUS Company (OCULUS, Wetzlar, Germany). Alternatively, pseudo-stereoscopic images with a standard digital fundus camera can be obtained. In this case, two non-stereoscopic pictures are taken subsequently from two different angles mimicking thus a stereo view. Unfortunately, a pseudo-stereoscopic picture is not an optimal solution for a lack of reproducibility as the amount of shift is depending on the (varying) pupil diameter and on the subjective approach of the

photographer. For example, an inconsistency of the camera angle can lead to false positive or false negative judgment with regard to progression in glaucoma.[8,11]. Therefore, the ideal method for stereoscopic documentation is *simultaneous* stereophotography, whereas pseudo-stereoscopic techniques are less frequently used nowadays.

Recent follow-up imaging techniques such as the Heidelberg Retina Tomograph (HRT, Heidelberg Engineering, Inc., Heidelberg, Germany) have shown to be comparably accurate for diagnosing the optic nerve head damage.[2], however, in estimating glaucoma progression criteria such as haemorrhages or disc pallor cannot it is inferior to stereophotography. So far, a good stereophotography of the optic nerve head remains the best method for the morphological evaluation in glaucoma.
Examples of a stereoscopic optic disc finding documentation are shown in Fig. 2 and Fig. 3. For viewing a classical stereo-viewer or software for quantitative analysis can be applied.

Since analogue simultaneous stereoscopic fundus cameras such as TOPCON TRC-SS were broadly used in the earlier decades and may be part of the equipment of many ophthalmologic departments and clinics, we present a simple and a low-cost solution for converting this high-quality documentation system into a digital one in order to document the stereoscopic image. An important aspect is that the attached digital camera must have a full frame sensor (36 x 24 mm) in order to capture the full image produced by the conventional TOPCON fundus camera, which would not be possible with cameras with smaller sensors.

CONCLUSIONS

As a conclusion, by transferring a conventional photo-based simultaneous stereoscopic camera into a digital unit we were able to realize a solution for 3D morphological documentation in ophthalmology without the disadvantages of the analogue stereoscopic photography (financial and time effort as well as spacy storage, retrieval requirements and non-suitability for direct transfer into electronic records) as well as those of the pseudo-stereophotography (lack of reproducibility).

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COMPETING INTERESTS

None

REFERENCES

1 Martinello M, Favaro P, Muyo Nieto GD, et al. 3-D retinal surface inference: stereo or monocular fundus camera? *Conf Proc IEEE Eng Med Biol Soc* 2007;2007:896-9.

2 Pablo LE, Ferreras A, Fogagnolo P, et al. Optic nerve head changes in early glaucoma: a comparison between stereophotography and Heidelberg retina tomography. *Eye (Lond)* 2010;24:123-30.

3 Hoffmann EM. [Optic disc photography and retinal nerve fiber layer photography]. *Ophthalmologe* 2009;106:683-6.

4 Budenz DL, Anderson DR, Feuer WJ, et al. Detection and prognostic significance of optic disc hemorrhages during the Ocular Hypertension Treatment Study. *Ophthalmology* 2006;113:2137-43.

5 Miglior S, Zeyen T, Pfeiffer N, et al. Results of the European Glaucoma Prevention Study. *Ophthalmology* 2005;112:366-75.

6 Gaasterland DE, Blackwell B, Dally LG, et al. The Advanced Glaucoma Intervention Study (AGIS): 10. Variability among academic glaucoma subspecialists in assessing optic disc notching. *Trans Am Ophthalmol Soc* 2001;99:177-84.

7 Krohn MA, Keltner JL, Johnson CA. Comparison of photographic techniques and films used in stereophotogrammetry of the optic disk. *Am J Ophthalmol* 1979;88:859-63.

8 Chang RT, Budenz DL. Diagnosing glaucoma progression. *Int Ophthalmol Clin* 2008;48:13-28.

9 Sallo FB, Peto T, Leung I, et al. The International Classification system and the progression of age-related macular degeneration. *Curr Eye Res* 2009;34:238-40.

10 Davis MD, Gangnon RE, Lee LY, et al. The Age-Related Eye Disease Study severity scale for age-related macular degeneration: AREDS Report No. 17. *Arch Ophthalmol* 2005;123:1484-98.

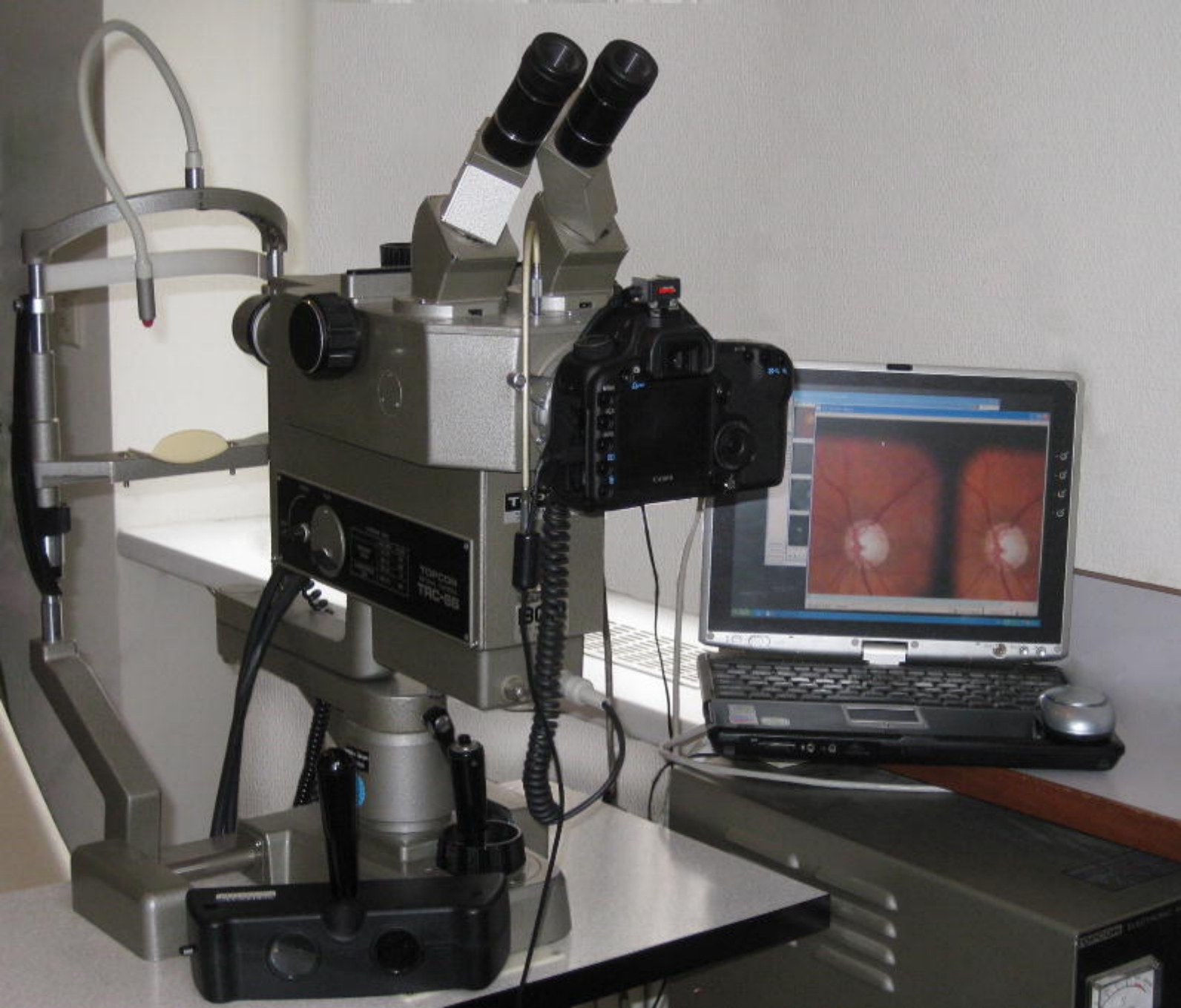
11 Knudsen LL, Skriver K. A 3-dimensional evaluation of the macular region: comparing digitized and film-based media with a clinical evaluation. *Acta Ophthalmol Scand* 2006;84:296-300.

FIGURE LEGENDS

Fig. 1: The analogue simultaneous stereo fundus camera TOPCON TRC-SS has been transformed into a digital system by adding the digital camera CANON EOS 5D, Mark II (21.10 megapixel, 36 x 24 mm full frame CMOS sensor).

Fig. 2: A simultaneous digital stereoscopic picture of an optic nerve head obtained with the introduced digital simultaneous stereophotography fundus camera. The pictures can be viewed directly on the computer screen by means of a stereo viewer (e.g. Screen-VU Stereoscope, Heidelberg Engineering, Inc., Heidelberg, Germany). Normal optic disc.

Fig. 3: A simultaneous digital stereoscopic picture of an optic nerve head obtained with the introduced digital simultaneous stereophotography fundus camera. The pictures can be viewed directly on the computer screen by means of a stereo viewer (e.g. Screen-VU Stereoscope, Heidelberg Engineering, Inc., Heidelberg, Germany). Glaucomatous optic disc.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