

GlauCAD – Glaucoma Prevention by Computer Aided Diagnostics

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Introduction

In Germany, more than 500,000 people suffer from the glaucoma disease. There are several types of this illness. In most cases the disease occurs together with a constantly increased intraocular pressure. This might finally lead to the destruction of the blood vessels and nerves of the retina. An increased intraocular pressure, however, is not necessarily the case and consequently, the examination of the intraocular pressure is not sufficient for diagnosis. Latest approaches try to draw conclusions directly from the 3D-geometry of the ocular fundus in order to find significant geometric characteristics which refer to the disease. Precondition for this attempt is the ability to precisely and robustly reconstruct the ocular fundus.

The database in this project comprises more than 15,000 stereo slides. Along with the basic requirements in the field of computer vision, this fact leads to even stronger demands concerning the

reconstruction module. First of all, the whole process has to be fully automatic. Only then such a huge number of pictures can be handled. Secondly, each process step must include an evaluation of its correctness. Due to algorithmic and numerical restrictions the calculation can fail in most process steps. If the system recognizes algorithmic problems (e.g. based on poor geometric conditions) or numerical problems, an estimation of the usability of the result has to be carried out. Thirdly, the algorithms have to be optimized in terms of performance.

Technical Aspects

The basis of reconstruction are stereoscopic image pairs of the ocular fundus. They were taken by moving the camera into two different positions. There is no further information about the camera, neither about its exact positions nor its orientation. Also, the internal camera parameters, like the foci, are unknown. All this information must be extracted out of the raw image pair.

The reconstruction process involves several steps (cf. figure 1):

- *Masking of the single images*
Irrelevant parts of the image that would disturb the computation (e.g. patient information) are masked out.
- *Registration of the image pair*
To facilitate the further reconstruction process, the two images are registered. In a first step, the significant contours of the images (predominantly blood vessels) are extracted. Using a Chamfer-Matching algorithm, the images are registered by minimizing the distance between the two contours (cf. figure 2).

German Abstract

Das EU-Projekt GlauCAD untersucht die Erkrankung des Glaucoms (Grüner Star) hinsichtlich möglicher geometrischer Beschreibungsformen.

Ziel ist die Entwicklung eines Softwarepaketes zur Auswertung einer medizinischen Datenbank von ca. 15,000 unkalibrierten Stereobildpaaren des Augenhintergrundes. Diese enthält den Krankheitsverlauf von Glaukompatienten über mehrere Jahre. Die Aufgabe des IGD innerhalb dieses Projektes ist die Erstellung eines Moduls zur vollautomatischen Berechnung der 3D-Geometrie des Augenhintergrundes aus den unkalibrierten Stereobildpaaren.

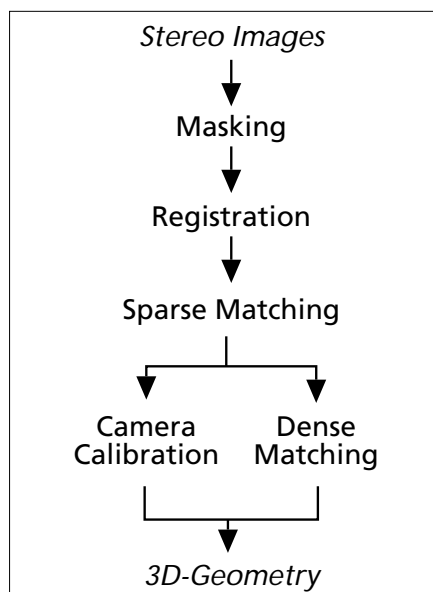


Figure 1: Reconstruction process

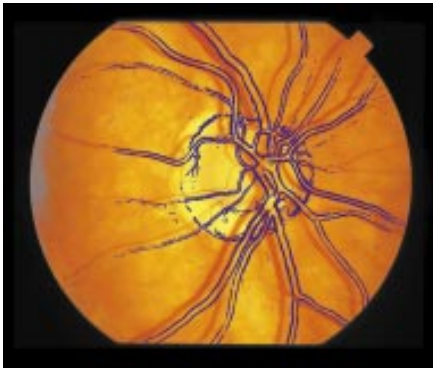


Figure 2: Projection of the contours of one image into the other image

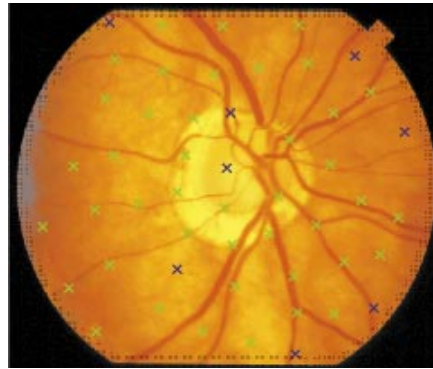
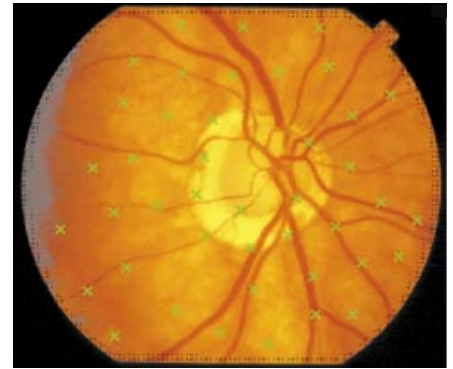


Figure 3: Corresponding feature points



- *Sparse Matching*
Here some initial point correspondences are calculated. In a first step, a certain number of special feature points in one of the images is detected. Subsequently, the corresponding points in the second image are obtained by minimizing the difference of gray values in a correlation window (cf. figure 3).
- *Camera Calibration*
Using the point correspondences obtained in the previous step, the Fundamental-Matrix can be calculated. This matrix characterizes the correlation of two projective mappings of an object. With this matrix, the internal and afterwards the

external camera parameters can be calculated. When extracting the Fundamental-Matrix, the geometric situation must be recognized (e.g. coplanar point sets) and the calculation has to be adapted.

- *Dense Matching*
Here the objective is to find as many point correspondences as possible. Therefore a template window of one of the images is guided along the epipolar line of the corresponding second image. The epipolar line in the corresponding image is the mapping of the line through the object point and the projection center of the first camera. Using specific

constraints (e.g. the neighborhood) the number of correct matches can be improved. The result is a disparity map that encodes the distance of corresponding points (cf. figure 4).

- *Calculation of the 3D-Geometry*
Using the disparity map and the camera parameters, a depth map can be created. For visualization of the depth information, it is triangulated and textured.

Conclusion and Outlook

We presented a way to reconstruct the 3D-geometry of an object by using two standard images only. When compared to active systems like laser scanners, this technique seems advantageous since no additional hardware is needed to obtain 3D-reconstructions. Future emphasis of our work will be the increase of robustness and calculating speed and the verification of computational accuracy.

Points of contact

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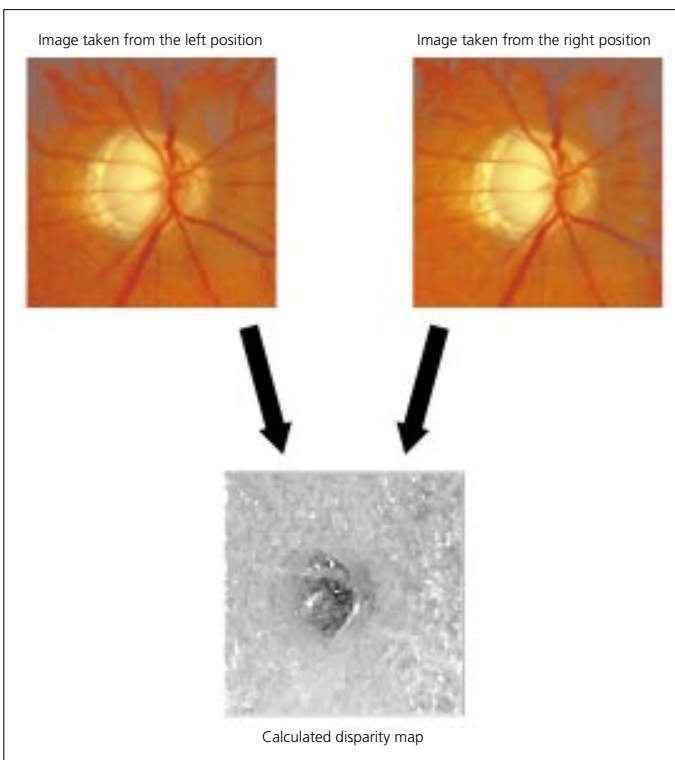


Figure 4: Depth reconstruction from an image pair