Flying Triangulation: a tool for automated medical diagnosis

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We demonstrate our "Flying Triangulation" (FlyTri) optical 3D sensor as a tool for automated medical diagnosis. We exemplarily present two applications: electroencephalography (EEG) electrode localization and the asymmetry detection in faces of facial nerve palsy patients. FlyTri allows for a simple, motion-robust, and contactless 3D acquisition of even complex objects.

1 Introduction

In the medical field, the demand for robust evaluation tools is steadily growing; any kind of user dependence or user influence has an adverse effect on the evaluation. To reduce the user influence the evaluation tools should be automated.

The measurement principle "Flying Triangulation" [1], [2] (FlyTri) enables a contactless and motion-robust measurement of complex objects. The sensor can be freely moved around the object while capturing 3D data (see Fig. 1).

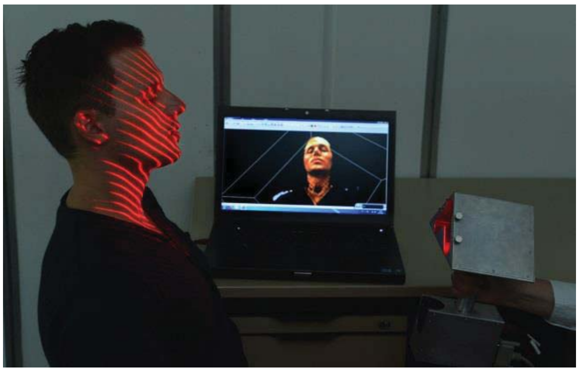

***Fig. 1** 3D image acquisition with a hand-guided FlyTri sensor (image: courtesy of MPL D. Ausserhofer).*

It combines a simple multi-line light-sectioning sensor with sophisticated algorithms. A series of 3D data is acquired which is aligned 'on the fly', without requiring any external tracking device. The current measurement progress is displayed in real time. After a few seconds a dense 3D model of the object is generated.

We describe representatively two automated evaluation tools in medicine which are based on 3D data acquired with our Flying Triangulation sensor: The first tool automatically detects the positions in 3D space of electrodes on an electroencephalography (EEG) recording cap. A precise knowledge of these positions is needed for neurosurgical planning. The second tool automatically determines asymmetries of facial features of patients having a facial paresis. Based on a reliable determination of such asymmetries, diagnosis and surgical therapy can be optimized to the improve patients' health and quality of life.

2 EEG electrode localization

The task is an automated 3D localization of medical equipment, for example of electrodes mounted on an electroencephalography (EEG) cap [3].

***Fig. 2** Automated localization of electrodes on EEG cap. Left: Person wearing typical EEG cap with 64 electrodes. Right: 3D model of person's head generated from FlyTri scan. Center: Automated processing of 3D model finds electrode centers (white sphere origins). Color map depicts similarity to reference (green: low, red: high).*

The standard method employs an electromagnetic 3D digitizer which needs to touch each electrode

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center. The contact with the patient's head generally leads to systematic errors in the positioning.

Our solution is completely contactless: First, an EEG cap worn on a person's head (see Fig. 2, left) is acquired by a hand-held FlyTri sensor and a dense 3D model is generated (see Fig. 2, right).

Next, the electrode centers are detected employing our novel descriptor-based method: One electrode in the 3D model is selected and serves as descriptor or reference. The centers of the electrodes are localized based on a similarity measure (see Fig. 2, center).

As a result, the electrode positions determined by the standard method display a mean deviation of 6.8 mm while the FlyTri-determined positions display a deviation of only 1.5 mm.

3 Facial paresis characterization

The task is an automated 3D asymmetry detection of a face for the classification of facial nerve palsy.

The standard method employs the visual 'House-Brackmann' scale: Different facial expressions of the patient are observed, resulting in one single, coarse score between I (normal) and VI (no movement) with high inter-rater variability.

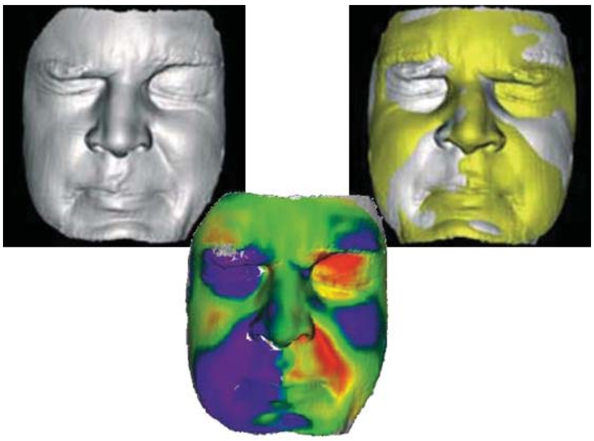

Fig. 3 *Capturing of facial palsy by comparing face sides. Left: 3D model is generated from FlyTri scan of a patient's face showing certain expression. Right: 3D data is mirrored and aligned to the original 3D data using symmetric facial areas. Center: Height difference map between both data sets shows localization and graduation of the facial palsy (purple to red: +/- 5 mm).*

Our solution is completely user independent: First, different facial expressions are acquired by a hand-held FlyTri sensor and a dense 3D model is obtained (see Fig. 3, left).

Then, left and right face side are used to find asymmetries. These are detected by mirroring and aligning 3D face models [4] (see Fig. 3, right). A height difference map between both data sets is computed (see Fig. 3, center: purple to red: +/- 5 mm). This allows for a determination of the distribution and degree of facial palsy.

As a result, the knowledge about local deviations of a few millimeters can be used to objectively determine the position and degree of facial palsy.

4 Summary and outlook

We presented two novel automated medical diagnosis methods enabled by the optical 3D sensor based on Flying Triangulation (FlyTri) as FlyTri allows for a contactless, user-independent acquisition of 3D object data with a hand-guided compact sensor unit. The ease of use, motion robustness, and scalability of FlyTri sensors opens a wide range of further applications, such as motion management [5].

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