“Videonystagmograph To Go”

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Abstract

Introduction: The aim of this study is to show a new tool for video documentation of nystagmus with ability to perform a 3D reconstruction of the inner ear position during the examination.

Materials and Methods. The proposed new tool (“videonystagmograph to go”) uses the camera and the integrated 9-axis absolute orientation sensor (MEMS) of nowadays smartphones for video documentation and 3D reconstruction of vestibular analyzer during the routine neurotologic examination.

Results. The results showed that the “videonystagmograph to go” is the first tool for video documentation of nystagmus with 4K video quality and ability for 3D reconstruction of vestibular analyzer in real time.

Conclusion. The aim of the authors is to implement this tool (“videonystagmograph to go”) into the routine neurotological examination.

Keywords: Neurotology; Videonystagmography; Frenzel goggles; Videonystagmograph.

Introduction

The neurotologic examination for objectifying nystagmus involves a variety of tests. Videonystagmography is the most widely used tool for the diagnosis and video documentation of nystagmus. [1] Although the technical development of videonystagmographs has made a huge advance it is still a stationary and not easy to work with device. [2, 3, 4] On the other hand the Frenzel goggles are still the diagnostic tool for many colleagues, because its mobility and easy to work. Fig. 1 (Copyright (c) Wolf Lübbers, Hannover)

But they don’t have the ability to record the nystagmus and this brings the physicians to the technical development of the last century. [5]

This article presents the design of a prototype videonystagmograph using the videocamera, gyro-scope, accelerometer and inclinometer of modern smartphones. The proposed model combines the mobility of the Frenzel goggles, videodocumentation of the videonystagmograph, telemedical options and original features, namely – 3D reconstruction of the inner ear during the examination.

None of the previously developed tests offer the possibility of showing the position of the inner ear (the semicircular canals, sacculus and utricle) during the examination.

Fig. 1 shows the original Frenzel goggles. (Copyright (c) Wolf Lübbers, Hannover)
Materials and methods

The proposed technical prototype of videonystagmograph, we used the features of mobile phone both for video documentation and for spatial orientation. The particular mobile phone used in our study has an integrated 9-axis absolute orientation sensor (MEMS). It is a combination of a 3-axis accelerometer, a 3-axis gyroscope and a 3-axis geomagnetic sensor. [6]

The video quality parameters for documenting vertigo nystagmus are as follows:

4K video 24 fps, 25 fps, 30 fps or 60 fps. In addition, the eye movement could be precisely coordinated with 2x optical and up to 3x digital zoom.

The slow motion video at 1080p could be at 120 or 240fps which allows for more than accurate diagnosis and characteristics of the nystagmus. [7]

The frame of the goggles is computer designed and 3D printed. The focus distance between the eyes and the front part of the goggles is (according to patient’s anatomy) between 6.5 and 7.5 cm in order to prevent the fixation (such distance is able to be focused for limited time by normal vision). Fig 2

The data from MEMS is recorded in csv format and contains timestamp and the measured values.

We use CAD software tool that is a general purpose parametric 3D CAD modeler. Python interpreter makes access to the API (Application Layer Interface) of all CAD modules and executes external programs as video player. Fig 3
Results

The proposed model ("videonystagmograph to go") was tested to 3 healthy volunteers (the authors) to show the ability of the model to record the postrotatory nystagmus and the corresponding data from the integrated 9-axis absolute orientation sensor (MEMS) to produce 3D reconstruction of the inner ear in real time. The presented new tool was presented and approved by the local ethic committee.

The video quality of the proposed "videonystagmograph to go" has the same parameters of the used smartphone. In the particular test the iPhone 12 was used and the video camera specifications are listed above. This is the first ever introduced videonystagmograph like tool with 4K video quality.

The focus distance between the camera and the eyes is 7 centimeters, which is practically impossible to accommodate during the whole examination and thus visual-fixation suppression is achieved.

Inner ear 3D model is imported in the CAD software and aligned to our local CAD coordinate system to represent the initial position of real human in the space. For the alignment of the inner ear 3D model are measured specific surface angles as represented in Fig. 4.

Both video frames and MEMS data may be recorded with different frequencies but averaging and interpolation techniques are used for data smoothing and increased precision of the 3D reconstruction. "csv" data file is read, we calculate transformation matrix and apply it to the 3D model. MEMS data and video data is synchronized using timestamp information.

Discussion

The proposed video documentation and 3D reconstruction of vertigo nystagmus provides the best current video parameters for precise diagnosis and world first objectification of the inner ear special orientation during the examination. This has great advantages in the diagnosis of patients suffering from vertigo and dizziness.

Although the "videonystagmograph to go" itself is a video documentation tool the presented model is capable of 3D reconstruction of the inner ear in real time. This allows the precise maneuvers in cases of BPPV where the crystal reposition is the gold standard in therapy.

The proposed model has all the advantages of the modern videonystagmographs with the flexibility of the Frenzel goggles.

The authors idea is to implement “videonystagmograph to go” as an everyday tool in neurootology.

References

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