AUCKLAND BIOENGINEERING INSTITUTE
THE UNIVERSITY OF AUCKLAND
NEW ZEALAND

USING A CONSUMER GRADE CAMERA FOR OBJECTIVE EYE MOVEMENT MEASUREMENT

Mehrdad Sangi, Benjamin Thompson, Cindy X. Guo, Jason Turuwhenua

The University of Auckland, New Zealand

Introduction

There is clinical interest in low cost consumer devices such as webcams and smartphone cameras for the measurement of visual function [1]. In this work, we investigated whether a webcam was sufficient to measure the velocity characteristics of optokinetic nystagmus (OKN), an involuntary sawtooth movement of the eye that may allow for rapid and objective clinical measurement of visual functions (see Fig. 1). OKN consists of both smooth pursuit (slow phase) and saccadic (quick phase) eye movements, each of which can provide important information relating to visual function [1], [2].

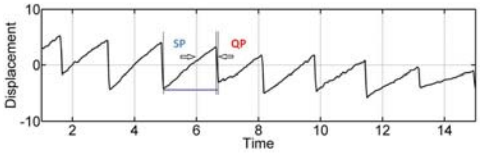

Fig 1. Sample of OKN displacement signal.

Method

The stimuli were square wave gratings presented on a cathode ray tube monitor (IBM P275, 1600 x 1200 resolution, and 75Hz refresh rate) placed 60cm from the observer. The duration of each presentation was 10s. Video footage of subjects (N = 5) was collected.

Fig 2. Experiment setup.

A LogiTech Webcam (spatial resolution of 1620 x 780 pixel, 30 fps) and a binocular Arrington eye tracking system (420 fps) recorded eye movements simultaneously. Webcam eye movements were processed using the Kanade Lucas Tomasi (KLT) tracking method to track pupil/iris features and hence estimate the eye displacement [3]. For comparison reasons, the signals were registered using downsampling followed by cross-correlation (see Fig. 3.b). The slow phase (SP)/quick phase (QP) velocities were estimated from the eye displacement signal by applying least squares fitting between each minima to each maxima and vice versa. Then the slopes of the fitted lines were calculated (see Fig. 3.c).

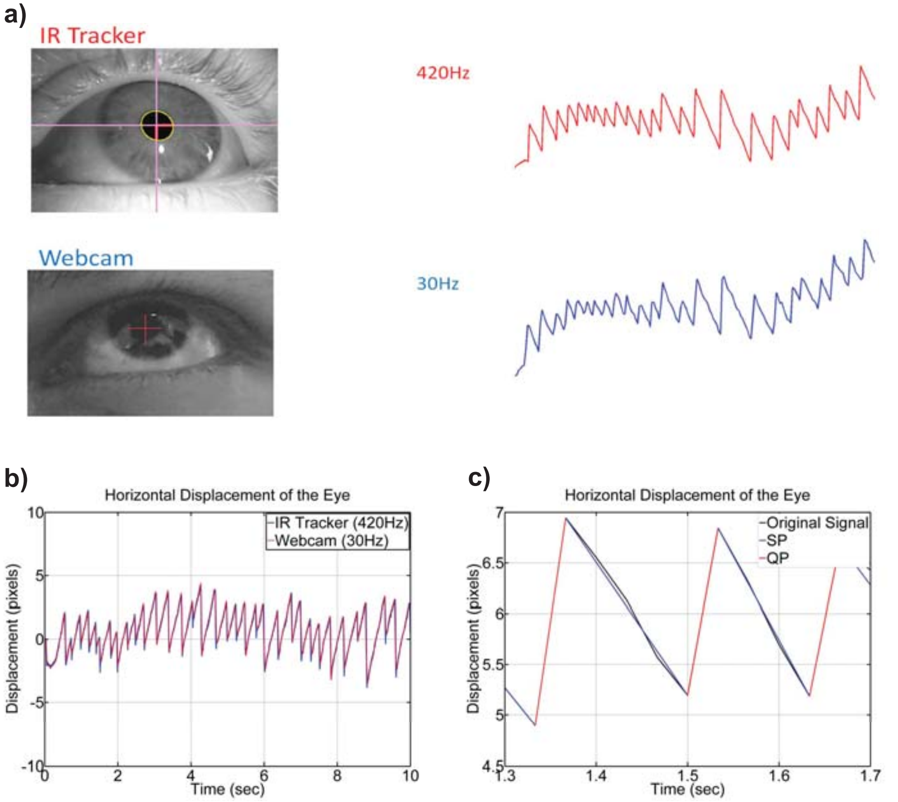

Fig 3. a) Eye displacement signals from IR tracker (red) and webcam (blue). b) Registered signals. c) Estimated SPs (blue) and QPs (red).

Results

There was a very good agreement between 30Hz and 420Hz signals:

Correlation = 97.27%±0.26%

MSE = 0.1935±0.0256 pixels

Table I shows the SP/QP estimation results. SP velocity can be estimated very well with 30Hz, but higher frame rates are necessary for estimating QP velocities. The standard deviation of QP velocities was much higher than that of the SP velocities.

Table I. SP/QP estimation results.

Frame Rate	SP Velocities (pixel/sec)	QP Velocities (pixel/sec)
30 (Webcam)	-12.32 ± 1.58	54.01 ± 29.79
420 (Input Signal)	-13.33 ± 2.53	74.19 ± 23.41

Conclusion

For the smooth pursuit (slow) phase of OKN there is no need to use expensive, high frame rate cameras to accurately estimate velocity, but for the saccadic (quick) phase of OKN, higher frame rates are required for accurate velocity estimation. With the technological advances in smartphone cameras, it might be possible to measure OKN objectively with use of a smartphone, which in turn could allow for the accurate assessment of visual function in young children and contribute to the early detection of visual disorders.

References

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