Eye Tracking in Ophthalmology: A Glimpse Towards Clinical Practice

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COLUMN ARTICLE

Still today, clinicians tend to carry out a subjective assessment of oculomotor functioning during clinical examination relying on direct observation of patients' eye movements, while objective eye movement recording remains relatively rare in current clinical practice.

Objective quantification of eye movements has great potential since it allows clinicians to achieve more detailed spatial and temporal resolution of the oculomotor behavior, make more precise quantitative determinations of eye-movement characteristics, and generate permanent records.

In recent years, the increasing number of reliable Eye Tracking (ET) technologies has raised growing interest in studying eye movements and gaze patterns on a quantitative basis.

The aim of ET is to detect and measure the point of gaze where one is looking or the motion of eyes relative to the head.

The video-based ET systems are the most promising and popular approach because of their noninvasive nature, and a number of technologies are now available, including head-mounted and glass solutions (e.g., Pupil Labs eye-tracker, SMI Glasses, Tobii Glasses).

However, they remain essentially research tools that can be accomplished successfully under laboratory conditions, since they usually require considerable amount of time for system setup and for visual test preparation. Moreover, programming skills for post-processing of the recorded eye data are usually required [1,2].

It may be increasingly useful for clinicians to have a sensitive eye tracker available for use during eye examinations, e.g. for support in the clinical decision-making. Therefore, the development of intuitive software tools and interfaces that may simplify the use of eye trackers in the clinical practice should be encouraged, e.g. by implementing automatic functions for data analysis and extraction of meaningful metrics for the clinical interpretation of the recorded eye data.

Our recent experience in this field has been with the commercial video-based ViewPoint Eye Tracker (Arrington Research, Scottsdale, AZ, USA). The ViewPoint system, as many other commercial eye trackers, is a stand-alone device with the primary function of recording eye movements, therefore functions for automatic processing and data analysis of the recorded signals are not provided.

To encourage the use of ViewPoint ET in the clinical practice of the Ophthalmology Unit of S. Orsola-Malpighi Teaching Hospital in Bologna we developed a MatLab toolbox (SacLab) specifically designed to encompass in a single package all the main functions needed for a comprehensive analysis of saccadic response using an ET system [3].

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SacLab consists of four processing modules that enable the user to easily create visual stimuli tests (Test Designer), record saccadic eye movements (Data Recorder), automatically extract saccadic parameters of clinical interest (Data Analyzer) and provide an aggregate analysis from multiple eye movements recordings (Saccade Analyzer) (Figure 1).

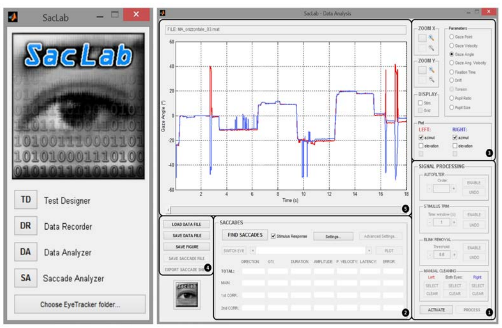

Figure 1: *SacLab toolbox.*

A key advantage of SacLab is that it allows the creation of customized visual tests also in a clinical setting by clinicians with no programming experience, by the easy handling of drop down menus and selectable boxes provided in the graphical user interface (GUI) of the Test Designer module. Moreover, automatic signal processing functions are provided to clean up the recorded signals from noise and artifacts (e.g. blinks) and algorithms are implemented to automatically recognize the main and corrective saccades and to calculate the saccadic parameters of clinical interest such as direction, amplitude, duration, peak velocity, latency and the saccade curvature.

We experimented SacLab with ophthalmologists, who had no programming experience and we received from them an enthusiastic feedback in terms of intuitiveness, ease of use and flexibility.

What is still missing in SacLab? We are working for improving the toolbox with additional analysis capabilities that can be used to the best clinical advantage. The idea is to collect data from the literature [4], and from results of clinical studies we have started [5,6] to characterize the saccadic movements in healthy subjects and in patients with different pathologies. The final aim is to implement functions in the Data Analyzer module that recognize the abnormal saccadic patterns and to provide the user with a list (drop-down menu) of possible pathologies associated with the recognized abnormal pattern.

Then, in the Saccade Analyzer module, metrics for aggregate analysis and data visualization could be customized for each specific recognized pathology in order to simplify the clinical interpretation of the measured data. As for example, in multiple sclerosis (MS) it has been documented the slowing of adduction saccadic movements with respect to the abduction movements and this disconjugacy of saccades has been measured by the Versional Disconjugacy Index (VDI), i.e. the ratio of abduction and adduction peak velocities. An increased VDI indicates a more severe slowing in adduction [7,8]. Considering this, a Saccade Analyzer customized for MS could be provided with the default plotting of two separate main sequences: one for adduction movements, one for abduction movements in order to enhance the expected saccadic disconjugacy in MS. The automatic calculation of the VDI can also be provided since it a sensitive index of MS severity.

As other example, in the thyroid-associated ophthalmopathy, changes in saccadic movements are clearly expressed by an inverse trend, if compared with normal subjects, of the "difference main sequence", i.e. the main sequence obtained by subtracting main sequence of the up-gaze from main sequence of the down-gaze [9]. According to this observation, it could be advisable to implement a Saccade Analyzer customized for thyroid-associated ophthalmopathy that provides as default plotting the difference main sequence, rather than the standard main sequence.

In conclusion, eye-tracking technology has huge potential beyond that of simply measuring eye movements. We hope that this editorial can stimulate and foster further research for development of easy-to-use tools and software interfaces to be applied to ET systems to encourage their clinical application in ophthalmology.

BIBLIOGRAPHY

1. Berger C., *et al.* "GazeAlyze: a MATLAB toolbox for the analysis of eye movement data". *Behavior Research Methods* 44.2

(2012): 404-419.

2. Gitelman DR. "ILAB: a program for post experimental eye movement analysis". *Behavior Research Methods* 34.4 (2002): 605-612.
3. Cercenelli L., *et al*. "SacLab: A toolbox for saccade analysis to increase usability of eye tracking systems in clinical ophthalmology practice". *Computers in Biology and Medicine* 80 (2017): 45-55.
4. Thurtell MJ., *et al*. "Disorders of Saccades". *Current Neurology and Neuroscience Reports* 7.5 (2007): 407-416.
5. Fresina M., *et al*. "Study of fusional convergence using eye tracking: preliminary results on subjects with normal binocular vision. Abstracts of ARVO 2015 Annual meeting, Denver (USA) 3-7 maggio 2015". *Investigative Ophthalmology and Visual Science* 56.7 (2015): 2917.
6. Benedetti C., *et al*. "Influence of textured backgrounds on fusional vergence: preliminary results using an eye tracker. Abstracts of ARVO 2015 Annual meeting, Denver (USA) 3-7 maggio 2015". *Investigative* Ophthalmology *and Visual Science* 56.7 (2015): 2918.
7. Ventre J., *et al*. "Saccade metrics in multiple sclerosis: versional velocity disconjugacy as the best clue?" *Journal of the Neurological Sciences* 102.2 (1991): 144-149.
8. Frohman TC., *et al*. "Accuracy of clinical detection of INO in MS - Corroboration with quantitative infrared oculography". *Neurology* 61.6 (2003): 848-850.
9. Schworm HD., *et al*. "Changes of saccadic eye movements in thyroid-associated ophthalmopathy". *Acta Ophthalmologica* 90.8 (2012): 713-720.