EVA – EYE TRACKING - STIMULUS INTEGRATED SEMI AUTOMATIC CASE BASE SYSTEM

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In a real world visual search is a common task depending from sensory, perceptual and cognitive processes. Different classes of eye movements are necessary to hold an image on the retina during head rotation or movement of the image, and to move the eye suddenly to a new point of interest in space. From a functional point of view, two major classes of eye movements are described in humans: those stabilizing gaze (optokinetic nystagmus, oculovestibular reflex) and those moving gaze (saccades, pursuits and vergence). Under natural conditions, however, a mix of all kinds of eye movements permit continuous scanning of the visual scene. The sequence of fixations and saccades during visual exploration is an expression of a number of cognitive processes; the use of standardized tasks with pre-defined spatial-temporal variables allows us to assess specific cognitive domains, such as perception, attention, memory, preference and motivation. Manipulating the search task can vary the demands on brain. In turn, brain modulates visual search by selecting and limiting the information available at various levels of processing.

The EVA software is a complete system based on a set of stimulus and patient's case able to stress brain functionalities in order to assess some cognitive functions.

Keywords: Eye Tracking, Vision, Neurology, Saccades, Case Base

1. INTRODUCTION

The study of fast and slow eye movements [1] [2] respectively saccadic and pursuit sub-systems provide important information about the neural system activity at several levels. The recent advances in eye tracking techniques, allow us to better measure saccades and pursuit expanding the spectrum of applications of eye movements research both in clinical and cognitive neurosciences.

2. OVERVIEW

The Eye-tracking-Vision Applications (EVA) is a complete system that is able to produce the stimulus, grab gaze parameters, fixations and saccades parameters and to analyze data in order to provide specific information on subject's performances related to the experimental setting. Saccades are induced by a microcomputer-controlled LCD stimulator and are recorded by eye-tracking system; eye-tracking commonly refers to all techniques for eye movements grabbing. Stimulator is a collection of trial test (gap test, anti-saccade test, overlap test, memory guided test, trial making test [7], et al…) which is able to stress some neurological cognitive functionalities. Finally all data are analyzed and compared with controllers (healthy subjects) in order to provide some ocular motor and cognitive parameters useful in diagnostic and rehabilitative applications.

3. ARCHITECTURE

EVA system is based on two databases and an algorithms library. Databases collect trial test protocols and healthy subjects. Library is a collection of signal analysis algorithm for saccades and fixations detection and statistics analysis algorithms.

The saccadic algorithm detects these fast eye movements by the velocity profile of eye position and then computes the principal saccadic parameters, peak velocity, duration and amplitude. As saccades may be affected by some artifacts such as nystagmus (alternating slow phase in one direction and fast movement in the other direction), patient's disease, patient's age, saccades interruption and noise); the algorithm depends strictly by velocity threshold which is set by the user. The most common detection methods do not always function without the user's control and aid. Typically, the saccades are presented on the Plot screen, together with the computed results of the analysis; they may be edited if necessary. EVA system uses a case base algorithm able to reject fake saccades automatically or semi-automatically.

Saccades algorithm is based on Fisher algorithm [8] however the user is able to reject fake saccade by guided interface able to register user input and to learn by user feedback.

Fixations algorithm is based on standard Widdel dispersion algorithm [9].

Best Sequence Algorithm is used only on a specific task (TMT) and it's based on distance based algorithm developed by Mannan, Rudock and Wooding [10], sampling only area of letters and numbers of TMT. During the second phase the procedure assigns a score for each correct single step, such as 1-A or A-2 (in the case of TMT).

ROI Based algorithm uses a "biased random model" dividing the screen in 5x5 regions and calculating the probability to move from a fixation to another fixation. The algorithm is used for scanpath analysis in order to compare different scanpath among subjects.

4. ANALYSIS STAGE

The second stage of EVA system is the analysis. According to trial test selected by user, the EVA system extracts some high level cognitive functionalities such as attentions, working memory capabilities, cerebellum status, motor programming control and it can be useful for making neural system model [3] [4]. The Figure 2 shows the analysis stage.

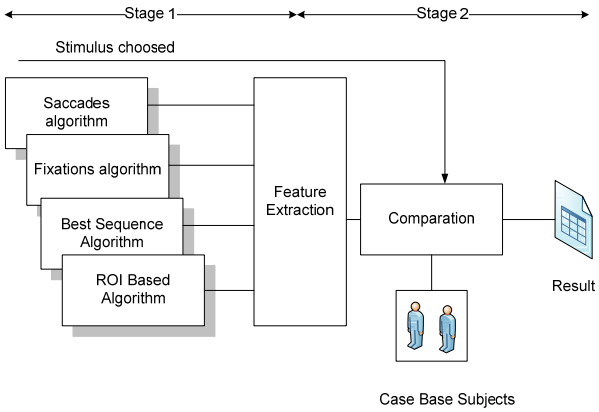

Figure 1: EVA System

The results are compared to subjects database comparing the subject's features to case base subjects features.

The following list represents a simple extraction of main features:

1. Subject age
2. Saccade Peak Velocity, Mean Velocity, Delay
3. Saccade Velocity/Amplitude
4. Saccades Mean Sequence
5. Anti-saccade error
6. Fixations dispersion and number
7. Score ability to do sequence
8. Revisited ROIs, ROI to ROI time
9. ScanPath Biased Model

The comparison formula among features is pre-defined feature-by-feature, for instance ScanPath Biased Model is compared by cross-correlation value; the global comparison between subject and case base subject projects the current subject to the nearest case patient. A diagnosis is associated to each case patient and may provide a usefully subject's diagnostic instrument.

The following formula describes the main algorithm:

$$\Delta F_i = \sum_j^m w_j \Delta_j (F_{i,j}, \tilde{F}_j) \qquad \textbf{[Eq. 1)}$$

Where $\tilde{F}_j$ is the j feature of current subject j=1..m where m=number of features available and $F_{i,j}$ is the j feature of the i case base subject. $w_j \Delta_j$ is the comparator operator multiplied by a factor w_j.

The approximated diagnosis is:

$$\tilde{D} = \{D_i | where\ i\ is\ the\ index \min(\Delta F_i)\} \qquad \textbf{[Eq. 2)}$$

The diagnosis is typically a descriptive analysis and a categorization of patients.

5. CONCLUSIONS

The proposed system aims to provide a full qualified application in order to evaluate clinical case by vision task. The system is able to be extended by further cases or further tasks and algorithm. Future works aim to implement a simple model of brain in order to provide to the doctor a simple view of some brain functionalities avoiding complex and invasive tests.

6. COPYRIGHT

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