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# Automatic eye fixations identification based on analysis of variance and covariance

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ABSTRACT

Eye movement is the simplest and repetitive movement that enables humans to interact with the environment. The common daily activities, such as reading a book or watching television, involve this natural activity, which consists of rapidly shifting our gaze from one region to another. In clinical application, the identification of the main components of eye movement during visual exploration, such as fixations and saccades, is the objective of the analysis of eye movements: however, in patients affected by motor control disorder the identification of fixation is not banal. This work presents a new fixation identification algorithm based on the analysis of variance and covariance: the main idea was to use bivariate statistical analysis to compare variance over $x$ and $y$ to identify fixation. We describe the new algorithm, and we compare it with the common fixations algorithm based on dispersion. To demonstrate the performance of our approach, we tested the algorithm in a group of healthy subjects and patients affected by motor control disorder.



## 1. Introduction

Eye movements are an essential part of human vision as they drive the fovea and, consequently, visual attention toward a region of interest in the space. This enables visual system to process an image or its details with a high resolution power (Privitera and Stark, 2000).

The study of eye movements is an up-and-coming tool to study neurological disorders in clinical applications. Voluntary eye movements (saccades, smooth pursuit) are controlled by several structures in the central nervous system, which may enable easier distinction between peripheral and central lesions (Juhola et al., 2007). Brain's structures of the paramedian pontine reticular formation and the vestibulo-cerebellum are involved in the coordination of eye movements and in vestibular responses (Leigh, 2006). Some other neurological diseases, such as cerebellar ataxia, have an influence on saccade velocity, accuracy or latency.

Therefore, a correct analysis of eye movements can lead to distinguish patients from healthy subjects.

The fixations and saccades are the main features of eye movements; fixations are samples of points around a centre point (centroid) with long duration ($\gg$50 ms); these eye fixations are intercalated by rapid eye jumps (saccade), which can be defined as rapid eye movement with velocities that may be higher than 500 deg/s and duration about 20–40 ms (Ramat et al., 2007); Fig. 1 shows a small portion of gaze sample during visual exploration on a psychological task: it is easy to identify three clusters of data points (fixations) and two saccades.

From a psychological point of view, the fixation is defined as the act of maintaining the visual gaze on a single location in order to make our environment visible (see Martinez-Conde et al. (2004) for a review of the role of fixations). From a technical point of view, fixation should be identified by a cluster of points around a centroid with a minimum duration; Irwin et al. (1990) found the theoretical minimum duration for a single fixation to be 150 ms, whereas Manor and Gordon (2003) argued that 100 ms can also be justified. Rayner (1998) indicated that the mean duration of a single fixation may depend on the nature of the task (225 ms on reading, 275 ms on visual search, 400 ms hand-eye coordination).

During fixation, the eye does not remain completely stable, but is affected by perturbations such as microsaccades, ocular drifts, and ocular microtremor, making it difficult to easily identify it by an algorithm.

### 1.1. Related works

In order to implement an efficient algorithm able to identify automatically fixations, the efforts have been concentrated on three parameters: fixations duration, dispersion and velocity.

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