A Low-cost Webcam-based Eye Tracker and Saccade Measurement System

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***Abstract*—**Eye movements are integrated with cognitive processes, which indeed make it a helpful research basis for the investigation of human practices. Eye movements can be deployed in discovering several cognitive processes of the brain. This research utilizes low-resolution webcam to develop an eye tracker and saccades measurement tool to extensively lower the gadgets expenses. A consistent algorithm is developed to suit the quality of the webcam using open-source software (Python) to record the time series of the eye location. Likewise, several algorithms are proposed to extract high-level eye movement saccadic measurements from the raw gaze outputs. A pilot study is performed on ten normal participants and Multiple Sclerosis (MS) patients. Experimental results demonstrate that the proposed system is quick, simple and efficient for eye tracking and saccade measurement. The developed tool can be used by clinicians and medical physicians for the diagnosis and identification of neurological disorders.

***Keywords*—**Eye-movements, Eye-tracker, Saccades parameters, Saccade latency, Amplitude gain, Peak velocity, Neurological disorders, Multiple Sclerosis.

I. INTRODUCTION

Recently, eye tracking has been addressed by the community to give an insight into brain cognitive processes. It has been utilized to study human behaviors in different fields, for instance, driving [1], image scanning [2], arithmetic [3], analogy [4], human-computer interaction [5], and reading [6]. In this context, eye-tracking and dynamic stimuli are analyzed. Dynamic stimuli refer to the moving objects (target) that the user is looking at which is either in the environment or on a computer screen in a stationary setup. During recent years, the interest in using dynamic stimuli has grown, both for stationary and mobile eye-tracking. Normally, researchers analyze eye movements in terms of fixations and saccades.

Fixations are the pauses over informative regions of interest while saccades are rapid movements between fixations. Saccade is a quick, simultaneous movement of both eyes between two or more phases of fixation in the same direction.

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Saccadic velocities, amplitudes, latency, and duration are the most common analysis metrics for studying human behavior. Latency is the time taken from the appearance of a target to the beginning of a saccade in response to that target. Amplitude is the size of the saccade, usually measured in degrees or arc minutes. Amplitude determines the saccade accuracy. This is sometimes denoted using "gain". The gain is the ratio of the actual saccade amplitude divided by the desired saccade amplitude. Peak velocity is the highest velocity reached during the saccade as shown in Fig. 1.

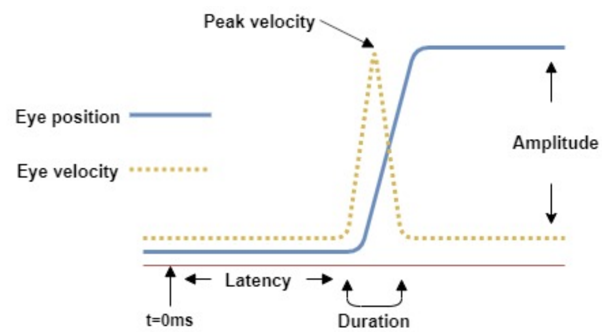

Fig. 1 Saccadic parameters [7]

The fourth saccade parameter is the duration which is the time taken to complete the saccade. Saccadic measurements have been used in various research domains such as deficient saccadic function being used to understand cognitive [8] or visual [9] processes, neurological inspection and diagnosis [10] or identifying practical shortfalls in everyday tasks [11, 12].

Recently, real-time computer vision algorithms have been deployed to detect the eyeball movement from a digital image sequence. Movement detection is utilized for fixation and saccadic gaze movement identification. Infrared cameras are widely used in the on-shelf commercial eye tracker [13]. The point, at which someone is looking, is located on the screen based on the relative locations of the pupil center in the video image of the eye. Video cameras are also used in commercial eye trackers. Webcam-based gaze tracker has less accuracy and cost than infrared-based eye trackers [14]. OpenCV library is exploited by most webcam-based systems to detect face and gaze position based on the relative position of the pupil within the standard geometry of eyes. The major bottleneck for eye-trackers is the algorithms that analyze the recorded eye-tracking signals. Analysis of eye-tracking data has many