Computers in Human Behavior 26 (2010) 1555–1563

Contents lists available at ScienceDirect

Computers in Human Behavior

journal homepage: www.elsevier.com/locate/comphumbeh

Influences of data filtering on human–computer interaction by gaze-contingent display and eye-tracking applications

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ARTICLE INFO

Article history:
Available online 19 June 2010

Keywords:
Eye movements
Gaze-contingent displays
Filter
Attentive displays
Eye-tracking

ABSTRACT

We describe an interactive gaze-contingent display (GCD) applied to clinical applications; the system uses a simple texture hole to inhibit peripheral vision, to test and stress overt mechanisms of visual searching in normal subjects. The correct use of GCD in vision research is affected by tremor of the hole, due to system noise, nystagmus, eye blinking, calibration and subject reactivity. These issues compromise the execution of task. In order to obtain a stable GCD hole, we implemented a predictive gaze-contingent display (PGCD), fitting through dispersion of fixations and modulating a filter. The paper describes the PGCD and compare it with the common technique, providing evidence that humans fit exploration based on the characteristics of the computer system; in particular we found significant difference applying PGCD or a simple finite impulse response filter. We suggest that a correct human–computer interaction applied to neuropsychological context must be developed taking in consideration both technical point of view and human behavior.

1. Introduction

Human–computer interaction is one of the most important aspect of computer system applied to neuro-cognitive and psychological studies and, in particular, on vision. On vision research a common method to test neuro-cognitive functionalities is to use multimedia applications and to register some special human features, such as latency, correct responses, hand or eye movements (Toet, 2006); in some particular cases a large amount attention must be spent to apply a correct human computer interaction technique. In fact, to investigate the influence of some cognitive functions, such as peripheral vision, scene understanding, parallel processing of human neural system, bias due to computer system issues (latency, reactivity) or human physiological features (eye blink, eye tremor) must be avoided.

A common method to study these functions of human vision is through eye-tracking application, which consists a remote-mounted (infrared) video camera able to record gaze data: horizontal and vertical movements, and pupil diameters (for a survey of eye-tracking applications Duchowski, 2002; Morimoto & Morimoto, 2005; Rayner, 1978; Rayner, Li, Williams, Cave, & Well, 2007).

From a system analysis point of view, eye-tracking applications should be distinguished from diagnostic or interactive system. In diagnostic mode, the eye-tracker provides data about the observer's visual search and attention processes. In interactive mode, the eye-tracker is used as an input device. From a general point of view, an interactive system responds to the observer's actions and interacts with him. Duchowski (2007) also distinguishes two types of interactive systems: (a) selective, where the point of gaze is used as a pointing device; and (b) gaze-contingent display (GCD), in which the observer's gaze changes the rendering of complex information displays.

1.1. Gaze-contingent displays

Gaze-contingent displays (GCDs) and applications, have been described in several articles (for example McConkie & Rayner, 1975; Pomplun, Reingold, & Shen, 2001) and have been used in various applications, such as reading, images and scenes perception, virtual reality, computer graphics, and visual search studies.

Recent researches (Vinnikov, Allison, & Swierad, 2008, 2006, 2002) have concentrated on correctly placing and displaying the hole on the image by various techniques and avoiding geometrical distortion using real images as source. GCD is thought to have an effect on visual perception and attention. Studies on the effects of GCD in visual perception have shown that it may influence the response of subjects during visual search. Murphy, Duchowski, and Tyrrell (2009) developed a gaze-contingent application and

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doi:10.1016/j.chb.2010.05.030