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VISIOBOARD: a new gaze command system for handicapped subjects

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Abstract- This paper describes a gaze command device dedicated to persons presenting reduced functions of hands or language. Original developments have been made in order to achieve a non invasive - no contact approach, to facilitate the use of the system by non technical personnel, to enhance its speed of command and to adapt it to various forms of handicaps.

I. INTRODUCTION

Gaze command is of great potential interest for persons presenting reduced functions of hands or language.

Several instruments have already been proposed for this purpose. However, their spread has been greatly limited because of weak performances and lack of adaptability to various forms of handicap. Techniques based on electro-oculography [1-3] and limbus reflectance [4] measure eye movements with little accuracy and allow typically no more than 4 choices at each gaze designation. The resulting data flow is more than one order of magnitude slower than keyboard or voice entry by "normal" subjects. It can be slightly improved by predicting software in specific applications such as word processing [5]. Techniques based on images of the pupil and corneal reflex [6-7] do achieve much better accuracy and, consequently, much higher data rates. However, they require a precise orientation of the image sensor toward the eye which can only be achieved through immobilization of the head or attachment of the sensor to an helmet. These constraints reduce significantly the acceptability of these techniques and the number of patients who can benefit from them.

The purpose of our research was to conceive new technical solutions allowing a reduction of these constraints.

II. METHODS

A. Eye movement sensor.

A transparent window located at the center of the designation board (Fig. 1) allows a direct viewing of the eye by the eye movement sensor.

Eye orientation is measured from the relative position of the pupil and the reflection of the illumination source over the cornea. The analysis of the video signal is performed at a rate of 30 Hz by specific electronics and a microprocessor [8]. Automated pattern recognition algorithms are implemented in order to eliminate artifacts such as partial masking of the pupil by eye lashes or eye lids and parasitic reflections. This technique allows absolute measurements of eye movements in all directions of gaze without artifacts from head movements [9].

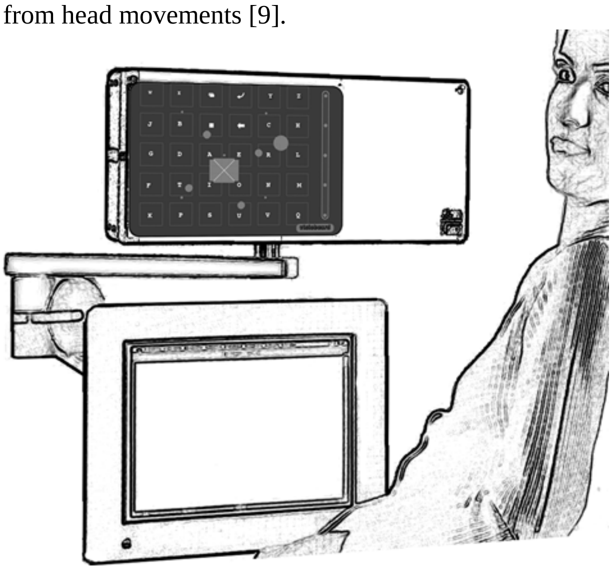

Fig.1 General set-up of the instrument showing the designation board (top) and the microcomputer monitor (bottom).

B. Eye detection and tracking (Fig. 2)

An ultrasound sensor is used to measure the distance to the head and to control the focus of the image sensor. 2 micro-stepping motors control the angular position of 2 mirrors defining the orientation of the eye movement sensor.

Once the head is detected, the apparatus automatically searches the eye by scanning the area facing the designation board. An optical pointer is used to assist the positioning of the patient.

Once the image of the eye is captured, it is automatically tracked so as to remain at the center of the viewing field of the sensor.

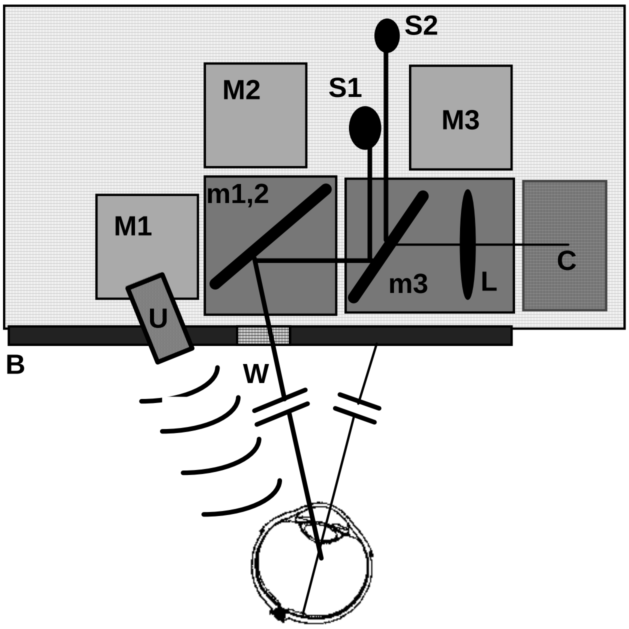

Fig.2 Optical schematic of the instrument
(B) frontal face of the designation board; (W) transparent window; (m1,2) mirrors used for searching and tracking the eye; (m3) beam splitter beam mirror; (S1) 880 nm led source illuminating the eye; (L) lens focusing the image of the eye on CCD sensor (C); (S2) visible light source pointer used to align the eye during he installation of the patient; (U) ultrasonic sensor used to measure the distance to the head; (M1,2,3) motors used to center and focus the image of the eye.

C. Calibration and gaze designation.

Calibration of gaze measurements requires the patient to fixate 5 light sources located at reference positions of the designation board. As they are defined by the geometry of the anterior chamber of the eye [9] and present very little variation over time, calibration coefficients can be stored for subsequent sessions. When calibration is completed, gaze designations can be made by looking at one of the 30 designation areas of the board (each of these areas is viewed under a 4 degrees angle). Designations are validated by the duration of fixation which is programmable so as to allow inexperienced users to explore the board before selecting one of the designation areas. Feedback is provided to the user by illuminating the designated area for a given period of time after validation.

The system can be used with a default calibration for patients who cannot calibrate. In that case, designations are made over a 6 areas (3 x 2) matrix. Specific filtering of the eye movements can also be applied for patients with eye movement disorders.

D. Interface with effector devices

The instrument can be used independently to generate messages on a control screen or to pilot assistive devices via an infrared interface. It can also emulate the keyboard and mouse of a standard micro-computer through a serial RS232 interface.

III. CLINICAL EVALUATION

This device was tested on 20 patients at the hospital Raymond Poincaré in Garches (Pr. Barois, Mme Petrequin). The pathologies included myopathies, Wernick Hoffman myopathies, tetraplegias and osteoarthrisis. 15 patients were able to use the communication aid successfully. After about 10 minutes of training, subjects were able to achieve speeds between 0.5 and 1 characters per second.

IV. CONCLUSION

This preliminary evaluation indicates that the performances of this new gaze command device allow a significant increase of the usefulness and applicability of gaze command to handicap subjects. However a long term evaluation is needed to confirm these results and determine more precisely the impact of this technology on health care. This evaluation has been undertaken in 3 rehabilitation centers in Bordeaux, Le Mans and Nantes.

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