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Mobile Embedded System for Human Computer Communication in Assistive Technology

Robert Gabriel Lupu, Florina Ungureanu, 
Computer Science Department 
Technical University of Iasi 
Iasi, Romania 
rupert@cs.tuiasi.ro; fungurea@cs.tuiasi.ro

Radu Gabriel Bozomitu 
Telecommunication Department 
Technical University of Iasi 
Iasi, Romania 
bozomitu@eeti.tuiasi.ro

Abstract—In this paper a new technology to communicate with people with neuro-locomotor disabilities using embedded systems and eye tracking approach is presented. The eye movement is detected by a special device and the voluntary eye blinking is correlated with a pictogram or keyword selection reflecting patient’s needs. The implemented eye tracking method uses image processing technique based on binarization algorithm.

Keywords: eye tracking, assistive technology, image processing, binarization algorithm, embedded systems

I. INTRODUCTION

Every human being, as a society member relies on communications to express its thoughts, wishes and needs to exchange ideas. Deaf or dumb people can express themselves through signs or handwriting and blind people have Braille alphabet as an alternative for communication. However there is a category of people with severe speech and motor impairment or with neuro-locomotor disabilities. Despite their affliction, these persons still have a very good level of understanding and perception. They can express themselves only in presence of an attendant or a caretaker and communication is basically gestural assisted. The caretakers can use e-tran frames [1] to guess a letter by following the gaze direction of the patient or making a direct selection by pointing a pictogram [2] or a letter from a board or by changing sheets with images (scanning method). In all cases, the patient needs to confirm or infirm the caretaker’s selection until the current one corresponds to his needs. This communication method implies continuous presence of the caretaker near bedside of the patient. A solution is to use a low cost device to assist the patient in communication process.

Taking into account that most of the neuro-disabled patients can move their eyes, this can be useful for eye tracking device [3] using electro-oculogram (EOG) signals and computing five kinds of intentions (four directions - up, down, right, left and one selection - blink) [4] can be used together with a computer to select a word from a menu. This device should be used by patient for a face to face conversation or a remote message sent via communication network [5]. Another approach is to use a camera for tracking the eye movements. Thereby camera mouse can be used to move a cursor on a computer screen and to browse a menu for suggestive pictogram selection [6].

In this paper we propose a mobile device for patient communication and also an optimised algorithm for video eye tracking implemented on embedded system. The goal is to replace the personal computer used by patient in some previous approaches with an embedded mobile system which has the advantage of low price and low power. The mobile patient device is part of the communication system named ASSISTSYS [7], designed and implemented in concordance with the international rules regarding assistive technology.

II. COMMUNICATION SYSTEM ARCHITECTURE

The communication system consists in three main modules: caretaker device, patient device and server. The caretaker device is a smartphone with GPRS and/or Wi-Fi communication module. The Java software application named AssistSysCaretaker running on caretaker device allows caretaker to receive keywords related to a certain patient’s need or wish.

Figure 1. Assistsys system communication principle

The mobile patient device is an embedded system running Angstrom OS and a software application named AssistSysPatient. The AssistSysPatient assists the patient in keyword selection process and transmits the selected keyword to the caretaker. The server is a PC, running application software named AssistSysServer which manages communication between patients and caretakers. If the patient makes a selection the corresponding keyword is sent to server. A
caretaker is selected and the keyword is forwarded to his communication device. The caretaker’s response is sent back to the server. If this is positive, it is considered accomplished. The keywords are selected by patient using eye tracking technique. For this we used a modified webcam mounted on a glasses frame and placed right underneath the eye at a distance of seven centimetres. The angle between eye axis and webcam axis is 30 degrees. Due to the uncontrolled specular reflection, the eye is illuminated uniformly by infrared light eliminating this inconvenient. For this, an IR filter was used and three IR LEDs have been mounted around the lens. The implemented eye tracking algorithm detects the eye movements and maps the eye position from webcam coordinates to the monitor coordinates moving the cursor corresponding to gaze position. In this way the patient can point an image related to a keyword. Moving the eye to left or right the device displays others keywords. The selection of a keyword is done by voluntary blink (eye closed or double blinking for one second).

![Figure 2. Functional diagram for AsistysPatient software](image)

The input layer manages image acquisition with 640x480 resolution and a rate of 25 frames per second. The acquired image is pre-processed (like horizontal flipping, filtering, inverse threshold binarization) in order to obtain suitable information for eye pupil detection by the second level. At each AsistysPatient application launching, the input layer also executes the module for region of interest (ROI) establishment (the image region where the eye pupil is).

The middle layer executes the eye tracking algorithm, the most important part of application. Thereby, this second layer determines the pupil position in the webcam coordinates, maps this position to the screen coordinates and moves the pointer on the screen accordingly to the eye movement. The word or pictogram selection (click) is made when two successive blinks are detected in a certain time. Based on eye movement and blinking, the user graphic interface reacts in different ways, in concordance with patient’s choice.

The output layer implements the communication with the server. The communication protocols are presented in detail in some previous papers [3,5,7].

### III. Mobile Patient Device

The mobile device structure is based on BeagleBoard XOM [9] containing the dual core processor TI DM3730, ARM kernel works at 1 GHz and DSP kernel at 800 MHz. The device disposers of 512 Mb SDRAM and the connectivity capabilities consist of DVI-D video output connector, audio output connector, USB 2.0 OTG port and Ethernet adapter.

The software application was written using Qt [10] as a cross-platform C++ integrated development environment and OpenCV library [11] for image processing. Should be noticed that hardware acceleration offered by DSP kernel is not used because the functions from OpenCV library are not optimised to run on digital signal processors. The software application is organized on three layers, as it is presented in fig. 2.

The input layer manages image acquisition with 640x480 resolution and a rate of 25 frames per second. The acquired image is pre-processed (like horizontal flipping, filtering, inverse threshold binarization) in order to obtain suitable information for eye pupil detection by the second level. At each AsistysPatient application launching, the input layer also executes the module for region of interest (ROI) establishment (the image region where the eye pupil is).

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The keywords list browsing is ensured by a friendly graphic user interface. In the beginning of application, the message “Blink twice to start keywords display!” is displayed on screen. After the display starts, the patient should move his eyes to right or left in order to rotate the categories or keywords list in concordance with gaze direction. The keywords collection is organized as a tree structure having wide and short topology. The breadth first traversal method is used for keywords searching and for an easy and fast comeback to the upper levels. “Go back” images are placed at the right and left limits.

If a category pictogram is selected by a voluntary double blinking, the corresponding keywords list is displayed and if a keyword is selected, its assigned message is sent to server. It should be mentioned that every keyword is accompanied by a related pictogram and a background text colour. These three information types form an image that could be selected by the patient. Each time when an image is displayed in the middle of the screen the patient hears the related keyword in his speakers.
IV. EYE TRACKING METHOD

The milestone of integrating eye movements into human computer interaction is the implementation of a reliable eye tracking method. Parkhurst and Li [12] proposed the Starburst algorithm that extracts the location of the pupil centre and the corneal reflection so as to relate the vector difference between these measures to coordinates in the scene image. After locating and removing the corneal reflection from the image, the algorithm identifies the pupil edge points using an iterative feature based technique. In the beginning of our research, the Starburst algorithm implementation on a PC provided good results for point of gaze detection although the stability was not very high. Due to important hardware resources requested by Starburst algorithm, it was almost impossible to obtain an efficient implementation for it on a mobile embedded system. Another approach was necessary to explore. The proposed method for eye tracking is based on the binarization algorithm and its diagram is presented in fig. 3.

The first task of eye tracking algorithm is performed by “Image acquisition” module and consists in image acquisition with 640x480 resolution and 25 frames/second. The acquired images are converted in grey images with 256 levels by “Image processing” module. A blur filter is applied to each image to reduce image details and noise, e.g. the bokeh effect produced by an out of focus lens or object shadow under usual illumination. Then, the image is horizontally flipped in order to obtain the same coordinates both for screen and webcam. These actions are necessary because the camera is facing the user and not the monitor so the eye movements are reversed.

The algorithm supposes that the darkness pixels from image correspond to eye pupil. But, some others points compete for darkness points feature and generate uncertainty in pupil position detection. This inconvenient is solved by establishing the region of interest within which the eye pupil is. This task is performed by “ROI setup” module, each time when application is launched or when user requests this operation. ROI setup consists in the following steps:

* Each image is bordered at the outer limits corresponding to eyebrows and corner of the eye where the light creates a shade most of the time. Bordering means filling with white and in this way a great amount of possible noise is reduced. Border thickness was empirically established.

* An inverted binary filter is applied. The threshold adapts itself (by increasing/decreasing) more accurate to the environment conditions after every acquired frame. Thus, if a change occurs in image illumination the algorithm succeeds to adapt itself to the new conditions in a few frames. Note that if the eye trace goes beyond region of interest because of sudden changed conditions, the image is considered not steady and waits the filter to adapt itself.

* For the obtained image, the percentage of white pixels (imgWP) in region of interest is computed. Then, it is checked if imgWP is in the settled range. Note that imgWP represents the white pixels percent for the whole image and was empirically established and ε is the accepted tolerance. If imgWP is in the settled range the mass centre of white pixels is computed and the ROI and binary threshold are settled. The ROI establishment is necessary to increase computation efficiency because every following calculus will be done in this region.

Figure 3. Eye tracking method diagram
After region of interest establishment, the "ROI setup" module is hold on and waits for a new request. Meanwhile, the message "Detection in progress" is displayed on the screen.

The next stage consists in detection itself and is performed by "Eye tracking" module. Each grey image already flipped and filtered previously is processed by the binarization algorithm. A threshold can be used to create binary image (each pixel is only black or white) from a greyscale image. The initial value of the binarization threshold is provided by "ROI setup" module and it is incremented or decremented to have a suitable value for next image.

The center of the eye pupil corresponds to the center of mass of the image with only white pixels from the region of interest. If the percentage of white pixels decreases very quickly (patient closes his eyes), a blink is detected and the binarization threshold is not modified.

In order to determine the point on the screen at which the patient gazes, a mapping function between webcam eye position coordinates and monitor coordinates was implemented. This is done by a calibration procedure. According to Parkhurst [12], the calibration method which has the lowest error degree is based on biquadratic function. This nonlinear mapping function needs nine calibration points for determining coefficients values. The points with known coordinates are displayed on the monitor in a 3x3 grid and divide the screen in four quadrants. The mapping functions are widely described in [13].

The patient gazes all the nine points one by one and the pupil positions are stored related to webcam coordinates. These calculations for mapping functions are done by "Calibration" module. "User input" module determines the cursor position on monitor screen. All calculations can be performed in real time.

Based on cursor position coordinates, the "User input" module decides to rotate the screen image to right or left in concordance with patient’s eyes movement. If the time between two consecutive blinks is shorter then a fixed value (1 second) these blinks are considered to be a selection of the image from the middle of the screen (a keyword or category of words).

The eye-tracking algorithm was tested with the help of 25 volunteers. There were encountered only two errors: the volunteers were highly makeup young ladies and some others value for img/WPS and accepted tolerance had to be chosen.

The binarization algorithm is sensitive to light intensity but the detection is stable and accurate in comparison with Starburst. Obviously, the most important advantage of binarization algorithm is lower computational effort that makes possible its implementation on embedded system

V. RESULTS AND CONCLUSIONS

The proposed communication system fits with assistive technology initiative and aims to provide a mobile and low cost device for human computer interaction. This research presented in this paper is based on a good collaboration with medical staffs from neurology hospitals. The doctors and nurses suggested important details regarding communication facilities. Patients’ reaction important hardware and software optimization.

The prototype of the proposed system has been tested at Clinical Emergency Hospital “Bagdasari-Arzen” in Bucharest. For each patient a bioethical agreement was accepted by the patient or his family. The evaluation and testing protocol consisted of system presentation and demonstration, patients’ acquaintance with the keyboard selection method using the special glasses with webcam assistance for calibration method and patient training.

After tests, every patient or family member filled a likert questionnaire with nine questions concerning the tested communication system. The questions considered the satisfaction degree of communication, system usability, communication based on keywords, keyboard selection mode, and system utility. The system was rated with 210 points from 225 maximum possible. The communication system was also evaluated by medical staff and the overall score was of 18 from a maximum of 25.

The experiments made with patients have confirmed a positive impact of the proposed communication solutions and the reliability and accuracy of the eye tracking method.

REFERENCES
