Abstract—The present article describes a new concept to detect the cephalic position. This concept conceives a methodology of low cost computational and provisional that it allows a man-machine communication, based on the localization of the voluntary cephalic position. The program works with image processing and the cephalic position has a rate of 1/50 of second. The system does not require calibration and the user just requires an emitter which has a weight smaller to 2 grams to interact.

Index Terms—Virtual keyboard, communication methodology, interactive communication, cephalic assistance, disabled.

I. INTRODUCTION

The man-machine interactive systems have been designed principally to be used with hands due to the approach that can be realized with them. In recent years various projects have been developed to provide the computer which has been denominated perceptual interfaces [1]-[4]. The aim of these interfaces is to communicate with the machine through gestures or corporeal movements [5] with the machine, nevertheless, the methodologies that have been used until this moment are computationally expensive, for this reason they are not suitable to be applied as useful interfaces.

In our laboratory we have developed a perceptual interface based on image processing [6] using a different concept. Instead of processing the cephalic image, we proposed to use the cephalic image with an active distinctive in the infrared (IR) spectrum, this allows to accelerate the localization process and to increase the localization precision. The contribution of this work of is the use of a spatial localization system in 2D which works by absolute scanning of the pixels and its development is based on the optimized recognition of images.

II. MATERIALS

The configuration of the work is divided in two basic parts, the first one consists on a LED IR TN153F ($\lambda = 929$ nm) with power of dissipation of 100 mW, current of consumption of 50 mA placed on the user’s head, this represents the interactive infrared identifier (IIR) and the second part consists of a spatial sensor and a spatial localizer using a personal computer with 350 MHz Pentium II microprocessor, a CCD Rainbow camera model 75 to 1:18 disposed with a IR filter in its focus, a frame grabber CX100 with 1/60 s low resolution ($256 \times 256$ pixels) working at gray scale (256 levels of gray).

The localization system is presented in Fig. 1; it consists of the IR emitter placed on the user’s head, the CCD register camera disposed with IR filter placed in front of the user, as well as the personal computer with the frame grabber and the main program for the acquisition, registration, analysis and localization. The software algorithms for the visual interface in the screen were implemented on the compiler of Microsoft Visual C++™.

III. METHOD

The recognition system of cephalic position of the user’s head is based on the idea of placing a radiant body of light in the head of this in such way that the camera constantly captures the image of the emission of IR light. The light emitter is placed in frame of eyeglasses which does not exceed a weight 10 g. To avoid any type of connection to the supply line that could represent any danger for the user due to bad or faulty instrumentation, it feeds with a 9 V battery to isolated the user electrically. Since the system is supposed to be used per prolonged periods of time, the consumption of power of an emitter is relatively elevated, that is why the time of operation must be reduced to prolong the battery’s life. For this reason, an a-stable oscillator was designed in order to have light emissions just within short periods of time. The oscillator frequency was set to 8.8 kHz to avoid aliasing distortion in the image.

An important issue in this work is the location of the camera, that it represents the sensor of space localization in our system. This is placed on the monitor of the computer with an adjustable revolving base to have the best angle in reception of the image. The user must be placed opposite to the monitor of the PC, in approximately 50-60 cm of distance, to which the manufacturers assure that the generated electromagnetic emissions do not affect the user’s health. The reason of appealing to that technique...
is the advantage that provides us the area of reception of the image that embraces the camera, which due the relation in the lenses of the same one, it results to be enough to capture the space of cephalic displacement. Another important issue is the visual feedback that the user has, since he can have pursuit its cephalic position that the sensor captures due to the acquisition and localization programs. This permits the user to regulate the system and it conforms him to move his head and changes the pointer’s position. In this way, he may relate visually in the screen the spatial changes.

The flow diagram of the main program is shown in Fig. 2. This acquisition block provides an image, like the one presented in Fig. 3, where the use of the IR emitter and IR filter incorporated in the camera allows a threshold that it facilitates the process of eliminating the objects and surrounding luminous fountains on illumination ambiences which are not uniform in real time.

Considering the characteristic wavelength ($\lambda$) of the IR light, and that this system can be used in different environments of natural and artificial illumination, optic cautions were taken so that this does not represent a conflict in the processing and the existence of the smallest possible “noise”.

After the infrared filter that corresponds to the first stage of thresholding in real time, it proceeds to digitize the image and after to this step it realizes the first part of the analysis of the captured image. An off the shelf CX100 from Imagination Vision System company was used as an interface for acquisition of the images. It transforms the input analog image into the digital 256 gray levels images. The acquisition speed of is 1/60 s. Faster acquisition card increases the cost in a substantial and unnecessary way, and slower interfaces will be insufficient for the interactive process.

The thresholding process converts the input grayscale image into a binary output image as given by

$$g(x, y) = \begin{cases} G_0 & \text{for} \quad f(x, y) > T \\ G_b & \text{for} \quad f(x, y) \leq T \end{cases}$$

(1)

where the threshold value ($T$), and the two levels of the intensity values of the output image $G_0$ and $G_b$ are chosen a priori.

The centroid function given by

$$x_c = \frac{1}{A} \sum_{i=1}^{n} x_i, \quad y_c = \frac{1}{A} \sum_{i=1}^{n} y_i$$

(2)

provides the coordinates where the center of the luminous object is located on the image. Both (1) and (2) allow that the location of the user’s space cephalic coordinates be determined instantly.

The mirror function given by

$$x_k = x_k \cdot R_{x,\theta = -90}, \quad y_k = y_k \cdot R_{y,\theta = -90}$$

$$R_{x,\theta} = \begin{bmatrix} \cos \theta & -\sin \theta & 0 \\ \sin \theta & \cos \theta & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

$$R_{y,\theta} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos \alpha & -\sin \alpha \\ 0 & \sin \alpha & \cos \alpha \end{bmatrix}$$

(3)

allows the user to relate his cephalic position on the screen as if it was a mirror. An important consideration is that the transformation space just is realized over $x_k, y_k$ points to save the machine time.

IV. RESULTS

Once the program has been optimized it proceeded to estimate with an instruction inside the main program the global time of localization, giving a time average of 0.02 s. To determine the space of the user’s work with our system a virtual reality helmet VF1 (Interactive Imagine Systems) was used as shown in Fig. 4, which provides the location of the head in degrees. It has a calibration software in YAW, PITCH and ROLL, each one with their own reference frame. Each axis has 12 bits position sensors.
The workspace coordinates of the VFX1 and their space transformation are presented in Fig. 5 to realize the analysis with the emitting. Figs. 6 and 7 show the results of the system’s workspace IR with visual feedback valued and the calibration system of VFX1, respectively.

Figs. 6 and 7, it can be appreciated that the user has a space of symmetric workspace in both sides of the screen ±45 in the X axis, and ±30 and ±22 degrees in the Y axis, where the localization precision will depend on the scaling factor that is required on the graphic platform.

V. DISCUSSION

Contrary to other systems [1]-[8], this system of space localization in 2D of discreet scanning of pixels is distinguished to be a friendly system for the user, because it does not require circuitry of unidirectional localization of the infrared emitter, eliminating the errors for calibration.

The system of cephalic localization has the following variable components: the diameter of the IR originator, the user’s distance to the camera, the camera’s focus and the camera’s degree of inclination. To evaluate the system, we used 10 different peoples which were asked to establish their preferences for daily space limits that a normal person has with a PC. The findings showed that the distance of 50 cm from the screen provides good interactive results. Experimentally, we found that it is superior to facilitate within the system a setting that allows the user to adapt his/her space interactive limits by himself/herself using the variable components of the systems.

Finally, we consider that the system of cephalic position, for their characteristics of speed and the user’s localization in two dimensions, it can be used to manage interactive graphic programs, that is to say, in informatics projects as a pointer of absolute localization in 2D, or as a virtual joystick using hysteresis areas of activation [9]. The access to a submenu can be realized by taking the advantage of the time or the user’s voluntary delay on any area of the submenu. The system can also be used in the analysis of the time of reaction in localization of objects, of virtual reality and attendance for motion disabilities among others.

VI. CONCLUSIONS

The present work not only represents a new navigation methodology for visual computer environments but also it extends its usage in other applications. The proposed communication methodology can be used by temporary immobilized patients like intensive care patient. The people with disabilities can have a fast training to develop any specific work with a computer tool. Other potential applications are in places which people are faced with reduced work environments or where the free hand disposition may be necessary, and it can enhance the human-machine communications.

Finally, the proposed tool allows establishing a standard in computer interaction, which can be used to develop different software that can interact with this tool.

REFERENCES

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