Gestures Controlled Audio Assistive Software for the Voice Impaired and Paralysis Patients

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Abstract-- Voice impairment is a barrier to the treatment of old age neurodegenerative disorders and paralysis where patients fail to convey their thoughts to doctors and caretaker. Though voice enhancers are available it’s very costly. The aim of our research work is to develop a ‘Gestures Controlled Audio Assistive Software’ (GECAS) which make the subject’s life easier and available free of cost to the people. The objective is to design software which enables severe cerebral palsy and also the voice impaired people to vocalize their basic needs like water, food, doctor and lavatory through a facial and body gesture. Our designed software is compartamentalized into two modules; one detecting subject’s gestures using Camera mouse and the other responding in audio output. It is created using Microsoft Visual Studio 2015 (a freemium platform) which open sourced. The designed software is implemented and tested on 32 subjects and the result was analyzed using statistical tool Minitab. The conclusion of the result showed impaired patients can operate the software as effectively and efficiently as a normal person which may help the subject to live more independent life and make their treatment easier.

Keywords-- Neurodegenerative Disorders, Paralysis Patients, Camera Mouse, Audio Assistive Software, Gesture Control.

1. INTRODUCTION

There is an increase in the people population who suffer from paralysis which afflict their ability of communication and also limits the movability hindering their basic needs like food, water, lavatory and calling for doctor in case of emergency [1]. This disability can be caused due to trauma, tumors, stroke, and neurodegenerative disorders and also as a result from traumatic injury which affects the central nervous system (CNS) or peripheral nervous system (PNS) or can be caused due to amputations of the lower or upper extremities. Popular assistive technology systems, which controls computer, are being used since the beginning of computer era [2]. Hitting the switch, it scans through a matrix of symbols, letters, words or phrases and this allows us to enter a data in a computer and act as an alternative to a traditional keyboard.

With the help of switch operations, each matrix entry can be chosen. Recent studies in the area concentrates on dynamically adapting column scan delays and matrix row for increasing the text entry without any complications of visual display [3]. Because of the inability of a physically challenged to communicate at effective rate, this is an important issue. [4] Physically challenged people who have the ability of moving their heads have other assistive technology options, like numerous commercially available alternatives to the regular computer mouse. Infrared emitters that were attached to user's head band, glasses, or caps are also being used. While others use a transmitter over the monitor and an
infrared reflector attached to the user's forehead or goggles [5]. The cursor on the screen is being controlled by the movement of user's head. A physical switch or a software interface are used make mouse clicks. Evans et al. recently defined infrared emitter control system which was head mounted as a 'relative' pointing device that behaves like a joystick. [6] An infrared based device was developed by Chen et al which included an infrared led, acting as transmitter on a mounted glass which can be activated using touch panel on the tongue, it also consists of infrared receiver which check for response. This setup can be used an alternative to keyboard [7]. Eye glasses electrodes, Helmets, and mouth sticks are wearisome to use. Head-mounted devices which are commercially available can often nonadjustable to fit on a child's head. In most cases, disabled subjects particularly young children, are annoyed been touched in their face and any devices attached to their heads. Reilly and O’Malley et al, developed, system based on infrared and the speckle pattern of skin resulting from the reflection of laser [8]. There are other commercial systems which are based on measuring corneal reflections. It determines pupil movement and position in an image of an eye of the user. [9]-[11]. Other available devices are based on electrooculography potential (EOG) measurement to detect movement of eye [12], [13], [14] or based on electroencephalograms signals [15], [16]. “Eagle Eyes,” was designed by Gips et al which is based on EOG-signal used to move the mouse with the help of eye movement [17], [18]. The requirement of careful calibration, keeping the head almost completely still and the expensiveness are the disadvantages of corneal reflection systems. For example, the Permobil Eye Tracker, which uses goggles with infrared light emitters and diodes for detection of eye-movement, costs between Rs.6,43,846.50 and Rs.14,60,686.10. Now, in modern world, research developments assure economical gaze-tracking solutions [12].

To overcome this problem, we developed an assistive software system which can be operated with basic movement of body parts which are unaffected due to paralysis such as eyes gesture, face movement or movement of a tongue. The software has been developed using a camera mouse system and Microsoft Visual basic IDE. The facial gestures or selected object movement is captured using a webcam and is processed using camera mouse which helps to select predefined option of the graphical user interface (GUI) and results in audio output [Fig.1].

The quantitative Analysis was carried out on 32 subjects who include 17 normal and 15 physically challenged persons. To check the feasibility of the software and comparative study was carried out by dividing the subject into various groups which were analyzed using statistical software Minitab and the result shows the great similarity between the mean and standard deviation (SD) values of both normal and physically challenged subjects which shows that the affected patients can use the software equivalently as the normal person.
2. MATERIALS AND METHODS

The design of the study is to use a Graphical User Interface developed using Visual Studio in integration with Camera Mouse system on impaired patients who were instructed about Camera Mouse System before s/he started using the program.

A. Camera Mouse Program

It is an open source software program installed on a windows computer which is equipped with a web Camera, keyboard and mouse. It consists of two computers that are combined together; a “user computer” and a “vision computer”. The Vision computer act as a back end program which is responsible for visual tracking algorithms and gives the present location of the feature that is tracked to the user computer. The output of vision algorithm is responsible for the cursor movement in the user computer which is acting as a front end display. [18,19].

![Fig. 2: Camera Mouse Interface of the Software](image)

B. Graphical User Interface

User Interface was designed using an integrated development environment (IDE) -Microsoft Visual Studio 2015 (Microsoft.). It is a GUI based IDE and is use to develop the front end user Interface of our application [20]. Microsoft SAPI (Speech Application Programming Interface) was used to produce audio output. This API provides a clear and accurate speech output with accurate recognition. [21].
C. Statistical Analysis

Firstly, subjects were given a short introduction of our software. After subjects were been comfortable to use the software they were assigned with 7 tasks which were calling doctor, nurse, asking for food, water, coffee, tea, and toiletry.

Three attempts to do each task were performed by the subject and the response time for each task was recorded in the form of data sheet.

Afterwards the calculated means were analyzed by using Minitab. The time series plot for the data was plotted for three group i.e.

a) Group 1: All Normal and Disabled Subject.

b) Group 2: All Normal and Disabled Subject of under age of 30.

c) Group 3: All Normal and Disabled Subject of above age of 30.

The data of 32 subjects were taken and stored in tabulated form which was imported as datasheet in Statistical analysis software (Minitab Express, Minitab, Inc., Pennsylvania). It is a general-purpose statistical software package designed for easy interactive use. The software was used to measure the mean and standard deviation of each group for each parameter, and inferential statistics.

D. Calculation

Firstly, subjects were given a short introduction of our software. After subjects were been comfortable to use the software they were assigned with 7 tasks which were calling doctor, nurse, asking for food, water, coffee, tea, and toiletry.

Three attempts to do each task were performed by the subject and the response time for each task was recorded in the form of data sheet.

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c) Group 3: All Normal and Disabled Subject of above age of 30.

The summary of statistics of each group for each parameter was found showing the mean, standard deviation, minimum and maximum values. [23] [24].
Mean $\mu = \frac{1}{n} \sum_{i=1}^{n} f x$

Where $x$ – mid interval value of each class; $f$ – frequency of each class; $n$-total frequency;

Standard deviation $(\sigma_x) = \sqrt{\sigma^2}$; where $\sigma$ – variance

3. RESULTS

For study investigation, 32 subjects taken, among which 12 were normal and 20 were physically challenged, 7 were voice impaired people, 5 were hemiplegic, and 7 were suffering from aging Neurogenesis.

They were divided into three group i.e.

a) Group 1: All Normal and Disabled Subject.

b) Group 2: All Normal and Disabled Subject of under age of 30.

The various results are showed in table 1, table 2 and table 3.

Table 1: Comparison of mean and standard deviation values of all normal and disabled subject

| Task | Mean all normal Subject | SD all normal Subject | Minimum | Maximum | Mean all disabled Subject | SD all disabled Subject | Minimum | Maximum |
|------|-------------------------|-----------------------|---------|---------|---------------------------|-------------------------|---------|---------|
| Doctor | 3.11 | 0.53 | 1.81 | 4.29 | 3.18 | 0.63 | 1.81 | 4.29 |
| Nurse | 2.74 | 0.42 | 2.07 | 3.63 | 2.75 | 0.29 | 2.29 | 3.63 |
| Food | 2.74 | 0.57 | 1.28 | 3.49 | 2.50 | 0.35 | 2.07 | 3.28 |
| Water | 2.83 | 0.32 | 2.10 | 3.54 | 2.88 | 0.43 | 2.10 | 3.84 |
| Tea | 2.83 | 0.48 | 1.63 | 3.92 | 2.61 | 0.60 | 1.93 | 3.92 |
| Coffee | 2.52 | 0.43 | 1.70 | 3.51 | 2.76 | 0.49 | 1.96 | 3.51 |
| Toilet | 2.29 | 0.60 | 1.53 | 3.63 | 2.50 | 0.23 | 1.57 | 3.57 |

Table 2: Comparison of mean and standard deviation values of normal and disabled subject of under 30 years of age

| Task | Mean Normal Subject<30 | SD Normal Subject<30 | Minimum | Maximum | Mean Disabled Subject<30 | SD Disabled Subject<30 | Minimum | Maximum |
|------|-------------------------|----------------------|---------|---------|--------------------------|-------------------------|---------|---------|
| Doctor | 3.03 | 0.48 | 1.86 | 3.51 | 3.23 | 0.41 | 2.85 | 3.87 |
| Nurse | 2.77 | 0.43 | 2.07 | 3.34 | 2.63 | 0.11 | 2.47 | 2.76 |
| Food | 2.78 | 0.58 | 1.28 | 3.49 | 2.59 | 0.37 | 2.22 | 3.15 |
| Water | 2.88 | 0.28 | 2.10 | 3.11 | 2.98 | 0.22 | 2.76 | 3.24 |
| Tea | 2.84 | 0.50 | 1.82 | 3.62 | 3.09 | 0.89 | 1.63 | 3.92 |
| Coffee | 2.59 | 0.37 | 1.84 | 3.12 | 2.64 | 0.55 | 2.06 | 3.31 |
| Toilet | 2.36 | 0.58 | 1.97 | 3.63 | 2.61 | 0.73 | 1.91 | 3.57 |
Table 3: Comparisons of mean and standard deviation values of all normal and disabled subject of above 30 years of age

| Task   | Mean Normal Subject > 30 | SD Normal Subject > 30 | Minimum Mean Normal Subject > 30 | Maximum Mean Normal Subject > 30 | Mean Disabled Subject > 30 | SD Disabled Subject > 30 | Minimum Mean Disabled Subject > 30 | Maximum Mean Disabled Subject > 30 |
|--------|--------------------------|------------------------|----------------------------------|----------------------------------|----------------------------|--------------------------|-----------------------------------|-----------------------------------|
| Doctor | 3.20                     | 0.65                   | 2.63                             | 3.76                             | 3.16                       | 0.70                     | 1.81                              | 4.29                              |
| Nurse  | 3.05                     | 0.34                   | 2.74                             | 3.30                             | 2.79                       | 0.32                     | 2.29                              | 3.63                              |
| Food   | 2.53                     | 0.45                   | 2.10                             | 2.91                             | 2.46                       | 0.33                     | 2.07                              | 3.26                              |
| Water  | 3.10                     | 0.47                   | 2.56                             | 3.49                             | 2.85                       | 0.48                     | 2.10                              | 3.84                              |
| Tea    | 2.37                     | 0.45                   | 1.63                             | 2.68                             | 2.44                       | 0.39                     | 1.63                              | 3.03                              |
| Coffee | 2.63                     | 0.44                   | 1.96                             | 3.00                             | 2.80                       | 0.48                     | 1.96                              | 3.51                              |
| Toilet | 2.40                     | 0.51                   | 1.87                             | 2.89                             | 2.46                       | 0.47                     | 1.57                              | 3.19                              |

Fig. 4: The Comparison of mean values of different groups were plotted on Time Vs Task
a) Group 1: All Normal and Disable Subject.

b) Group 2: All Normal and Disable Subject of under age of 30.

c) Group 3: All Normal and Disabled Subject of above age of 30.

The comparative result for group 1 which include all normal and disable subject showed: 2.72± 0.48 and 2.74± 0.47 which makes disabled person just .2 secs behind the normal subject. Similarly, for group 2 and group 3 the means value was found to be (2.75±0.46 and 2.83±0.47) and 2.76±0.47 respectively which suggested that the software response time is equivalent to both normal as well as disabled subject.

4. DISCUSSION

Perkins et al. made use of an environmental control program that allowed the disabled people to control the output devices (heaters, lights, radio and television) from the user control switches and were able to scan the controlled features which were displayed in a menu [2]. In Shein et al. (1984) developed a dual-computer system which had all the items displayed in Blissymbols for people who are unable to speak [3]. Gregg Vanderheiden et al. compared the long-range optical pointer and the SPA-SYN-COM (TM) pointing device. The comparison was done on the children with cerebral palsy and adults with high spinal cord injuries [4]. Takami et al. developed an environmental control system that helped handicapped people to operate in bed side. It used detection of three dimensional head movement and realization of three LED marks by image processing on the glasses [5]. D. G. Evans et al. designed a low-cost head-operated joystick using an infrared light emitting diodes (LED’s) and photo detectors for determining the head position, which was then converted into signals that emulated a Microsoft mouse[6]. By the Y. L. Chen et al. developed an eyeglass-type infrared (IR)-controlled computer interface for those suffering from spinal cord injuries to use a computer[7]. By the study of R. B. Reilly et al. had described an adaptive noncontact gesture-based system used for augmentative communication. Users were initially found to experience some difficulties in controlling the cursor about the application screen. Nevertheless, once the relationship between head movement, movement speed and movement of the resulting cursor were learnt, the user’s improvement with the system progressively increased. The success level and accuracy level were dependent on the training amount and on the degree of head control demonstrated by the user [8]. T. Hutchinson et al. developed Erica, a computer workstation that executed commands which were associated with the menu option displayed at the screen. It had a unique user interface and commands were executed through user’s eye-gaze on the computer screen. The most important limitation of their developed technology concerned the bright-eye effect and also required testing, training, targeting, data entry, and control setting based on different occupational [10].

In C. H. Morimoto et al. offered an eye gaze tracking system which was based on a robust affordable real-time pupil detector prototype which consist of two IR light sources synchronized with threshold value of even and odd fields of a video camera, calculation of vector between the centers of the CR (Corneal Reflection) and the pupil that result for an eye gaze tracking system that can used for Human Computer Interface. This real-time prototype is current running at 30 frames per second (frame-rate) using interlaced images of resolution 640 * 320 * 8 bits, on a dual PII 400MHz platform but their limitation is on free head motion [11].

In the previous discuss researcher their work and contribution are generally using only specific method for providing assistive control such as head movement, eye movement, coordinating lower limb and upper limb etc. and the system was quite less portable and not easy to use as it is not free motion movement and very specific parts’. In our purpose system has developed a features based on Visual Studio and camera mouse Software’s which can use to track any part of the end user body and also much
focused on patient specific and developed program can be modified for different places such as hospital ICU, Hospital canteens, Rehabilitation centers, and child care and physiotherapy center.

5. CONCLUSION

The designed software perform well and also it was very easy to use. The tracking System was very responsive and was accurately tracked a person’s nose and other body features with ease in case of both normal as well as disabled subjects for without any failures. Though the disable subject response time was slightly greater with a difference of few mille second which shows that disable person can use the software as efficiently as normal person which may help the subject to live an easier life and will overcome their day to day problems by fulfilling their basic needs.

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