

Eye Movement Based Electronic Wheel Chair For Physically Challenged Persons

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Abstract: A powered wheel chair is a mobility-aided device for persons with moderate/severe physical disabilities or chronic diseases as well as the elderly. In order to take care for different disabilities, various kinds of interfaces have been developed for powered wheelchair control; such as joystick control, head control and sip-puff control. Many people with disabilities do not have the ability to control powered wheel chair using the above mentioned interfaces. The proposed model is a possible alternative. In this paper, we use the optical-type eye tracking system to control powered wheel chair. User's eye movement are translated to screen position using the optical type eye tracking system. When user looks at appropriate angle, then computer input system will send command to the software based on the angle of rotation of pupil i.e., when user moves his eyes balls up (move forward), left (move left), right (move right) in all other cases wheel chair will stop. Once the image has been processed it moves onto the second part, our microprocessor. The microprocessor will take a USB output from the laptop and convert the signal into signals that will be sent to the wheelchair wheels for movement. Also, the pressure and object detection sensors will be connected to our microprocessor to provide necessary feedback for proper operation of the wheelchair system. The final part of the project is the wheelchair itself. The rear wheels will provide forward. The front two wheels will be used for steering left and right. All four wheels will be connected to our microprocessor that will send signals to control the wheels and thus the overall movement.

Index Terms: Electronic wheel chair, Daugman's Algorithm for finding center of the pupil, Eye movement based wheel chair, Daugmans algorithms, Integrodifferential operator, Finding pupil location, Electronic wheel chair using Image analysis method or technique.

1 INTRODUCTION

THE ability to move freely is highly valued by all people. However, it is sometimes difficult for a person with a physical disability. Nowadays, an electric wheelchair is commercially available for disabled people. It generally requires considerable skill to operate. Moreover, some disabled people cannot drive an electric wheelchair manually, even with a joystick, because they lack the physical ability to control the movement. To enable a disabled person to drive a wheelchair safely and easily so that they can enjoy a higher quality of life, researchers have proposed several electric wheelchair systems. The use of voice commands to control an electric wheelchair is one research result. A small number of command words and high-performance voice recognition are employed in this system. An electric wheelchair control with electro-oculography (EOG) techniques has also been proposed. In this case, the different commands for the wheelchair are derived from the electro-oculography (EOG) potential signals of eye movements. A system for electric wheelchair control using the eyes was proposed in 2007. A commercially available web camera on a head-mounted display (HMD) which the user wears is used to capture moving pictures of the user's face.

captured image data, detecting and tracking movements of the user's eyes, estimating the line-of-sight vector, and actuating the electric wheelchair in the desired direction indicated by the user's eyes. One of the key essentials of the proposed system is detecting and tracking the eye movements. This article will be an eye movement based controlled wheelchair system. A spectacle mounted camera will track eye movement and control a wheelchair to go forward, stop, left or right. The most challenging aspects will lie in finding a good way to differentiate iris and pupil locations, determining the eye's movement, and controlling the wheelchair's wheels in proper movement.

2 PROBLEM STATEMENT

To develop an eye movement controlled wheel chair for physically challenged persons to move in any desirable direction.

3 LITERATURE SURVEY

The existing computer input devices such as keyboard, mouse, and the other input devices have been used to interact with digital instruments. These computer input devices cannot be operated by handicap persons. In this paper, a computer input device by human eyes only is proposed for handicap person and also for wearable computing. The existing computer input devices can be divided into five categories:

- (1) Bio-potential based method which utilizes potential from user's body actions acquired by using special instrument. Instrument such as Electrooculography (EOG) [1], Electromyography (EMG), and Electroencephalograph (EEG) [2], Search coil can be used for measuring bio-potential. The search coil output can be used as sources of computer input for handicap person. EOG method [3] uses voltage differences between fore and aft surface of eyes.
- (2) Voice Based method [4], which use user's voice as source input. Voice analysis is used to analyze user's voice and convert into digital data. The weakness of this system is vulnerable against noise. Other voices which come from surrounding user may affect the

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A computer mounted on the electric chair processes the

system.

- (3) Motion based method [5], utilizes other normal movement organs to operate computer input. Head, foot, and etc. can be used to control computer input.
- (4) Image Analysis method [10]-[15], utilizes camera to analyze user's desire and convert into digital data. Several image processing methods are used to analyze user's desire. The user's desire itself can be done by Gaze based [6], [7], [9] analyze user's desire from users gaze, Face based analyze user's desire from face expression, and the others.
- (5) Search coil method [8] uses induced voltage with coil including in contact lenses attached to user's eyes.

METHOD	ADVANTAGES
Bio-potential based method.[1]	Potential Difference can be calculated easily in both light and dark Environments.
Voice Based Methods[2]	<ul style="list-style-type: none"> ▪ Increases Productivity ▪ Can help people who have trouble using their hands ▪ Can help people who have cognitive disabilities
Motion Based Methods[3]	A motion based wheelchair can have the option to allow for more physical support, including adjustable seating such as tilt and recline. Motion based wheelchair users can also adjust the height of the chair to see their environment more clearly
Search Coil[4]	Coil signals provide a better signal stability. Therefore, coil signals are better suited for the analysis of fine details of eye movements.

METHOD	DRAWBACKS
Bio-potential based method.[1]	Poor gaze direction accuracy compared to video tracker, relatively costly
Voice Based Methods[2]	Less accurate on: <ul style="list-style-type: none"> ▪ Background Noise ▪ Channel variability ▪ Speaker variability ▪ Speaking style ▪ Sex of the speaker ▪ Anatomy of vocal tract ▪ Speed of the speech
Motion Based Methods[3]	Uses human effort to navigate like joystick, etc., for a handicapped with any of the organs failed is not useful.
Search Coil[4]	Burden to user, here measuring time is limited to approximately 30 to 60 .They have limited Lifetime.

4 PROPOSED METHODOLOGY

4.1 System Overview

Consists of three main parts:

- (1) Spectacle mounted camera and laptop system that will track the camera wearer's eye.

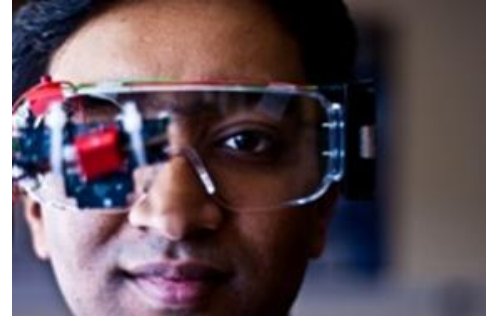


Fig. 4.1 Proposed Camera Position

- (2) The microprocessor will take a USB output from the laptop and convert the digital output to electric signals that will be sent to the wheelchair wheels for movement.



Fig. 4.2 Microprocessor

- (3) A signal triggered Wheel Chair.



Fig. 4.3 Electronic Wheel Chair

4.2 General Architecture

In Image Capturing Module, we capture the image using MATALAB and after perfect capturing of image it send to Image Analysis Module where segmentation of image is done and processing of finding the pupil and its direction is found out. In Microprocessor Interfacing, how to interface the generated electric digital output to electric input is discussed. And finally Microprocessor interfacing with wheelchair is discussed in that module.

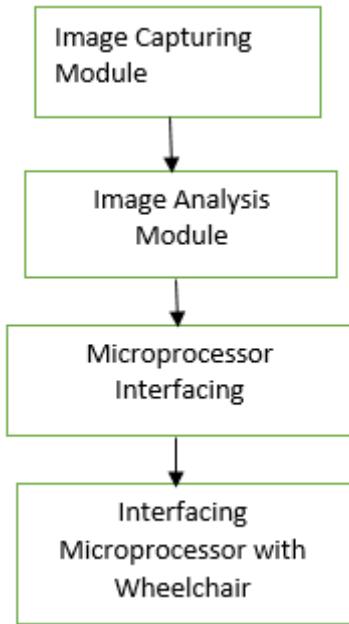


Fig. 4.4 General Architecture Diagram

4.2.1 Image Capturing Module

Image Capturing is to capture a sequence of iris images from the subject using a specially designed camera. In iris recognition image capturing is a very important step. Since iris is small in size and dark in color, it is difficult to acquire good image. The image is then changed from RGB to gray level for further processing. It is to capture a sequence of iris images from the subject using a specifically arranged camera. With an average diameter of 12 mm, a camera must have enough resolution to capture the details of the iris pattern.

4.2.2 Image Analysis Module

The main objective of segmentation is to remove non useful information, namely the pupil segment and the part outside the iris (sclera, eyelids, skin). Daugman proposes an integrodifferential operator to find both the pupil and the iris contour. The algorithm will perform the iris recognition in two phases. The algorithm used in the first phase, uses the knowledge that a pupil is a very dark blob of certain minimum size in the picture, and no other segment of continuous dark pixels are of the same size. The algorithm finds the center of the pupil and the two radial coefficients as the pupil is always a perfect circle. The second algorithm takes the information of the pupil center and tries to find direction in which the eye looks.

1. Finding center of the pupil.
2. Finding the direction in which eye looks.

STEP 1. Finding Center of the pupil.

Libor Masek's idea that reduces complexity significantly by scaling down all images to a constant image size to speed up the whole process. First step is to calculate the Gaussian blur function. A Gaussian blur (also known as Gaussian smoothing) is the result of blurring an image by a

Gaussian function. Mathematically, applying a Gaussian blur to an image is the same as convolving the image with a Gaussian function. This is also known as a two-dimensional Weierstrass transform [14-15]. The Gaussian blur is a type of image-blurring filter that uses a Gaussian function (which also expresses the normal distribution in statistics) for calculating the transformation to apply to each pixel in the image. The equation of a Gaussian function in one dimension is

$$G(x) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{-\frac{x^2}{2\sigma^2}} \quad (1)$$

Where x is the distance from the origin in the horizontal axis, y is the distance from the origin in the vertical axis, and σ is the standard deviation of the Gaussian distribution. When applied in two dimensions, this formula produces a surface whose contours are concentric circles with a Gaussian distribution from the centre point. Values from this distribution are used to build a convolution matrix which is applied to the original image. Each pixel's new value is set to a weighted average of that pixel's neighbourhood. The original pixel's value receives the heaviest weight (having the highest Gaussian value) and neighbouring pixels receive smaller weights as their distance to the original pixel increases. This results in a blur that preserves boundaries and edges better than other, more uniform blurring filters. Pupil location is found using Daugman's algorithm or otherwise known as integrodifferential operator for finding iris location. Using this we will track the location of pupil and get the coordinates of the centre of the pupil. Formula used by Daugman is

$$\max_{(r,x_0,y_0)} \left| G_\sigma(r) * \frac{\partial}{\partial r} \oint_{r,x_0,y_0} \frac{I(x,y)}{2\pi r} ds \right| \quad (2)$$

Where $G(r)$ function represents Gaussian Filter where the image is scaled to sigma size. It is the smoothing function blurred at a scale set by sigma, searching iteratively for the maximal contour integral derivative at successively finer scales of analysis through the three parameter space of centre coordinates and radius with x_0 , y_0 and r values. The equation thus becomes as

$$\max_{(r,x_0,y_0)} = \left\{ \frac{\partial}{\partial r} \int_0^{2\pi} I(r * \cos\theta + x_0, r * \sin\theta + y_0) \right\} \quad (3)$$

The speciality of this equation is even when the eye is at certain phase angle it can detect the center of the pupil, this is because line integration is checking the maximum gradient circle in that particular center values. That is for particular point it going to check at what angle the gradient is maximum. After obtaining the center coordinates of both iris and pupil we check both circles doesn't overlap and stays one inside the other that is inside iris circle pupil circle should be present and therefore decided that the obtained circles are correct and if fails then restart of the whole process takes place.

STEP 2: Finding the direction of the pupil

The input image given to the MATLAB for processing will produce an output image with the coordinates of iris and pupil. The size of the output image will be 320*240. The output image will be divided into nine blocks and the iris

coordinates in the center block will indicate the pupil position as Straight. Whereas the block in the second row and third column will indicate the position of pupil as left and similarly the block in second row and first column will indicate the pupil position as Right and the block in first row and second column will indicate the position of pupil as Top and the block in third row and second column will indicate the position of pupil as Bottom. The 320*240 output image will be divided into nine blocks by fixing the coordinates of each block. The 320*240 images will be considered as a rectangle with length 320 and of breadth 240. Since the breadth of the rectangle is responsible for dividing the rectangle into three rows, 240 should be divided into three parts. But in order to reduce errors the Center or Second row is given a little smaller width. Similarly the length of the rectangle is responsible for dividing the rectangle into three columns 320 should be divided into three parts. To reduce errors the center or second part is made of smaller width. The coordinates of each output block is shown below.

Block (1, 2): The output coordinates of the iris satisfying below condition will detect the pupil position as Top.

Condition: if ((x > 120 and x < 188) && y < 105))

Block (2, 1): The output coordinates of the iris satisfying below condition will detect the pupil position as Right.

Condition: if ((y > 105 and y < 130) && x < 120))

Block (2, 2): The output coordinates of the iris satisfying below condition will detect the pupil position as Straight.

Condition: if ((x > 120 and x < 188) && (y > 105 and y < 130))

Block (2, 3): The output coordinates of the iris satisfying below condition will detect the pupil position as Left.

Condition: if (x > 188 && (y > 105 and y < 130))

Block (3, 2): The output coordinates of the iris satisfying below condition will detect the pupil position as Bottom.

Condition: if ((x > 120 and x < 188) && y > 105))

	0	120	188	320
105		Block (1, 2)		
130	Block (2, 1)	Block (2, 2)	Block (2, 3)	
240		Block (3, 2)		

Fig. 4.5 Proposed Direction Detection Technique

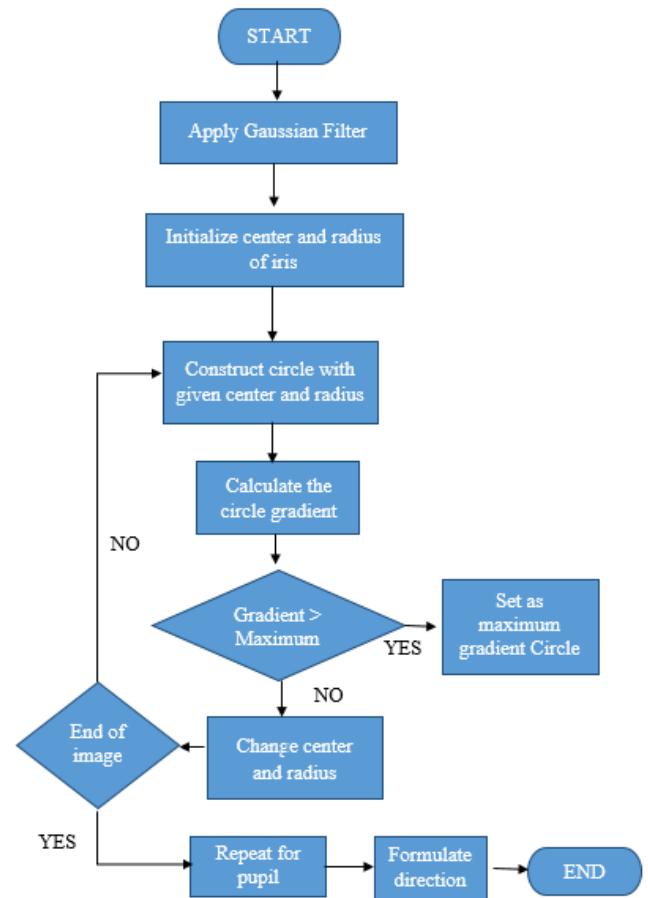


Fig. 4.6 Block Diagram for Image Capturing Module

5 EXPERIMENTAL RESULTS

1. The input and its corresponding images shown below are produced after using Daughman's algorithm on input image for processing in MATLAB. The position of iris and pupil detected will be highlighted with the help of a circle as show below. And the position of the image is detected and the decision for the given below input image will be produced as Straight.

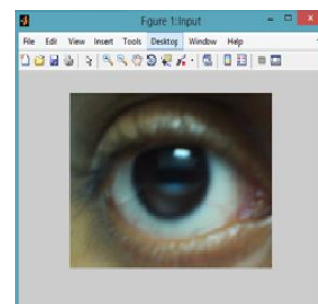


Fig. 5.1a Input for straight looking eye

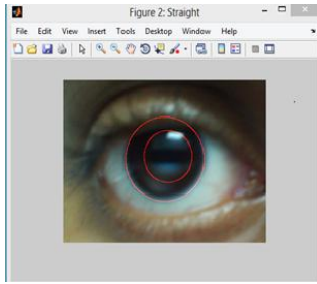


Fig. 5.1b Output obtained as straight looking eye

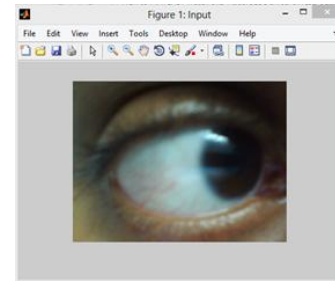


Fig. 5.3a Input for Left looking eye (as per user) and the image looks Right (as per computer)

- The input and its corresponding images shown below are produced after using Daughman's algorithm on input image for processing in mat lab. The position of iris and pupil detected will be highlighted with the help of a circle as show below. And the position of the image is detected and the decision for the given below input image will be produced as Right.

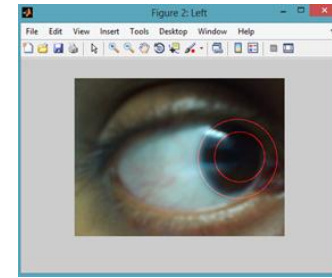


Fig. 5.3b Output obtained as Left looking eye (as per user) and the image looks Right (as per computer)

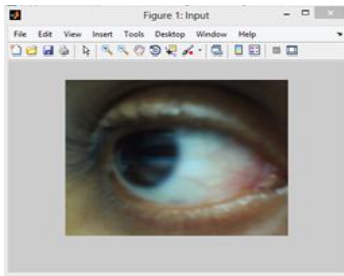


Fig. 5.2a Input for Right looking eye (as per user) and the image looks Left (as per computer)

- The input and its corresponding images shown below are produced after using Daughman's algorithm on input image for processing in mat lab. The position of iris and pupil detected will be highlighted with the help of a circle as show below. And the position of the image is detected and the decision for the given below input image will be produced as Top.

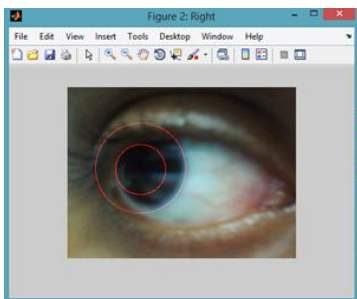


Fig. 5.2b Output obtained as Right looking eye (as per user) and the image looks Left (as per computer)

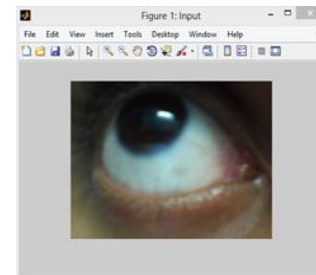


Fig. 5.4a Input for Top looking eye

- The input and its corresponding images shown below are produced after using Daughman's algorithm on input image for processing in mat lab. The position of iris and pupil detected will be highlighted with the help of a circle as show below. And the position of the image is detected and the decision for the given below input image will be produced as Left.

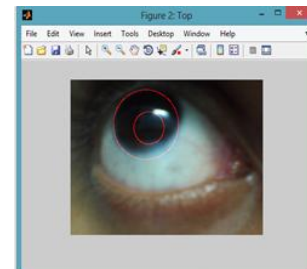


Fig. 5.4b Outputobtained asTop looking eye

- The input and its corresponding images shown below are produced after using Daughman's algorithm on input image for processing in mat lab. The position of iris and pupil detected will be highlighted with the

help of a circle as show below. And the position of the image is detected and the decision for the given below input image will be produced as Bottom.

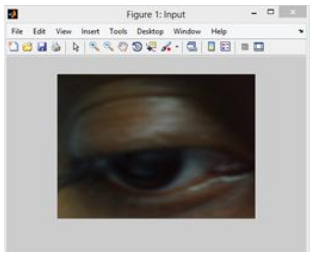


Fig. 5.5a Input for Bottom looking eye

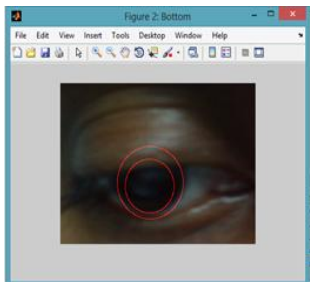


Fig. 5.5b Output obtained asBottom looking eye

6. The output produced from the mat lab will be sent as a digital signal to the microprocessor for wheelchair movement through RS-432 port. Below figure shows the simulation of hardware implementation by glowing a led for a particular digital input. Since we have five wheel chair movements the five digital inputs sent to the microprocessor will be as follows:

- 100 - Indicates the wheelchair movement as Straight by glowing the First LED named as D1.
- 010 - Indicates the wheelchair movement as Left by glowing the Second LED named as D2.
- 110 - Indicates the wheelchair movement as Right by glowing the Third LED named as D3.
- 001 - Indicates the wheelchair movement as Top by glowing the Third LED named as D4.
- 101 - Indicates the wheelchair movement as Bottom by glowing the Fourth LED named as D5.

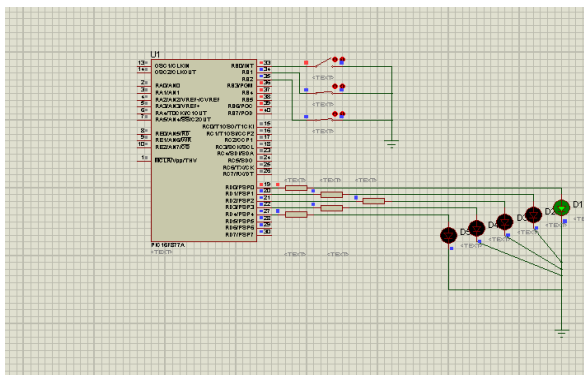


Fig. 5.6 Output obtained in simulator

6 CONCLUSION

This paper has presented a wheelchair system using eye movements, in which pupil detection that is segmentation is done using Daugman’s algorithm and deduction of direction in which pupil looks is decided by fixing range to the particular direction as user looks. Detection of pupil is done even on illumination unless the illumination is covering whole eye, this is because when the light hits the pupil and illumination spreads on the pupil covering whole pupil which ignores those pixels so as we treat the illumination spots it will leave behind a maximum change edges that cannot be determined and the operator will consider another position to be a iris location. This process works even if image taken in little dark environment.

7 REFERENCES

- [1]. K. T. V. Grattan, A. W. Palmer, and S. R. Sorrell, ‘Communication by Eye Closure-A Microcomputer-Based System for the Disabled’, IEEE Transactions on Biomedical Engineering, Vol. BME-33, No. 10, October 1986.
- [2]. Q.X. Nguyen and S. Jo, ‘Electric wheelchair control using head pose free eye-gaze tracker’, Electronics Letters, Vol. 48 No. 13, 21st June 2012.
- [3]. Rory A. Cooper, ‘Intelligent Control of Power Wheelchairs’, IEEE Engineering in medicine and Biology, 0739-51 75/95, July 1995.
- [4]. Djoko Purwanto, Ronny Mardiyanto, Kohei Arai, ‘Electric wheelchair control with gaze direction and eye blinking’, Artif Life Robotics, 14:397–400, May 18, 2009.
- [5]. Rinard et al., ‘Method and Apparatus for monitoring the position of the eye’, United States Patent, 4,145,122, Mar. 20, 1979.
- [6]. Er. Vijay Dhir & Dr.(Ms) Maitryee Dutta., ‘New Method of IRIS RECOGNITION Based on J.Daugman’s Pinciple’, Second International Conference on Emerging Trends in Engineering and Technology, ICETET-09.
- [7]. J.G.Daugman, “How iris recognition works”, IEEE Trans. Circuits and Syst. for video Tech. 14(1), 21-30(2004)
- [8]. Barea R, Boquete L, Mazo M, López E “Wheelchair guidance strategies using eog”. Journal of Intelligent and Robotic Systems 34: 279–299, May 2002.
- [9]. Iáñez E, Úbeda A, Azorín JM, Perez-Vidal C “Assistive robot application based on an rfid control architecture and a wireless eog interface”. Robotics and Autonomous, May 2012.
- [10]. Sibert LE, Jacob RJK “Evaluation of eye gaze interaction. In: Proceedings of the SIGCHI conference on Human Factors in Computing Systems”. New York, NY, USA: ACM, CHI '00, 281–

288, 2000.

- [11]. Society AE “American electroencephalographic society guidelines for standard electrode position nomenclature”. *Journal of clinical neurophysiology* 8: 200–202, 1991.
- [12]. Chen Y, Newman W “A human-robot interface based on electrooculography.” In: *Robotics and Automation, 2004. Proceedings. ICRA '04. 2004 IEEE International Conference on volume 1*, 243–248 Vol.1, 2004.
- [13]. G. Andrews, R. Askey and R. Roy, “Special Functions”, Cambridge University Press, New-York 1999.
- [14]. A. Erdelyi and all, “Tables of integral transforms”, Vol.II, Mc Graw-Hill Book Compagny, New-York 1954.
- [15]. S. Mitra, T. Acharya: “Gesture Recognition: A Survey, *IEEE Transactions on Systems, Man, and Cybernetics*”, Part C: Applications and Reviews, Vol. 37, No. 3, May 2007, pp. 311 – 324.
- [16]. L.R. Rabiner: “A Tutorial on Hidden Markov Models and Selected Applications in Speech Recognition”, *Proceedings of the IEEE*, Vol. 77, No. 2, Feb. 1989, pp. 257 – 286.
- [17]. S.K. Pal, S. Mitra: *Neuro-fuzzy “Pattern Recognition: Methods in Soft Computing”*, John Wiley and Sons, NY, USA, 1999.
- [18]. J. Liu, L. Zhong, and J. Wickramasuriya V. Vasudevan: “uWave: Accelerometer-based Personalized Gesture Recognition and Its Applications, *Pervasive and Mobile Computing*”, Vol. 5, No. 6, Dec. 2009, pp. 657 – 675.
- [19]. H. Junker, O. Amft, P. Lukowicz, G. Tröster: “Gesture Spotting with Body-worn Inertial Sensors to Detect User Aactivities, *Pattern Recognition*”, Vol. 41, No. 6, June 2008, pp. 2010– 2024.
- [20]. T. Schlömer, B. Poppinga, N. Henze, S. Boll: “Gesture Recognition with a Wii Controller, 2nd international Conference on Tangible and Embedded Interaction”, NY, USA, pp. 11 – 14.