Design and Implementation of Unique Video Oculographic Algorithm Using Real Time Video Processing on FPGA

Karthik K.P.¹ Basavaraju S.²
¹M.Tech Student ²Guide
¹²Department of Electronics & Communication Engineering
¹²Sathagiri College of Engineering, Bangalore

Abstract— Electro-oculography describes an eye-gaze interface using a biological signal, electro-oculogram (EOG). This interface enables a user to move a computer cursor on a graphical user interface using eye gaze movement alone. It will be useful as a communication aid for individuals with mobility handicaps. Although EOG is easily recordable, drifting and blinking problems must be solved to produce a reliable eye-gaze interface. This method will be painful process since the electrodes are pierced around the eyes in order to measure the potential difference using electrodes and to record the blink of an eye. Therefore video oculography is used in the proposed system.

Key words: EOG, Video Oculography, Eye – Gaze Interface.

I. INTRODUCTION

According to a study initiated by the Christopher & Dana Reeve Foundation, there are nearly 1 in 50 people living with paralysis—approximately 6 million people. That's the same number of people as the combined populations of Los Angeles, Philadelphia, and Washington, D.C. And that number is nearly 33% higher than previous estimates showed. Paralysis in the United States shows over a million more people in the U.S are living with paralysis than previously estimated. Below are the prevalence and demographics of paralysis according to that survey(1).

![Fig. 1: Statistics and Demographics of Paralysis](image1.png)

One type of the paralysis is motor neuron diseases (MNDs). MNDs are a group of progressive neurological disorders that destroy motor neurons, the cells that control essential voluntary muscle activity such as speaking, walking, breathing, and swallowing. Normally, messages from nerve cells in the brain (called upper motor neurons) are transmitted to nerve cells in the brain stem and spinal cord (called lower motor neurons) and from them to particular muscles.

Amyotrophic lateral sclerosis (ALS), also called Lou Gehrig's disease or classical motor neuron disease, is a progressive, ultimately fatal disorder that disrupts signals to all voluntary muscles. Many doctors use the terms motor neuron disease and ALS interchangeably. Both upper and lower motor neurons are affected. Symptoms are usually noticed first in the arms and hands, legs, or swallowing muscles. Approximately 75% of people with classic ALS will develop weakness and wasting of the bulbar muscles that control speech, swallowing, and chewing. Muscle weakness and atrophy occur on both sides of the body (2).

A. Stephen Hawking

Stephen Hawking was born on January 8, 1942, in Oxford, England. At age 21, while studying cosmology at the University of Cambridge, he was diagnosed with Amyotrophic Lateral Sclerosis. Despite his debilitating illness, he has done groundbreaking work in physics and cosmology, and his several books have helped to make science accessible to everyone (4).

![Fig. 2: Stephen Hawking](image2.png)

He has the most common form called amyotrophic lateral sclerosis and there is no cure. Symptoms start in the hands and feet and muscles often become stiff as well as weak at first. The electrical signals from the brain and spinal cord to the muscles become damaged and eventually stop, although the reason why is unclear. One or two people in every 100,000 people in the UK have this form of motor neuron disease, around 5,000 people in total.

It is rare to develop the condition under the age of 40, as Prof Hawking did. It usually begins between the ages of 50 and 80.

Progression varies and about seven in ten people die within five years of diagnosis, with only one in ten living for more than ten years (5).

The problem with the existing solution is that after a while there is a probability that his cheek movement may also cease to work and also the other method existing it will be painful when the electrodes are pierced around the eyes in order to measure the potential difference using electrodes and records the blink of an eye.

B. Electro-oculography

A type of electrophysiological retinal testing is done to measure the difference in the electrical potential between the front and back of the eye in response to dark and light.

Electro-oculography describes an eye-gaze interface using a biological signal, electro-oculogram (EOG). This interface enables a user to move a computer cursor on a graphical user interface using eye gaze movement alone. It will be useful as a communication aid for individuals with mobility handicaps. Although EOG is easily recordable, drifting and blinking problems must be solved to produce a reliable eye-gaze interface (7).
This method will be painful process since the electrodes are pierced around the eyes in order to measure the potential difference using electrodes and to record the blink of an eye. Therefore video oculography is used in the proposed system.

II. LITERATURE SURVEY

In recent years, applications for developing help systems for people with several disabilities have increased. Various research groups around the world have begun to set up cooperation projects to help elderly and/or disabled people with communication and mobility, with the aim of increasing their quality of life and allowing them a more autonomous and independent lifestyle and granting them greater social inclusion. Also, the progressive lowering of the cost of computers, has led to the development of PC-associated handling applications, mainly using graphic interfaces.

There are several methods of sensing eye movement, some are more accurate than electro-oculography (EOG) technology, but most of them are far more expensive and bring much inconvenience and discomfort to users. The EOG method is non-invasive, low cost and easy to use. In addition, EOG is the most widely used technique in measuring bio-potential, in eye-disease diagnosis and in human behaviour studies. The eye acts as a dipole, with the front of the eye (cornea) electrically positive with reference to the electrically negative back of the eye (retina), as shown in Figure 3. This phenomenon was first observed by Emil du Bois-Reymond in 1848 and was the beginning of EOG. EOG is based on the saccadic eye movements that are characterized by a rapid shift of gaze from one point of fixation to another.

![Fig. 3 A) EOG Signal Variation by Eye Movement. b) Ocular Dipole Model(8).](image)

There are several works where EOG has been used as an assistive technology besides assisted communication systems. For example, a system to control wheelchairs for physically impaired users, or EOG signals applied to control a robot. Most of this research has been motivated by the idea of enhancing quality of life, especially for disabled people who suffer from severe motor impairments(8).

Victims of severe paralysis, amputees and other physically challenged are unfairly deprived of an acceptable standard of life. Spinal cord injuries (SCI) and Progressive Motor Neuron Diseases (PMND) could cause a condition known as Quadriplegia which leads to loss of muscle functionality below the neck due to which the subjects are constantly dependant on others for their mobility. In such cases, ocular control is either not affected or affected last. Keeping in mind these constraints in muscle control and disease progression, a cost effective solution is developed in order to assure victims of paralysis a greater degree of independence and better quality of life. The idea involves the design and implementation of an eye-gesture controlled electric wheelchair using the bio-medical technique of Electro-Oculography (EOG).

EOG Signal Acquisition Electro oculography (EOG/E.O.G.) is a technique for measuring the resting potential of the retina. The resulting signal is called the electro-oculogram. The main applications are in ophthalmological diagnosis and in recording eye movements. The eye, a seat of resting potential, acts as a dipole in which the anterior pole (corner of the eye) is positive and the posterior pole (retina of the eye) is negative.

This difference in potential can be explained by the metabolic activities in the eye which can be measured by means of EOG. The EOG signal has a magnitude in the range of 100 to 1000 μV with a frequency range of 0 to 30Hz.

![Fig. 4: EOG Horizontal and Vertical Differential Signal](image)

银-银氯化物 (Ag-AgCl) 电极被放置在眼睛的各个角落（内侧和外侧）。电极用于捕捉EOG信号和水平向移动。当被测者将视线朝左移动时，电极的位置在眼外侧靠近电极，而内侧远离电极。这种现象如图4所示。在相似的条件下，电极被放置在内侧和外侧，眼睛的这种移动可以用于测量EOG信号在眼球移动方向上的改变。图4展示了在垂直方向上的差异。实际的差异在潜在的重要性上可以被转化为眼的运动方向。

III. METHODOLOGY

A. Block Diagram

![Fig. 5: Block Diagram of Video Oculography](image)

In this system, the components are camera, FPGA kit and also a wheel chair. Above Fig. 5 shows the block diagram of Video oculographic algorithm system using real time video processing. Camera is placed in such a way that the eyes of paralyzed person in the wheel chair are exactly pointing to the camera. The blinking of the eyes is recorded from the camera and it’s interfaced with a FPGA kit where the processing takes place. Latterly, depending upon the several algorithms that we had created the FPGA kit will process the image.

Therefore, we plan to study, design and implementation of unique set of video ocularographic algorithms using real time video processing on FPGA to identify the blinks of the patient correctly.
B. Digital Image Processing

Digital image processing is a component of digital signal processing. Digital image processing has several advantages analog image processing it collection of algorithms to be apply to input data and keep away from problems for instance the build-up of noise and signal deformation during processing. Digital Image Processing involves the modification of digital data for improving the image qualities with the aid of computer. The processing helps in maximize the clarity, sharpness of image and details of features of interest towards extraction of information & further analysis.

C. Image Enhancement

Image Enhancement processes an image which is suitable for particular application. Such as sharpening or de-blurring an out of focus image, highlighting the edges of image, improving the contrast of image or increase the brightness level of an image, remove the noise from noisy image.

1. Used for Contrast Enhancement
2. Intensity, saturation and hue transformations
3. Edge enhancement
4. Producing the synthetic stereo image

D. Image Pre-processing

Pre-processing images removes low frequency background noise, normalizing the intensity of the individual particles images, removing reflections and masking portions of images. Image pre-processing is the technique of enhancing data images prior to computational processing. Pre-processing is applied on images at the lowest level of abstraction and is to reduce undesired distortions and enhance the image data which is useful and important for further processing. It is required for improving the performance of image processing methods like image transform, segmentation, feature extraction and fault detection.

E. Image Segmentation

Image segmentation is the process of partitioning a digital image into multiple segments that is set of pixels, pixels in a region are similar according to some homogeneity criteria such as colour, intensity or texture, to locate and identify objects and boundaries in an image. The numbers of segmentation techniques are as follows (7).

1) Segmentation Based on Edge Detection

The edge detection segmentation is detecting the edges or pixels between different regions that have rapid transition in intensity are extracted and linked to form closed object boundaries. There are two main edge based segmentation methods grey histogram and gradient based method.

a) Grey Histogram Technique

The edge detection technique depends on the selection of threshold T and it is difficult to search for maximum and minimum grey level intensity because grey histogram is uneven for the impact of noise.

b) Gradient Based Method

Gradient is the first derivative for image f(x, y), there is abrupt change in intensity near edge and there is little image noise.

Edge detection methods requires a balance between detecting accuracy and noise immunity, if the level of detecting accuracy is high, noise may bring in fake edges making the outline of images unreasonable and if the degree of noise immunity is excessive, some parts of the image outline get undetected and the position of objects may be mistaken. Thus, edge detection algorithms are suitable for images that are simple and noise free as well often produce missing edges or extra edges on complex and noisy images.

F. Image Analysis

Image analysis is concerned with making a quantitative measurement from an image to produce a description of image. Image analysis techniques extract the certain features that aid in the recognition of an object.

IV. Algorithm Implementation

Fig. 6: Flow Chart of Video Oculography

V. Result

Input source image is as shown in the Fig 7. The source image is taken from the web cam.

Fig. 7: Source Image

Input RGB image is converted into HSV colour model which separates the chrominance and luminance before extracting the features. The converted HSV image is shown in the Fig 8.

Fig. 8: HSV Image

The HSV image is a 3 layer image of Hue, Saturation and Value. These three layer are separated into
Design and implementation of unique video oculographic algorithms using real time video processing on FPGA will be carried out. Electrooculography describes an eye-gaze interface using a biological signal, electro-oculorgram (EOG). This interface enables a user to move a computer cursor on a graphical user interface using eye gaze movement alone. It will be useful as a communication aid for individuals with mobility handicaps. Although EOG is easily recordable, drifting and blinking problems must be solved to produce a reliable eye-gaze interface. This method will be painful process since the electrodes are pierced around the eyes in order to measure the potential difference using electrodes and to record the blink of an eye. Therefore video oculography is used in the proposed system.

VI. CONCLUSION

In the Fig. 9 S image is considered for the further use because it easy to distinguish between background and eye.

On application of segmentation on S image; the output is as shown in the Fig. 10

Fig. 10: Segmented Image

Morphological operations are applied on the obtained segmentation result.

Fig. 11: Eroded And Dilated Image

REFERENCE