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A Survey on Eye-Blink Based Communication System for People with Motor Neuron Disease

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ABSTRACT: This paper introduces a communication model build on eye-blink detection for people affected with Motor Neuron Disease. In this paper, we are showing various methodologies for face and eye blink detection. Using this proposed model, patients can contact with care givers any time they want when they lie on the bed. When the patient needs something, only blinking and eye motions can launch the call out action for their need. This disease is incurable and the patient becomes inexpressive, so this model incorporates visual technologies such as eye blink detection, eye centre localization and conversion of the eye blink to speech to help the sufferers in expressing themselves. Here, we aim to build a cost-effective, electrode less, fast and accurate system.

Keywords- Motor Neuron Disease, Electro-Oculography, VideoOculography, Haar Cascade Classifier, k-NN (k-Nearest Neighbour) Algorithm, OpenCV.

I. INTRODUCTION

Motor Neuron Disease is an ailment where the nerves in the spine and brain stops functioning. This is a rare form of neurodegenerative disease which can cause severe harm to patients. This disease causes weakness in muscles concerning hands, feet or voice. Due to this, the subject is unable to express himself. The major problem is that the patients can't connect with the world, i.e. there isn't a situation allowing exchange of ideas or messages. Motor nerve is damaged and ceases to work. As a consequence, the damaged nerves connected to muscles stops working. This disease can occur to anyone at any age, but mostly it occurs to more men than women after the age of 40.This disease comes in different types. The types of this disease depends upon whether they are hereditary or not and which neurons are affected. ALS, or Lou Gehrig's disease, is the most common type**.** The other types are Primary lateral sclerosis, Progressive bulbar palsy (PBP), Progressive muscular atrophy (PMA), Spinal muscular atrophy (SMA).The different types have common symptoms, but they vary in speed and severity.

Nowadays there are various methods that are being proposed for the patients to communicate to the external world such as Brain wave technique and Electro-oculography. In these processes, electrodes are penetrated through the dermis of the skin. So, this procedure is distressing and the patient will not be comfortable as the sick person will be having complete consciousness. And then comes another idea to develop an eye-motion detection system for the paralysed victims.

There are two manifestations in motor neuron disease, lower motor neuron and upper motor neuron lesion. The lower neutron is a lesion that has an effect on the nerve fibers which moves from ventral horn of spinal cord to the muscle in connection with. An upper motor neuron upsets the nerve fibers, which runs from spinal cords anterior horn to the muscle with reference to.

The invalids putting up with this disease have problem with speaking. Speech problem is very hard to adjust. The patients can't converse like others, which becomes a major impediment to understand them. A system can be built which uses different visual technologies helping the patients to convey their messages.

II. LITERATURE REVIEW

Some people suffer from speech disorder leading to brain damage and paralysis. It can also cause motor nerve damage and that person cannot communicate. The only way out is talking in the form of eye movement. The patient can talk with the help of eye blinking by using no- invasive technique. We are giving the input of eye blinking of the patient. From this, we are going to build a model by taking the messages from the patient. From this model we can succeed in dealing with the communication problem of the paralyzed patients.

Speech, language and hearing disorders are mainly caused by birth defects. The occurrence varies from one racial group to another. The common defects of Down's syndrome such as neurofibromatosis and cerebral palsy happen to occur in equal frequency in black and white Americans. Health professionals should be aware of the special problems and positive features of the black children with birth defects. Poor nutrition, inadequate financial support, insufficient medical care are the root causes of this. Sometimes traditional therapy and folk medicines come to their rescue. Some ailments like hemoglobinopathies, polydactyl and external ear malformations are more prevalent among black people. But diseases like cleft lip and palate, neural tube defects, and phenylketonuria are rare diseases in black children.

Motor neuron disease (MND) is one of the major diseases that leads to paralysis of the patients. The patients' muscle will be weakening day by day rendering the patients paralysed. The only way to express their feeling is in the form of eye blinking. But the scenario is improving. Different system and methods are used for the communication model here. In this model, the eye blinking is converted into some data which is an expensive method. So the eye blinks are again converted to morse code.

In motor neurone disease, the patient can't communicate with the external world. Locked-In Syndrome (LIS),motor neuron diseases such as Amyotrophic Lateral Sclerosis (ALS) and Cerebral Palsy are included in the prevalent illnesses that disturb verbal communication. Augmentative and Alternative Communication(AAC) implements have been evolved that uses signals from the patient and turns them into form of data that can be conveyed. A low-cost device unlike AAC devices can be built. This device construes and transforms eye-blinks from the case to a universally accepted communication code-The Morse code.

The suggested analysis is considered to find out the consequences of varied external parameters using well known methods by learning brainwave responses to various parameters of environment. Alpha, beta and gama waves, the different types of brainwave frequencies are generated by the neurons in the human brain. Brain wave measuring devices used by the medical professionals measures EEG. The EEG data can be transferred to mobile phones for brain mapping. There should be invention of communication systems for handicapped people. Affective and cognitive responses are unceasing fluctuating changes in human brain. M-Sense (mobile Sense) is an Android mobile application with an inexpensive hardware which estimates brainwave parameters and takes needful steps using the embedded algorithms. m-Sense connects to the EEG Sensor TGAM Chip B3 (cube) Band consisting of one dry EEG sensor with well enough form factor and Bluetooth data connectivity. A user with dysfunction can wear the EEG headset and can carry out fundamental tasks like making a voice call or sending a text message. The mobile application is protected with password and the user can perceive the actions being taken on the mobile device. Disabled people can also control home appliances if it's bluetooth enabled.

It is always a difficult task for those suffering from motor neuron disease to be in communication. Research is going on to help these people. Some video oculugraphy methods exist, but they aren't of much help to them and are pretty complex methods. We can use simple eye blinks to communicate. The eye blinks are converted to morse codes, represented by a dot or a dash, helping in transmitting messages. So a novel algorithm is used to recognise the ocular region of the face and also to recognize the eye blinks by image processing. The algorithms were devised for a Spartan 3e series of FPGA and tested with MATLAB 2011b software. Assessments carried out under various lighting conditions for an extended group of people gave an exactness of 92% to identify different blinks.

Some people suffer with high disability such as amyotrophic lateral sclerosis. Due to this disability of the patients, they can only have the eye motion based communication system. There are a few distinct ways to trace the eye movements from the reflection of the light and electrooculographic potential (E0G). We can acquire facial expression from the camera and record the blink of eye in different modes of light. Low cost eye blink system can be made for amyotrophic lateral sclerosis patients. Only low cost web camera and computer are needed to perform this experiment.

A) Face Detection

Boundary between two similar regions is known as edge. Edge detection is mainly used to detect discontinuities in an image. It is a tool used for image segmentation. It identifies the boundaries between projects, outlines, and background image. It also can be used for improving the quality of the blurred image. The digital image is divided into multiple sets. There are various methods for edge detection. According to the needs, edge detection can be implemented.

We can represent real time system for patients who are unable to answer the call physically. We are using Haar cascade algorithm for extracting information from facial expression of the patients. If the eye blinks are detected based on the eyelids, then it is used for controlling the mobile phones. We can develop the detection accuracy by using the smoothing filter. From this algorithm, we can find out the distance between eye and the phone to improve the overall precision of the system.

Human computer interface is the interface communication between patients and computer system. This interface finds out the blink of the eye and take them as input commands. This uses the image processing methods like haar with features for eye ball tracking. In this interface, we use web camera without using light. This interface test is done for 49 patients. Vision based setup is built for detecting the eye blinks and human computer interface for the disability patients. The eye blinks are noted and categorized into short eye blinks and long eye blinks.

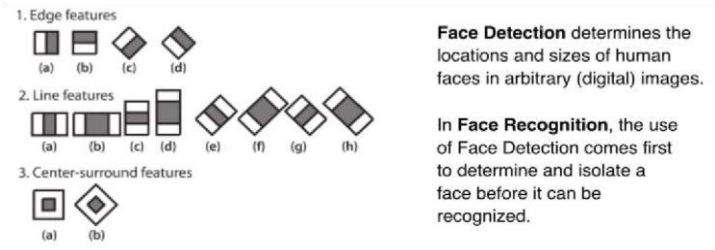
Haar Cascade Classifier and Camshift algorithm is used to detect the face and get facial axis information. This axis information along with the position of the eye is used in Adaptive Haar Cascade Classifier to get the position of the eye ball. A new algorithm known as the eyelid state detecting value is used to examine the open and closed states of the eye, hence calculating the number of eye blinks. The algorithm uses the threshold value of closed and open eye states. Using this information, an eye blink interval can be calculated which can further help in analyzing short and long blinks.

In feature extraction, the algorithm uses training data to best identify features that it can consider a face.

B) Eye blink detection

The stimulus in the brain is used to compute the electronic activity in the brain by placing electrodes in various parts of the head, the impulses taken down in the form of Electro Encephalo Gram(EEG). To identify the blinks of a patient, these signals are used. The methodology used to serve the paralysed to communicate through eye activity is called Oculography. There are two methods Electro Oculography(EOG) and Video Oculography(VOG). In EOG, electrodes are positioned around the eyes to measure the blink of the eyes, it calculates using the electrical impulses produced while blinking of the eye. The other method is VOG, in this approach we utilise a camera to record the activity of the eye. Once the facial images are acquired, algorithms are used to find the eye activity and their status. The process slows down because of the complexity of algorithm.

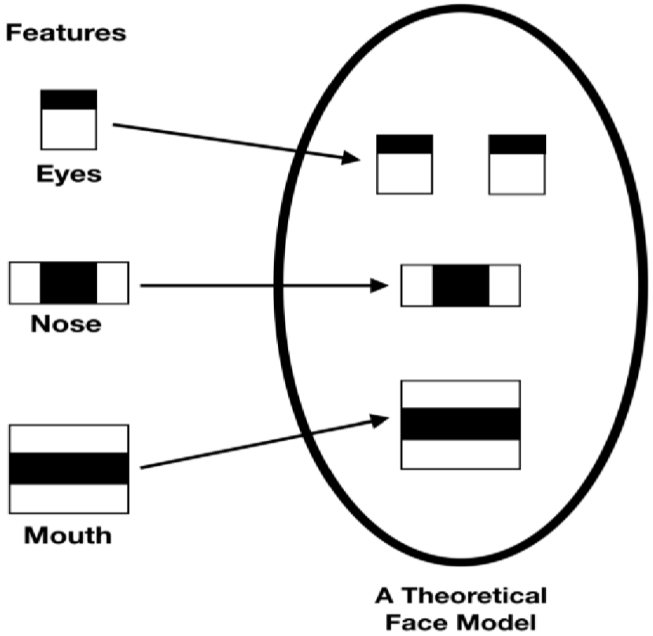
Eye localization technique is used to detect the eyes from a set of facial counters. The difference between the image frames together with optical flow computation is taken to detect the eye movements. Difference between two successive frame means that eye movement has occurred and so the direction as well as the magnitude of the optical flow calculated tell us whether a blink has occurred or not. In case the eye had blinked, it is tracked using Kanade Lucas Tomasi tracker. An accomplishment of 97.0% was found by using this technique of eye ball blinking detection.



This is a brief illustration of Features Extraction and the whose eyes are fully functional can communicate with the difference between Face Detection and Face Recognition. Face outside world. The eye blink signals are acquired using detection is about locating, while face recognition is about disposable electrodes made of Ag/Agcl kept on orbital and identifying canthus position of the eyes. The blink signals are classified to get the eye blink pattern .The patterns are processed and hence messages or emails are sent through a graphic user interface designed with the help of MATLAB.

Electro-oculography (EOG) signals measure various types of eye movements which can be used for human-machine interfaces (HMI).EOG signals are usually corrupted with noise due to uncontrolled head gestures. Usual filtering and preprocessing techniques are not capable to get rid of this noise. Head-movement noise removal from EOG signals by using a biorthogonal wavelet transform to extract the level-4 approximation coefficients is what we are aiming at K- nearest neighbour (kNN) classifier is used here. This technique enhances the conducting of existing techniques too. This new technique is actually best suitable for real-time applications.

There are many techniques for measuring the blinking of the eye along with eye movements. A head-mounted mask is used which contains small cameras to record the patient eye movements. The blinks recorded are converted into sentences. The recorded video of the infirm is the feed-in for the detection of the eye movements. The number of eye blinks is converted into words and sentences. The method proposed uses less cost.



Eye movements are detected using Video Oculography also. In this small video, cameras are mounted on head and IR illuminations are used to image the eye. Algorithms are developed for extracting vertical and horizontal torsional movement of the eye. Eye blink determining algorithms are also created. New approaches for measuring torsional movement of eye are presented in the algorithms.

Video oculography is performed by converting the eye blinks recorded from the camera into sentences in less time. No first hand engagement with the inmate is required if we use Video oculography which basically uses a camera to record the movement of the eyes. The algorithm developed works in various background lightings to convert the blinks to speeches. The software uses OpenCV to process the videos. iBall Face2Face HD camera is used to capture images both in day and night time. The speaker which is attached to the Raspberry Pi is used to generate the sound.

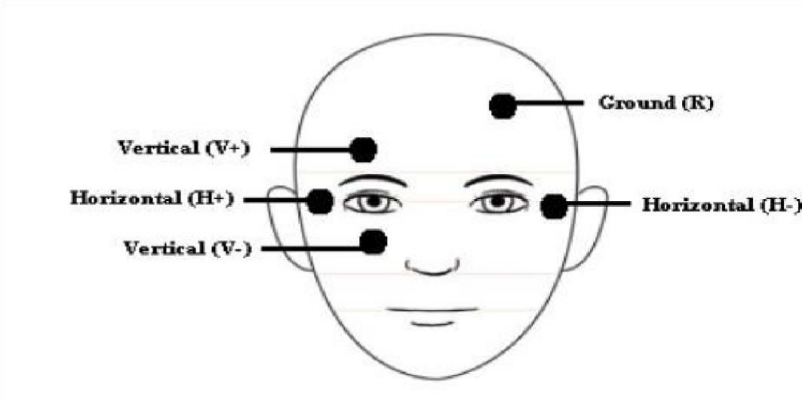
Nowadays to interact with computer, eye gaze is used. Eye movements are used to control the computer. It does not require any training because it is controlled by the individual. Motion of an eye correlative to the head is known as eye tracking. There are techniques for eye tracking such as video oculography, Infrared Pupil Corneal reflection, Electrooculography. In video oculography, cameras are placed to identify the movements of the eye. In corneal reflection, IR waves are used to find accurately the point of gaze, the only disadvantage being that it cannot be used in variable light conditions. In electro oculography, electrodes are placed around the eye to measure the blink of the eye.

People with speaking disability or other motor neuron disability may find difficult to interact with others. So a communication system is built to interpret what those people want. Eye gaze tracking system uses web cam on the pc to identify the head movements. The system built uses patient's eye gaze as the cursor to choose menu on the screen. The important feature of the eye in this model is the iris center. When the patient looks at different angles, the position of the iris coordinate also changes. There are several steps in this system like eye localization, segmentation, eye center detection and menu click. We can make use of haar cascade method to detect the eye movement in the face as the response is quick, but the weakness is that if the user did not look straight at the screen, it won't be able to detect the eye accurately.

A cost effective approach can be built by capturing the images using a web camera. In this approach the difference between the successive frames are taken and eye ball is tracked by making a template using 4 box around the eye ball. Pattern matching technique is then used to classify different types of blinking.

Research is going on to make a latest portable, low cost and wearable structure to measure Electro-Oculogram(EOG) signals. The structure consists of three electrodes for registering EOG, an instrumentation amplifier and signal conditioning unit, and a computer with a tailored EOG analysis software. The electrodes are implanted in a frame of a spectacle that supplies alterable settings for various head sizes. The electrodes are made of dry Ag-AgCl sensors for measuring the data. The software comprises

of options like sensor noise removal, power line noise removal, blink detection, cascade detection, etc. The arrangement has been examined against a standard commercial Polysomnography system.



Electrode placement in EOG.

III. PROPOSED MODEL

We are making a cost effective communication model for motor neuron disease patients so that they will be able to communicate their basic needs to the outside world.

In our communication model we will use web camera to get the images in real time. A face detecting algorithm will be used to recognize the face of the patient. This algorithm will be based on Haar Cascade. The patient will be able to choose an option of his choice by blinking his eye at the appropriate option on the display. Depending upon the blink choice appropriate voice messages will be sent through the speakers connected to the laptop. Raspberry Pi will be used to connect hard wares like fan and led build to the communication model. The paralyzed patient will be able to switch on/off the lights and fans using his eye blinks.

IV. CONCLUSION

The main idea of this model is to develop a real time Video Oculography system that can be the bridge between the patient and the external world reducing their communication gap. Eye blink detection is a challenge in a real-time system, so we are trying to come up with an accurate model. The motivation of this model is to fulfil the needs of the disabled who can't communicate using normal human interaction.

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