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A Survey on Assistive Technology for ALS Patients

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Abstract: Amyotrophic Lateral Sclerosis is a medical disorder where control over the whole body is lost due to degenerative neurons. These kinds of patients find it almost impossible to move around or even speak. This paper focuses on methods that have been proposed to help such kind of people. Though these methods might be accurate, they are extremely expensive. A method which is cost effective and also accurate which can help these people to commute and communicate is the need of the hour.

Keywords: MND; ALS; EOG; Hough Transform; Machine Learning

I. INTRODUCTION

Motor Neron Disease, often referred as MND is a condition that affects the nerves in the spine and brain, thereby causing them to lose function over time. It is also known as Amyotrographic Lateral Sclerosis (ALS). Though a rare disease, it is a severe form of neuro degenerative disease.

Motor Neurons are nerve cells that send electrical output signals to muscles, affecting the muscles ability to function. MND can appear at any age but symptoms usually appear after the age of 40 years. It affects more men than women. The renowned English physist Stephen Hawking lived with ALS [Amyotrophic Lateral Sclerosis] for many decades until his death in March 2018.

Guitar Virtuoso Jason Beckar is another example of someone who has been living with ALS for several years.

A. Stages of MND

The following are the three stages of MND.

a) Early Stage – In this stage, symptoms develop slowly. Typically, symptoms are usually found in the following areas -arms & legs, mouth or the respiratory system. This disease includes few more symptoms such as weakening grip which makes it hard to pick up and hold things, muscle pains, cramps, twitches, slurred speech, weakness in the arms and legs and breathing problem.

b) Intermediate Stage - As the condition progresses the early symptoms remain and become more severe and this is said to be the intermediate stage, where the patient experiences muscle shrinkage, difficulty in moving, joint pain, difficulties in swallowing etc.

c) Advanced Stage - eventually, when the patient enters into the advanced stage of ALS, he should need help to move, eat or breathe, which could be life threatening.

There is no cure for MND, but treatment may slow progression and maximize the individual's independent and comfort. Techniques includes the use of supportive devices and physical therapy.

In time, a person may need special devices for

a) Moving around

b) Communicating with others

c) Feeding & Swallowing

d) Breathing

B. Dr Stephen Hawking

One of the most famous people ever to have lived with MND is Professor Stephen Hawking, who was diagnosed with motor neuron disease when he was only 21.

Technological advancements have allowed Hawking to communicate through a text to speech device. Before Prof. Hawking lost the mobility in his hands, he had used a thumb switch and a blink-switch attached to his glasses to control his computer and select the correct letters. He now uses muscle movement in his face, combining squeezing his cheeks and "blinking" which activates an infra-red switch which can scan and select characters (letter by letter) on the screen in order to compose speeches, surf the Internet and send e-mails.

This paper focuses on systems that can be helpful to assist MND patients in in their day-to-day chores.

II. LITERATURE SURVEY

A. *"An Eye Tracking Algorithm based on Hough transform"*

Aleksei Bikhalov and Viktoriia Chafonova

The main methods for eye localization in image processing are methods based on Hough Transform (HT), Circular Hough Transform (CHT) and Elliptical Hough Transform (EHT).

In HT, normally it follows a method called voting, where a circle template passes through each point of image and overlaps with each other in the place where the most qualities of intersections are found. Thus, the point of center of circle that is the iris will be detected.

Determining the location of eye using CHT requires at least three necessary dimensions. In EHT, it can detect the eye boundaries more accurately but has a larger quality of varieties. Using head-mounted camera system and applying HT, Young et. al developed an algorithm of obtaining iris location but this has some amount of errors horizontally as well as vertically.

Another method of eye localization is usage of neural network. Swell and Komogosrtsev proposed one, where they trained the network by looking at 48 places markers on the screen and collected data to estimate iris localization and gaze tracking. They obtained high enough accuracy.

The advantage is that they have developed an algorithm that would allow processing automatically and efficiently of frames even with low resolution frames and with insufficient contrast and brightness.

The drawbacks are:

- Each method is too complex and cannot be applied in every industry.
- Also many existing methods do not always allow detection of an iris in low-resolution frames.

B. *"A New Directional Intention identification approach for Intelligent wheelchair based on fusion of ECG Signals and Eye Movement Signal"*

Tongbo Li , Junyou Yang , Dianchum Bai , Yina Wang

Many people lose their ability to move due to some natural disasters, traffic accidents, diseases and many other reasons. Many elderly people have problem such as inconvenience in mobility and weakness in their limbs which causes inconvenience and distress to themselves or others. This poses great difficulties for patients with limb movement disorders, certain handicapped persons with disabilities and mobility impaired seniors. Therefore, new human-computer interactions are been developed. Also, a new method of controlling the wheelchair, using elector-electroencephalograph signals to control the direction of motion and eye signals to control the speed of wheelchairs.

For most people with limb movement disorder, their eye function is normal, they can turn freely, and they can gather information about their surroundings through their eyes. In ordinary life, we can use our eyes to indicate others and convey different information. Therefore, it is more feasible method to collect the Electro-OculoGram signals (EOG) generated by different eye movement as different control commands.

The main three steps that are involved here are:

1) Data acquisition using mixed signal oscilloscope which is used to collect EOG signals.
2) Data processing methods
3) Direction in tension recognition method

Hence, the acquisition, processing, feature extraction and pattern recognition of the EOG signals and eye movement signals are introduced. By combining the eye movement signal and the EOG signal, the invalid EOG signal is removed, and the accuracy of the EOG signal is significantly improved. It also improves the accuracy of classification, and it provides a convenient condition for controlling the robot with the use of the combination of EOG signal and eye movement signal.

This method helps the patients having limb movement disorders, to convey the information that they want to convey. However, the following might be the shortcomings.

- Recognition of multiple eye movements leads to poor accuracy and recognition rate.
- There is requirement of wearable devices and the operation is complicated.
- Only use of eye movement signals is defective because it triggers motion signals only when the sight line reaches specific area. But for some old people with eye diseases, they are difficult to quickly and accurately reach a certain area.

C. *"Hierarchical Multi-class Iris classification for liveness detection"*

Zihui Yan, Lingxiao He, Man Zhang, Zhenan Sun and Tieniu Tan.

Iris recognition has become increasingly popular. The security risk of iris recognition is increasing rapidly because of the attack by various patterns of fake iris.

For example, a German hacker Organization called Chaos Computer club cracked the iris recognition system of Samsung Galaxy S8 recently. Due to these risks, the iris liveness detection has become important process in iris recognition systems. In order to identify the fake iris images with single pattern, the State-of-the-art algorithms are used, which mainly rely on hand-crafted texture features.

The approach called Hierarchical Multi-Class Iris Classification (HMC) for liveness detection based on CNN is used. It mainly focuses on iris liveness detection of multi pattern fake iris. This method learn the features of different fake iris patterns using CNN and classifies the genuine or fake iris images by hierarchical multi-class

classification. This classification takes various characteristics of different fake iris patterns and they are divided into two categories by their fake areas. In order to identify these two categories of fake iris images, there are two steps.

1) Experimental results which demonstrate higher accuracy of iris liveness detection than any other state-of-the-art algorithms.

2) HMC that achieves best results with nearly 100% accuracy.

Though this method provides utmost security, the processing time can be extremely huge, considering the complexities involves in the algorithm.

III. CONCLUSION

Most of the papers online either use classifiers and circle detection based algorithms. Though the accuracy may be high. the shortcomings of these techniques are mentioned above. Thus, there is a requirement of the algorithm that is fast in processing and also can be implemented live.

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