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A Novel, Innovative, Non- Invasive Chin Controlled Assistive Appliance for Effective Communication of Quadriplegic Patient with the Caretaker

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ABSTRACT:
Spinal cord injuries, stroke, cerebral palsy and other neuromuscular disorders may lead to quadriplegia, a condition that results in loss of sensory and motor function of four limbs and torso. The increasing incidence of quadriplegia is of deep concern to all workers in the health and rehabilitative sciences. The affected people will be psychologically affected as well. This has led to the development of various assistive appliances to help the quadriplegic individuals communicate their intentions and emotions by enabling them to use the head and neck muscles to operate the appliance. This article presents a novel, innovative, non- invasive chin controlled assistive appliance for communication of quadriplegic patient with the caretaker and enable them to socialize with others.

KEY WORDS: Quadriplegia, Assistive appliance, Infrared (IR) Sensors, Neckstrap

I. INTRODUCTION:

High quadriplegia is defined as a complete or virtually complete motor paralysis of all four extremities, with the degree of completeness depending on the exact level and degree of involvement.[1] Traumatic injuries, tumours, infections, or congenital malformations that cause spinal cord damage can render patients quadriplegic.[2]The degree of paralysis depends on the extent of involvement and the level of the spinal cord injury. In 1967, Walsh[3] suggested that the most common causes of this disability are automobile and diving accidents. In addition, health professionals provide rehabilitative services for many patients who have varying degrees of function loss resulting from debilitating diseases. Frequently, these patients have only the use of the head and neck regions and require mouth held prostheses to perform compensatory functions.[4] People whose hands are paralyzed are a heavy burden to others. Being handicapped, these people depend on others in the performance of the simplest everyday tasks. Therefore, it is of primary importance to rehabilitate them, at least to the extent of reducing their dependence on other people.[5]Intra-extraoral devices fabricated for a patient to enable them to perform certain tangibly constructive procedures will boost their morale and motivation, and thus reduce vegetative existence tendencies[6].

Assistive appliance that help severely disabled, communicate their intentions to others would enable them to pursue self-care, educational, vocational, and recreational activities and therefore greatly improve their quality of life. This technology would not only ease the individual's need for receiving continuous help, releasing a dedicated caregiver and reducing their healthcare and assisted-living costs, but may also help them to be employed and experience active, independent, satisfying, and productive lives[7,8]. This paper describes an innovative, non-invasive, cost-effective electronic system which uses Infrared (IR) sensors, Arduino Uno micro-controller and wireless Bluetooth module HC05 to create communication between quadriplegic patient and the caretaker.

II. TECHNIQUE OF FABRICATION:

a. Fabrication of neck strap
b. Mechanism of action
c. Communication of messages

a. Fabrication of Neck Strap: A neck strap made of a biocompatible plastic in accordance with the girth of the patient's neck is constructed. 4 Infrared (IR) sensors are placed equidistantly on the inner side of the strap, facing towards the patient's chin. The wavelength range of the infrared used is between 1000 – 10000 nm. Each IR sensor consists of: an IR LED (light emitting diode) similar to TV remote control and an IR Transmitter LED.

b. Mechanism of action: There is a built - in circuit for each IR sensor module that emits IR signals from IR LED. When IR falls on any object, it reflects back and the reflected IR is made to fall on IR Photodiode and this converts the IR intensity to equivalent voltage. The output of

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the IR transmitter-receiver module is high in absence of obstruction i.e., when IR light is not falling on the photodiode, the output is high. When IR module is obstructed i.e., when IR light falls on photodiode, the output is low. When the quadriplegic patient gets his/her chin near an IR transmitter-receiver module, obstruction is created and through the signal conditioning circuits, signal is modulated and the output will be low. Inducing an obstruction on any of the IR transmitter-receiver module through his/her chin, the signal conditioning circuits present will modulate the mechanism and the output will be low. (Figure 1)

Figure 1: Neck Strap with IR sensors

c. Communication of Messages: These 4 IR transmitter-receiver modules are connected to an Arduino Uno micro-controller board through wires. The IR output signals are scanned by the microcontroller and when the output is low (due to obstruction from any of the IR module), there will be a corresponding text message stored in the programme. This message will be transmitted through HC05 Bluetooth Module that is paired with a readily available application downloaded in android phone of the patient's care taker and that text message will be displayed on the caretaker's phone. Then, the care taker can attend quadriplegic patient immediately to fulfil his/her needs (Figure 2).

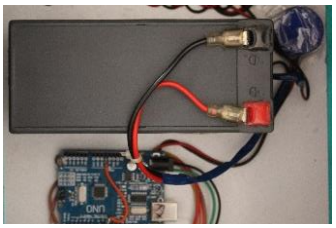

Figure 2: Arduino Uno Microcontroller Board with HC05 Bluetooth Module

Coded text messages are as follows:
I am hungry and thirsty, feed me please.
I am feeling bored, I need some refreshment.
I want to use restroom, please help me.
I need immediate help, I am in danger.
By this, the patient can have some communication with the care taker in their absence and the caretaker can also continue with their routine work

III. DISCUSSION:

As people with severe disabilities strive to improve their quality of life, they are eager to adapt and incorporate innovative assistive technologies in their daily lives.[9,10]
There are various innovative appliances stated in the literature. Jeonghee Kim et al.,[12]had suggested a tongue-drive system that enables people with severe disabilities to control their computers, wheelchairs,

and smartphones using voluntary tongue motion. For this, a small magnetic tracer on the tongue either glued to the tongue for short-term temporary use (a few hours) or embedded in a titanium tongue stud for attachment to the tongue via a piercing for medium- to long term use was done. This technique is invasive as they involve piercing of the tongue for placement of an activating component of the appliances.

K.A. Unnikrishnan Menon et al.,[13]had suggested a tongue controlled assistive device using optical sensors. Here the tongue movement was sensed using infrared (IR) sensor, mounted bilaterally near user's cheek. Patient's tongue was used to change the reflection intensity of the sensor and this signal change is converted into user commands through signal processing. These commands were then wirelessly transmitted to PC/Smartphone through which the user can control their home environment, move a wheel chair or pass information to their care taker.

However, this technique had the disadvantage of unintentional activation while signalling of the IR Sensors during different facial movements.

The innovative technique described in this paper overcomes these disadvantages by incorporating obstacle IR sensors placed on a neckband that gets activated only by intentional chin movement close to the sensor. There is no invasive procedure associated with this innovative assistive appliance. As mentioned, although there are technologies that have assisted quadriplegic patient with communication, they are either invasive or of high precision for patients to learn or expensive or technologically tough to fabricate. Henceforth, this paper presented an innovative technique for communication between the quadriplegic patient and the caretaker, that are non- invasive, cost effective, easy to device and learnt by the patient.

IV. CONCLUSION:

With proper training and follow up, a conventional mouthstick system can be an effective means of helping the quadriplegic person to interact with the environment, whereas this innovative appliance aids in conveying the person's needs and emotions to the caretaker. This appliance bridges the gap between technology and the need where in the patients can overcome their physical constraints and communicate their basic needs to their care taker with ease and accuracy.

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