Design and Implementation of Wireless Rehabilitation Aid for Tongue Disorders

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Abstract— The tongue is a muscular hydrostat which is a part of oral cavity. The interaction of tongue with palate is essential for articulation of speech and swallowing of food. Patients with neurological disorders have impaired speech and swallowing problem. In this work, a device is envisaged to provide a non-invasive rehabilitation aid for speech and swallowing disorders. The proposed device serves as both diagnostic and therapeutic tool. The parameters of the proposed device are tongue pressure measurement and tongue color detection along with neuromodulation stimulator (tongue stimulator – therapeutic aid). The output, which is a waveform (tongue pressure) and an image (tongue color) are transmitted wirelessly outside the oral cavity to the computer. This device is used to investigate and quantify the degree of tongue disorder. Periodic rehabilitation therapies along with the proposed device, increases the chances of recovery of functional tongue disorders by 50% within a short interval of time.

Keywords— Tongue pressure measurement, tongue color detection, tongue stimulator.

I. INTRODUCTION

There is an increase in the number of patients who are affected with cerebrovascular and neurological diseases (Parkinson disease). These diseases leads to speech impairment and swallowing disorders (dysphagia). Orthodontists are also interested in studying the tongue pressure as it is vital to study the growth of mandible and the position of teeth.

Older techniques used to study the tongue pressure are based on videofluorography and videoendoscopy. This provides a quantitative analysis of tongue pressure and jaw movements. However, the above techniques are mostly avoided due to the unwanted exposure to the radiations.

Tongue diagnosis plays an important role in Traditional Chinese Medicine (TCM). Tongue diagnosis is based on instant inspection of the tongue. Proficiency of tongue diagnosis is based on the experience of the medical practitioners. The tongue chromatic, geometric & texture features play key role in assessing a person’s health condition. Pathological conditions of organs affects the color of the tongue.

Tongue is a direct way to stimulate the brain as it is rich in nerve fibers and it is connected by two major cranial nerves to the brainstem. Patients with neurological disorders are unable to carry nerve impulses efficiently. Neural impulses are responsible for sensory perception. The activity of damaged neuron to efficiently produce nerve impulses can be stimulated by electrical stimulation along with targeted rehabilitation therapies. The stimulator is also used as a therapeutic aid for patients who have suffered a brain injury or trauma. The gait of the patients can also be improved. Hence, with the stimulation of nerve ending, the treatment of chronic disease and trauma can be treated effectively.

In our work, we have designed a non-invasive rehabilitation aid which measures the tongue pressure, detects tongue color and gives electric stimulation (therapeutic aid) to the tongue. The measured parameters are transmitted wireless to the reading unit (PC-Mat Lab) which is placed outside the oral cavity. The aid proves to be cost effective, light and biocompatible. This device may find application as both implantable and wearable system.

II. WIRELESS REHABILITATION AID FOR TONGUE DISORDER

A. Pioneering of the Rehabilitation Aid

The concept of the proposed device will lend a great helping hand in near future to the speech pathologist and otolaryngologist. The projected device consists of three pressure/force sensors, a miniature color camera and an electrode (stimulator). The entire setup is supported by a voltage source of 0-9V battery. The
sensors, electrode and camera are connected to a circuit for pre-processing and the data is transmitted outside the oral cavity wirelessly.

B. Input Modalities

The input modalities of the proposed device are pressure/force sensors and a camera. The pressure/force sensor measures strain due to the applied force. The proposed device uses a silicone based piezo resistive strain gauge in which resistance increases when pressure is applied. Strain gauges are connected to form Wheatstone bridge circuit which improves the efficiency of the sensor and condenses errors. A miniature color camera is used to capture the image of the tongue.

The sensors can be enclosed in a disposable case which increases the ease for usage of multiple patients. The casing reduces the need of replacement of the pressure sensors and electrodes frequently and also proves to be cost effective.

C. Pre-Processing

The first pre-processing step is done by a multiplexer. A multiplexer selects multiple analog signals and converts it to a single signal line. Multiplexers are mainly used to deliver large amount of data over a selected period of time and bandwidth.

In the second step, an Analog-to-Digital Converter (ADC) is used. This system converts analog signal to digital signal. The analog signal in our project is the force exerted on the sensor and light captured by the camera.

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After conversion, the digital signal is given to a microcontroller. A microcontroller contains one or more processor cores embedded in a single chip along with memory and programmable input/output peripherals. The microcontroller employed in our project is Arduino UNO. Arduino UNO is one of the advanced type of microcontroller. Unlike conventional type, Arduino has both hardware and software combined in a single circuit. The Arduino can be interfaced with several peripheral devices like camera, internet, smart phones and computers. Hence it is cost effective and flexible to use. It finds a wide range of applications in electronics and specially to design medical equipment.
D. Communication

A wireless communication device is used in our project, which is based on ZigBee technology. It is suitable for transmission of low power signals, with effective noise reduction. It has low power consumption and hence limits the transmission distance to 10-100 meters line of sight. It is used for low data rate application with longer battery life.

![Fig 4: ZigBee Transmitter](image)

The ZigBee software is loaded to a computer which is directly fed into Mat Lab. Thus the image of tongue and the tongue pressure waveform can be analyzed using image processing and signal processing in Mat Lab respectively.

E. Tongue stimulator (therapeutic aid)

Tongue stimulator is used as a therapeutic aid. The electrode used for stimulation is made up of metal which is highly efficient and biocompatible. The stimulator is placed on the surface of tongue and the system delivers 5V positive pulses. The system delivers triplets of 0.4-60 microsecond wide pulses at 5 microsecond intervals.

III. RESULT

The tongue pressure was measured using the aid. The obtained waveform paves way for various research and studies about the tongue and its movement. The waveforms can be analyzed for various disorders of tongue. There is change in the waveform pattern for in dry and wet conditions of the oral cavity.

![FIG 5: Sample Output](image)

The image of the tongue tells about the feature of the tongue such as color, texture, and geometry. Mouth ulcers, oral cancers, bacterial/fungal infections can be identified in patients.

Tongue stimulator plays a vital role in rehabilitation of the tongue. Various parts of brain can be stimulated directly using tongue stimulator. With electric stimulation, the nerve endings are triggered and along with functional therapies, the chances of recovery has been increased up to 50% in a short span of time.

IV. CONCLUSION

The wireless rehabilitation aid for tongue disorders was designed. The obtained output paves way for studying and analysis of tongue and its disorders. This kit can find a wide range of applications in medical field, which acts as a both diagnostic and therapeutic tool.

V. REFERENCES


