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 the oral cavity. The interaction of language with the palate is essential for the articulation of speech and swallowing of food. Patients with neurological disorders have impaired speech and swallowing problems. A device is envisioned to provide a non-invasive rehabilitation aid for speech and swallowing disorders in this work. The proposed device serves as both a diagnostic and therapeutic tool. The proposed device parameters are tongue pressure measurement and tongue color detection along with neuromodulation stimulator (tongue stimulator – therapeutic aid). The output, 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 and the proposed device increase 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 affected by cerebrovascular and neurological diseases (Parkinson's disease). These diseases lead to speech impairment and swallowing disorders (dysphagia). Orthodontists are also interested in studying tongue pressure as it is vital to study the growth of the mandible and the position of teeth.

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

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

The tongue is a direct way to stimulate the brain as it is rich in nerve fibers and two major cranial nerves connect it 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 neurons to efficiently produce nerve impulses can be stimulated by electrical stimulation and targeted rehabilitation therapies. The stimulator is also a therapeutic aid for patients who have suffered a brain injury or trauma. The gait of the patients can also be improved. Hence, with nerve ending stimulation, the treatment of chronic disease and trauma can be treated effectively.

Our work has designed a non-invasive rehabilitation aid that 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), placed outside the oral cavity. The aid proves to be cost-effective, light, and biocompatible. This device may find application as a both implantable and wearable system.

II. WIRELESS REHABILITATION AID FOR TONGUE DISORDER

A. Pioneering of the Rehabilitation Aid

The proposed device's concept will lend a great helping hand shortly to the speech pathologist and otolaryngologist. The projected device consists of three pressure/force sensors, a miniature color camera, and an electrode (stimulator). A voltage source of 0-9V battery supports the entire setup. The
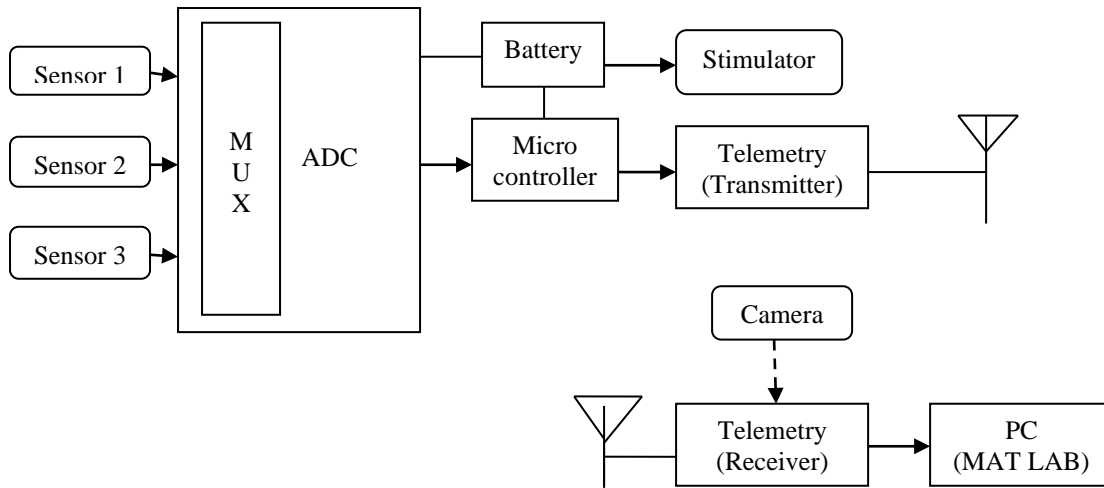
Fig 1: Block Diagram

Sensors, electrodes, and cameras 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 piezoresistive strain gauge in which resistance increases when pressure is applied. Strain gauges are connected to form a Wheatstone bridge circuit, which improves the sensor's efficiency and condenses errors. A miniature color camera is used to capture the image of the tongue.


Fig 2: Pressure sensor

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

C. Pre-Processing

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

In the second step, an Analog-to-Digital Converter (ADC) is used. This system converts the analog signal to a digital signal. Our project's analog signal is the force exerted on the sensor and light captured by the camera.
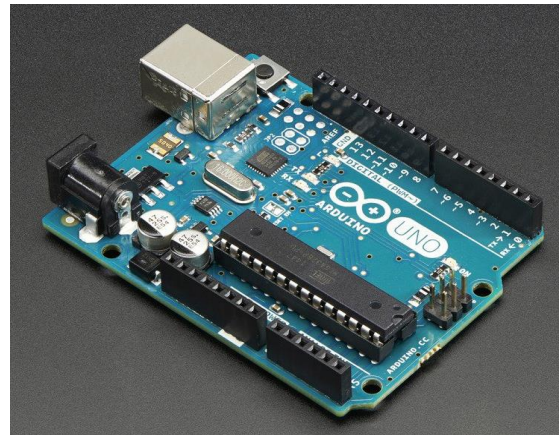
Fig 3: Arduino UNO

After conversion, the digital signal is given to a microcontroller. A microcontroller contains one or more processor cores embedded in a single chip and memory and programmable input/output peripherals. The microcontroller employed in our project is Arduino UNO. Arduino UNO is one of the advanced types of the microcontroller. Unlike conventional types, Arduino has both hardware and software combined in a single circuit. The Arduino can be interfaced with several peripheral devices like cameras, internet, smartphones, and computers. Hence it is cost-effective and flexible to use. It finds a wide range of applications in electronics and especially 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 the 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 applications with longer battery life.

Fig 4: ZigBee Transmitter

The ZigBee software is loaded to a computer, which is directly fed into Mat Lab. Thus, the tongue and the tongue pressure waveform image 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 the 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 the way for various research and studies about the tongue and its movement. The waveforms can be analyzed for various disorders of the tongue. There is a change in the waveform pattern for in dry and wet conditions of the oral cavity.
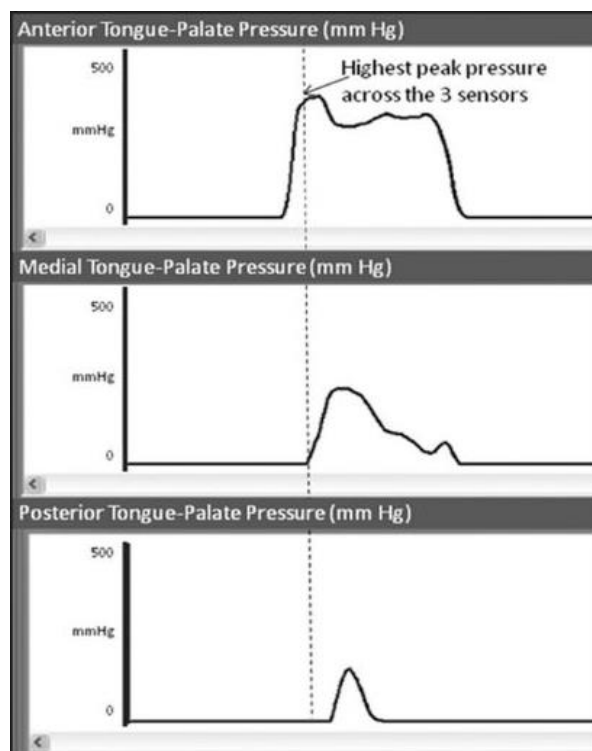

FIG 5: Sample Output

The tongue's image 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.

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

IV. CONCLUSION

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

V. REFERENCES

[1] E. Sardini, M. Serpelloni, and S. Pandini, "*Analysis of tongue pressure sensors for biomedical applications,*" Conference paper June 2014.

[2] Stöhr, "*Wireless sensor system for monitoring spatially resolved tongue pressure,*" Test Conference 2011.

[3] Kiran S Patil, Pallavi S Deshpande, "*Tongue Diagnosis: A Non-Invasive Approach to Detect Diabetes Mellitus & Diabetic Retinopathy Using Color, Texture & Geometry Features,*" International Journal of Innovative Research in

Science, Engineering and Technology, Vol. 4, Issue 7, July 2015.

[4] Kazuhiro Hori, Hiroshige Taniguchi1, Hirokazu Hayashi, Jin Magara, Yoshitomo Minagi, Qiang Li, Takahiro Ono & Makoto Inoue, "*Role of tongue pressure production in oropharyngeal swallow biomechanics*," Physiol Rep, 1 (6), 2013, e00167, doi: 10.1002/phy2.167.

[5] E. Sardini, M. Serpelloni, R.Fiorentini, "*Wireless Intraoral sensor for the physiological monitoring of tongue pressure*," Transducer 2013, Barcelona, Spain, 16-20 June 2013.

[6] O. Chenu, N. Vuillerme, J. Demongeot, and Y. Payan, "*A Wireless Lingual Feedback Device to Reduce Overpressures in Seated Posture: A Feasibility Study,*" PLOS one 4(10), 2009, pp. 1-8.

[7] C.M. Steele, G.L. Bailey, S.M. Molfenter, E.M. Yeates, and K. G. Martin, "*Pressure profile similarities between tongue resistance training tasks and liquid swallows*," J. of Rehabilitation Research & Development 47(7), 2010, pp. 651–660.

[8] Müller, R.; Schuster, G.; Hohlfeld, O. et al.: Telemetrisches Messsystem zur Bestimmung des Druckes der Zunge gegen den Gaumen. Biomedizinische Technik. Vol. 48, 2003, S. 226-229.

[9] Stöhr, I.; Manderscheid, M.; Werthschützky, R.: Neuartiges polymerbasiertes Packaging von Silizium-Druckmesselementen zum Einsatz in der Kieferorthopädie. In: 9. Dresdner SensorSymposium, Dresden 2009

[10] T. Spencer, J. A. Olson, K. C. McHardy, P. F. Sharp, and J. V. Forrester, "*An image-processing strategy for the segmentation of microaneurysms in fluorescein angiograms of the ocular fundus*," Comput. Biomed. Res., vol. 29, pp. 284–302, 1996.

[11] M. Niemeijer, B. van Ginneken, J. Staal, M. S. A. Suttorp-Schulten, and M. D. Abramoff, "*Automatic detection of red lesions in digital colour fundus photographs*," IEEE Trans. Med. Imag., vol. 24, no. 5, pp. 584–592, May 2005.