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Smart Health Assistant for Dysphagia and Stroke: A Novel Machine Learning-Infused Solution

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Abstract— There is a rise in health care solutions with the intervention of innovative technologies that helps to address critical health issues. This proposed smart health monitoring device represents a novel approach to mitigating the risks associated with dysphagia and stroke by utilizing machine learning techniques to analyze three crucial biological signals such as pressure on tongue, SPO_2 (oxygen saturation) in blood and heart rate. One notable aspect of the device is its capacity to provide users with real-time health monitoring, offering them valuable empowerment. Patients can check their vital sign values at any location and time of the day. A predefined threshold value acts as a crucial benchmark, and if the measured output deviates from this baseline, an automatic alert is triggered. This alert signals a potential risk of stroke, prompting immediate attention. In the event of a threshold breach, the device initiates communication with healthcare providers. An automated message is sent to the hospital, ensuring that medical professionals are promptly informed about the patient's critical health condition. The data analysis is carried over the machine learning algorithm for the accurate results.

Keywords—machine learning, bio-signal analysis, early detection, stroke and dysphagia mitigation

I. Introduction

A stroke occurs when the brain is deprived of sufficient blood flow, resulting in the demise of brain cells.There are two main categories of strokes: (a) ischemic, which occurs due to inadequate blood flow, and (b) hemorrhagic, caused by bleeding. In both cases, specific regions of the brain experience impaired functionality. Signs of a stroke include issues with movement or sensory experiences on one side of the body, trouble understanding or speaking, feelings of dizziness, and loss of vision on one side. These symptoms usually appear soon after the stroke occurs. If they last for one or two hours, it suggests a transient ischemic attack (TIA), often referred to as a mini-stroke. Haemorrhagic strokes may manifest with an intense headache. Stroke symptoms can persist, resulting in long-term complications such as pneumonia and urinary incontinence. Elevated blood pressure stands as the foremost risk element for stroke, alongside other factors like smoking, obesity, high cholesterol, diabetes, prior transient ischemic attacks, advanced kidney disease, and atrial fibrillation. Ischemic strokes commonly result from the obstruction of a blood vessel, although there are less frequent underlying causes. Conversely, haemorrhagic strokes result from bleeding either directly into the brain or into the space between the brain's membranes, often associated with a ruptured brain aneurysm. The diagnosis includes a physical examination, complemented by medical imaging like CT or MRI scans. While a CT scan can exclude bleeding, it might not detect early-stage ischemia. Further assessments, including an electrocardiogram (ECG) and blood tests, are conducted to identify risk factors and eliminate other possible causes.It is crucial to recognize that low blood sugar can produce symptoms resembling those of a stroke. The symptoms encompass:

a. Paralysis
b. Loss of sensation or strength in the leg, arm, and face, especially on one side of the body
c. Challenges in speaking or comprehending speech
d. Cognitive impairment
e. Slurred speech
f. Visual disturbances, such as challenges with clarity in one or both eyes, blurred or dimmed vision, or seeing double
g. Walking difficulties
h. Impaired balance or coordination
i. Vertigo
j. Abrupt, intense headache of uncertain cause

Integrating the power of machine learning into healthcare, particularly in the context of addressing challenges such as dysphagia and stroke, presents a promising avenue for innovative solutions. Machine learning, a branch of artificial intelligence, empowers systems to learn from data and autonomously make forecasts or choices without direct programming.In the realm of smart health assistants, leveraging machine learning techniques offers the potential to enhance diagnostic accuracy, personalize treatment approaches, and improve patient outcomes. This paper introduces a novel machine learning-infused solution aimed at tackling the complexities of dysphagia and stroke management, highlighting its potential to revolutionize patient care and clinical practices in these critical areas of healthcare.

The paper comprises an introductory section that elucidates the project's domain. Section 2 encompasses a literature survey, delving into prior research papers and their operational prototypes. Section 3 outlines the experimental setup, elucidating the design methodology and the components utilized. Section 4 entails the presentation and discussion of results, providing a comprehensive overview of the outcomes derived from our methods. Finally, Section 5 encapsulates the conclusion and outlines the future prospects of our project.

II. RELATED WORKS

Cardiovascular diseases (CVD) stand as a predominant cause of global mortality, a trend mirrored in India. A significant portion of CVD-related fatalities occurs suddenly, offering little opportunity for timely medical intervention. To mitigate these unforeseen deaths, precautionary measures are imperative. Ongoing surveillance of essential bodily metrics, such as pulse rate,heart rate and electrocardiogram (ECG) readings for a clear depiction of the current health status, becomes crucial for individuals with heart conditions. In a previously published work [3], the authors detailed a 3-tier architecture of the health monitoring system leveraging the WSN technology. This system is designed to provide continuous monitoring of specific body parameters in patients. Utilizing various biosensors capable of measuring heart rate, body oxygen levels, and temperature, the researchers affixed these sensors to an Arduino Nano board. The recorded signals are then transmitted to a server through wireless communication facilitated by Node MCU ESP8266.

Traditional advanced cardiac monitoring techniques, like echocardiography (Echo) , computed tomography scan (CT scan) and magnetic resonance imaging (MRI) are excessively costly and do not offer extended monitoring capabilities.In a study [4], researchers investigate the possibilities of uninterrupted and non-intrusive cardiac health monitoring using inconspicuous sensors. The goal is to offer an affordable and practical alternative for early detection of possible cardiac anomalies. The study highlights the limitations of relying solely on electrocardiogram (ECG) signals for cardiac health monitoring, emphasizing that ECG provides limited insights into multiple cardiac functions, predominantly through electrical signals.

As outlined in [5], dysphagia, characterized by difficulty swallowing, is a common aftermath of stroke, affecting approximately 76% of acute stroke patients. The impact of dysphagia extends beyond the understandable reduction in the quality of life (QOL), with ramifications for post-stroke issues like malnutrition, dehydration, and pneumonia, the latter being a notably grave outcome, accounting for at least 10% of post-stroke deaths within 30 days of hospitalization. The incidence rate could potentially be higher without prompt intervention for acute swallowing issues. Moreover, individuals experiencing dysphagia after a stroke often exhibit notable challenges such as increased aspiration risk, dependency on assistance for eating, reduced rehabilitation potential, leading to prolonged hospital stays, and a higher likelihood of requiring nursing home placements.

In [6] , study was conducted on 31 stroke patients based on 3 parameters – tongue mobility, dysphagia and tongue pressure analysis using Iowa Oral Performance Instrument. A total of six measurements were done including three for anterior and three for posterior tongue pressure. Statistical analysis revealed that dysphagia was linked to tongue pressure. Post-stroke patients experiencing dysphagia exhibit reduced anterior and posterior tongue pressure compared to individuals without dysphagia.

In the study referenced in [7], the objective was to assess the efficacy of a specific resistance training program targeting the tongue in enhancing swallowing abilities among stroke survivors grappling with dysphagia.The group subjected to the experimental training demonstrated significant statistical enhancements were observed in both the anterior and posterior regions of the tongue among the experimental group. Conversely, the control group showed noticeable improvements solely in the anterior region of the tongue.

Assessing tongue function is crucial for the rehabilitation of swallowing and eating abilities in a clinical setting. In [8], a disposable device specifically designed for clinical use was employed to measure tongue pressure. The objective of this study was to set standard benchmarks for maximum tongue pressure among adult Japanese individuals.A total of 853 subjects (408 male, 445 female; aged 20-79 years) were included, revealing that, while males may experience a faster decline in strength with age, both genders exhibited parallel decreases in strength over time.

In [9], the objective is to create a device for continuous monitoring of vital indicators, periodically measuring heart rate and temperature. The device is programmed to activate an alarm if the measured signal falls above or below predetermined values. Furthermore, it employs Bluetooth technology to transmit this information to be displayed in Android applications, facilitating storage in database files for retrieval as needed.

III. EXISTED METHODOLOGY:

Investigating alternative methods to conventional approaches, researchers explore continuous and non-invasive cardiac health monitoring through discreet sensors.The goal is to offer an affordable and practical solution for early detection of potential cardiac anomalies. It has been discovered that relying solely on electrocardiogram (ECG) signals for cardiac health monitoring may not yield comprehensive insights,as ECG primarily furnishes fundamental insights into different cardiac functions through electrical signals.Furthermore, the current methodology allows for heart rate measurement through temperature assessment, where an abnormal increase in temperature indicates anomalies in the body. The mentioned surveys also suggest that dysphagia can be addressed through lingual exercises. Regular engagement in these exercises has the potential to effectively manage dysphagia.

The problems associated with existing methods includes:

- The expense associated with the device is prohibitive.
- Patients are required to visit the hospital daily for device usage.
- The device is challenging to operate and leads to adverse effects on patients.
- The device solely identifies the likelihood of a stroke occurrence.

In the proposed protocol, this equipment is used for real time purposes. The cost of our equipment is less when compared to the available one. This equipment is easy to read and it is learner friendly. Doesn’t have any side effects to the patient. Decisions will be accurate as the machine learning technique is employed.

IV. PROPOSED DESIGN:

To overcome the problem we come up with this novel device and the process and the circuit diagram is given below. The Bio signals such as heart beat rate tongue pressure and saturated oxygen level is measured from the human body with the help of customized sensor. The subsequent step involves processing this data on the Arduino board and will be shown in the LED with the help of machine learning technique ,and Simultaneously, the data is taken to the Doctor with the help of Mobile App. If the displayed output exceeds the threshold value that has been programmed then it alerts both doctor and patient that there is a possibility for them to get a stroke .

The sensors accurately predict tongue pressure, oxygen saturation levels, and heart rate in patients. Both sensors are connected to the Arduino board via connecting wires. Placing the silicon tubing against the hard palate inside the mouth and applying pressure allows for the collection of various measurements, including pressure and heart rate. The LCD display exhibits the output of these measurements, showcasing heart rate in BPM, oxygen saturation (spo2) in percentage, force in grams, and pressure in psi. Additionally, the system provides audible feedback indicating whether a person's pressure level is within normal range or abnormal. Simultaneously, this information is transmitted to the doctor via the MIT mobile app.

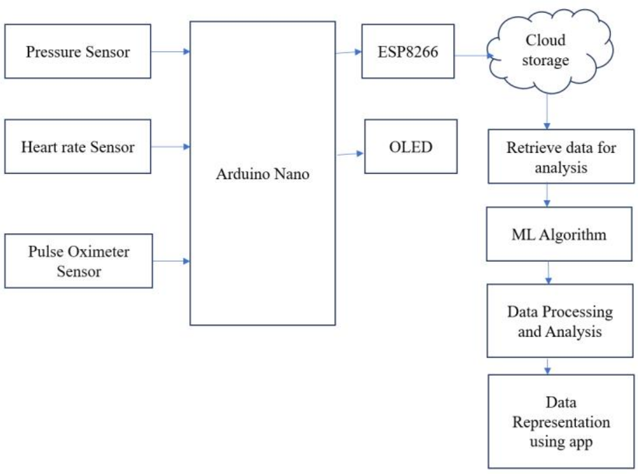

Fig.1. Block diagram for setting up the proposed system

A. *Silicon Tubing:*

It is made up of silicon (Si). It is placed on the patient 's mouth for pressure taking purposes.

B. *Arduino NANO*

The Arduino Nano, powered by the Atmega328p microcontroller, provides a compact and flexible option for a multitude of electronic projects. Its diminutive size makes it well-suited for applications with spatial limitations. The inclusion of a USB interface facilitates straightforward programming and communication, establishing it as a favoured selection within the maker community. Furthermore, the Arduino Nano boasts compatibility with a variety of sensors and shields, expanding its functionality for a wide array of embedded systems.

C. *SENSORS:*

a. Pulse or Heart rate Sensor

The Pulse Sensor is a meticulously crafted heart-rate sensor, ready to use and compatible with Arduino, appealing to a diverse range of users such as students, artists, athletes, makers, and game or mobile developers who desire effortless incorporation of real-time heart rate data into their endeavors.This sensor easily attaches to a fingertip or earlobe and connects directly to Arduino using jumper cables. Additionally, it comes with an open-source monitoring application that visually displays your pulse in real-time. The operational principle of the pulse sensor is straightforward, employing two surfaces – one equipped with a light sensor and LED , while the other features a circuit dedicated to amplification and cancellation of noise.Positioned above a vein, such as the ear tip or fingertip, the LED emits light directly onto the skin. When placed over a vein and the heart starts pumping, blood flow within the veins occurs. By monitoring this blood flow, the sensor can effectively measure the heart rate.

b. Pressure Sensor

A pressure sensor operates by transforming pressure into an analog electrical signal. The steam age witnessed a notable surge in the demand for pressure measurement devices. In the initial stages of pressure sensing technology development, mechanical methods utilized Bourdon tube gauges to visually indicate pressure through needle movement. In modern times, electronic methods are predominant, employing pressure transducers and pressure switches. Pressure transducers typically comprise a sensing element with a fixed area, which reacts to fluid pressure by exerting force on this area. The deflection of the internal diaphragm resulting from this force is gauged and converted into an electrical output. This facilitates pressure monitoring via microprocessors, programmable controllers, computers, and comparable electronic devices. Most pressure transducers are engineered to generate a linear output proportional to the applied pressure.

c. Pulse Oximeter

Pulse oximeter sensors use light to measure the oxygen saturation level in the blood. They typically include an infrared LED and a photodetector. These sensors often have a digital or analog output and can be interfaced with Arduino for data acquisition.

D. *OLED*

A type of organic light-emitting diode (OLED), alternatively referred to as an organic electroluminescent (organic EL) diode, falls under the category of light-emitting diodes (LEDs). It incorporates an emissive electroluminescent layer made up of a film containing organic compounds that generate light upon the application of an electric current. Positioned between two electrodes, with at least one typically being transparent, OLEDs are utilized in the development of digital displays for various devices, which includes computer monitors ,television screens portable devices such as handheld gaming consoles, smartphones, and PDAs. Ongoing research aims to enhance white OLED devices for their application in solid-state lighting technologies.

E. *MIT App*

App Inventor is a tool utilized for creating applications for Android phones. Users can access it via a web browser, using either a connected an emulator or a smartphone.The App Inventor servers store and manage your projects, allowing you to build apps by interacting with the App Inventor Designer, where components are chosen for the application.

V. RESULT AND DISCUSSION

The patient should be seated properly, and the sensor should be positioned correctly inside their mouth before supplying power. Position the silicon tube on the hard palate inside the mouth while applying gentle pressure to the pulse sensor with your finger. This sensor measures both the heart rate and the saturation level of oxygen simultaneously. The Arduino receives data from sensors, and the Arduino UNO is programmed using machine learning techniques employing various threshold values. The collected data is then compared to these thresholds, which helps determine whether the readings are within normal ranges or abnormal.

The Fig.2. shows the result obtained in OLED. Thus, patients can recognize their symptoms and independently seek admission to the hospital.

Fig.2. Obtained data on OLED

Detecting stroke based on input parameters such as heart rate, SPO2 (blood oxygen saturation), force, and pressure typically involves building a machine learning model for binary classification (stroke or non-stroke).

Random forest classifier ML algorithm is chosen for the analysis of stroke detection. This ensemble approach often results in a more robust and accurate model. It provides a measure of feature importance. This can help identify which input parameters (heart rate, SPO2, force, and pressure) contribute the most to the prediction, aiding in the interpretation of the model's decision. Random Forest is capable of capturing complex relationships and non-linear patterns in the data. As physiological parameters like heart rate, SPO2, force, and pressure may have non-linear relationships with the risk of stroke, Random Forest can be effective in capturing these nuances.

Random Forest tends to be less prone to overfitting compared to individual decision trees. This is important, especially when dealing with medical data where the model needs to generalize well to new, unseen data. Random Forest can handle missing values effectively. In real-world scenarios, it's common to encounter datasets with missing or incomplete information, and Random Forest can provide reliable predictions even in such situations.

Random Forest has hyperparameters that can be tuned to optimize its performance. Additionally, it generally performs well across a variety of datasets, making it suitable for generalization to different patient populations. Parallelization enables the training of individual trees within a Random Forest, enhancing computational efficiency, particularly for extensive datasets. Through the fusion of multiple decision trees, Random Forest mitigates the variance linked with individual trees, resulting in a model that is more steadfast and dependable.

Random Forest can provide class probabilities, indicating the likelihood or confidence of an instance belonging to each class. For binary classification, this typically involves probabilities for both "stroke" and "non-stroke." The final class prediction is often determined by a threshold (e.g., 0.5), where probabilities above the threshold are assigned to one class, and those below to the other.

The below output is taken with the help of Mobile App Fig.3..

Fig.3. Data obtained on Mobile App

A total of 1000 human subjects from different ranges of age from 20 years to 50 years are taken for the analysis.

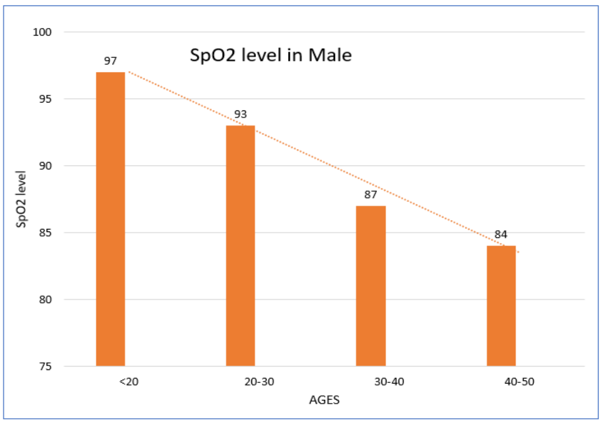

Fig.4. SPO2 in Male

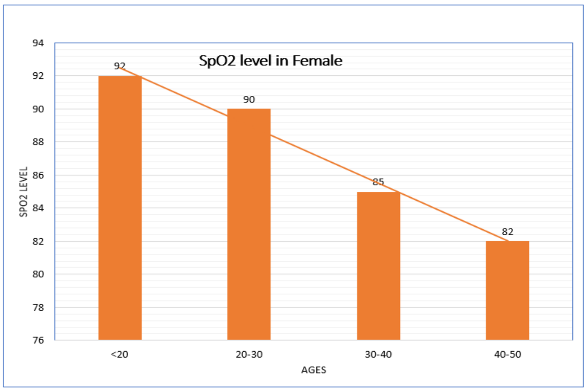

Fig.5. SPO2 in Female

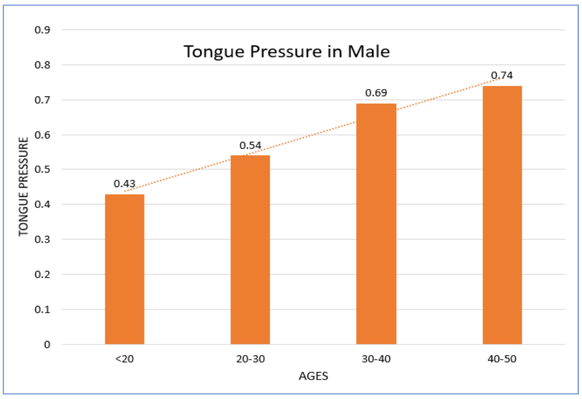

Fig.6. Pressure in Male

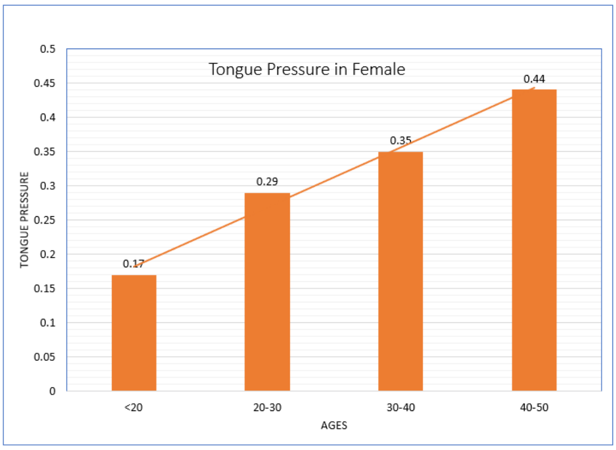

Fig.7. Pressure in Female

Fig.4 and Fig 5. Depicts that While SpO2 levels can vary with age, they do not consistently decrease over time. Typically, SpO2 remains stable across age groups in healthy individuals. However, age-related conditions like lung diseases or cardiovascular issues may impact SpO2 levels.Fig.6. and Fig.7 depicts that tongue pressure increases with age and Tongue pressure in male is higher than in female. Tongue pressure can be influenced by age-related changes in muscle strength, oral health, neuromuscular control, and functional abilities. While muscle strength typically declines with age, the impact on tongue pressure can vary. Additionally, factors like oral health, neuromuscular control, and health conditions can also affect tongue pressure levels in older adults.

VI. CONCLUSION

In the proposed model, a device is developed aiming at providing substantial assistance to the elderly and individuals with heart-related conditions. The device proves valuable by enabling early-stage disease prediction without necessitating a hospital visit or consultation with a doctor. The primary objective is to minimize prolonged hospital stays. Patients can also receive consistent health updates. Future enhancements may involve refining the device by reducing its size and optimizing cost-effectiveness, thereby enhancing user comfort.

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