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Augmentative and Alternative Communication Device for Speech Impaired Patients with IoT

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ABSTRACT:

Individuals suffering from speech disorders or severe muscular weakness soon may have a way to communicate with other people. Children and adults who are unable to communicate through regular speech must make use of body language, gestures, or Augmentative and Alternative Communication (AAC) tools to express themselves effectively. A Special device has to be developed and to be available to the needy peoples is a penchant innovation. AAC device can offer a comprehensive, user-friendly, and secure solution for speech-impaired patients, enhancing their communication abilities and overall quality of life.Therefore, we have initiated a project to help and monitor a partially paralyzed patient with speech-impairment. We develop a device that could capture speech pattern of the patient from his/her active body part gestures. By this the patient could convey his/her thoughts as well as the health condition could be recorded.Developing a high tech AAC with the available state of MEMS sensor technology used for gesture analysis. An accelerometer, Force Sensitive Resistor (FSR) and Flex Sensor can be used as a collective approach for AAC and can be a Assistive Technology Systems (ATS). Almost all the sensors in this AAC-ATS accepts DC source voltage and delivers analog signals corresponds to the physical impacts applied to it.Psychologically it benefits the patient's attitude towards life as he/she is made able to think and do something without the help of a care- taker with this device. Further, an IoT technology can be used in case if a doctor-patient conversation of health condition is desired.

KEYWORDS: Assistive Technology, speech impairment, gesture recongnition, MEMS Sensors, Accelerometer, Flex sensor, IOT in Healthcare, patient monitoring.

1. INTRODUCTION

The Augmentative and Alternative Communication (AAC) incorporates the individual's full communication abilities and may include any existing speech or vocalizations, gestures, manual signs, and aided communication. Augmentative and Alternative Communication (AAC) is truly multimodal, permitting individuals to use every mode possible to communicate. Over time, the use of Augmentative and Alternative Communication may change, although sometimes very slowly, and the Augmentative and Alternative Communication systems chosen today may not be the best systems tomorrow.Augmentative and alternative communication (AAC) describes multiple ways to communicate that can supplement or compensate (either temporarily or permanently) for the impairment and disability patterns of individuals with severe expressive communication disorders. According to the American Speech- language-hearing Association (ASHA), Augmentative and Alternative Communication methods range from a pen and paper to electronic devices that generate speech.Augmentative and Alternative Communication (AAC) is an area of clinical and educational practice that provides people with communication disabilities with a set of strategies and devices to express their thoughts, needs, and ideas. Typical Augmentative and Alternative Communication users are children and adults with cerebral palsy, autism spectrum disorders, Down syndrome, Angelman syndrome, aphasia. A conservative estimate of Augmentative and Alternative Communication (AAC) users is in the tens of millions worldwide. One of the purposes of Augmentative and Alternative Communication is to support the development of communicative competence to enable effective and efficient social interactions.Augmentative and Alternative Communication (AAC) allows a user to communicate by pointing to a symbol, such as an image representing an object or an action, instead of using speech. There are two different types of Augmentative and Alternative Communication devices: low-tech devices, which include communication boards and paper based symbols, and high tech devices such as speech generating devices (SGD), personal computers, mobile phones and tablets. In the last few years the use of AAC apps available on tablets has been steadily increasing.

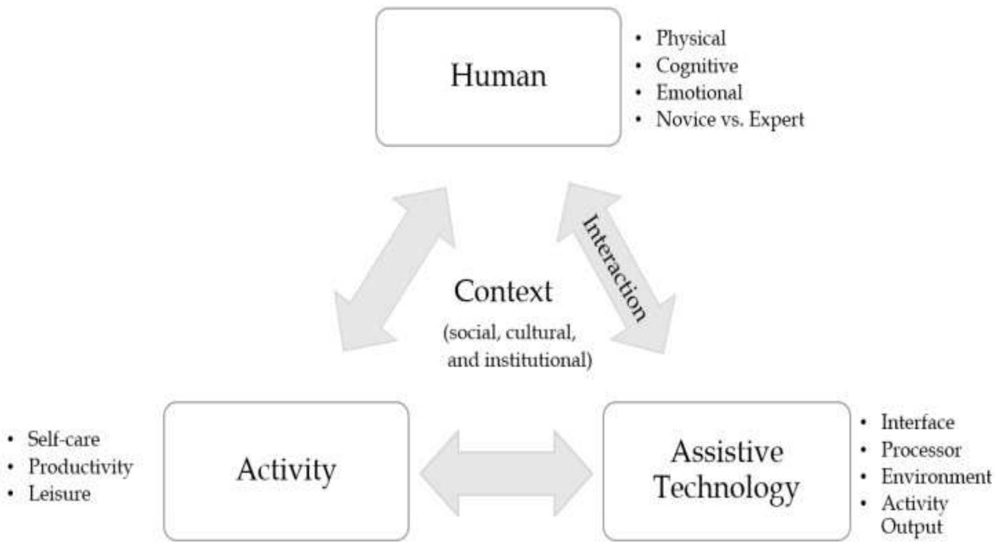

Figure 1:The model of human activity assistive technology(HAAT)

2. RELATED WORK

The Augmentative and Alternative Communication (AAC) system has seen significant advancements over the years, offering crucial support to individuals with speech and physical impairments. Studies highlight how AAC devices empower users by providing speech output or visual symbol-based communication, greatly enhancing their ability to express thoughts, desires, and emotions (Light & Drager, 2007). Research has shown that the integration of advanced technology, such as eye-tracking and voice recognition, provides an intuitive and efficient way for users to interact with AAC systems, particularly for those with severe motor disabilities (Huang et al., 2016). In addition to standard input methods, the use of gesture-based communication has gained traction as an innovative solution for individuals with limited physical movement (Cavalcante et al., 2018). The evolution of personalized AAC systems, where the device adapts to the user's unique patterns and preferences, further enhances communication (Balandin & Morgan, 2009). These adaptive systems not only offer efficiency but also make the process of communication more natural and engaging. The future of AAC looks promising with the ongoing integration of artificial intelligence (AI) and machine learning (ML). Researchers are exploring how these technologies can enable real-time context-based communication, further personalizing the interaction and overcoming many of the limitations of traditional systems (Sims et al., 2020). This integration holds the potential to make AAC systems smarter, faster, and more responsive, enhancing their effectiveness and making them accessible to an even wider range of individuals. The development of Augmentative and Alternative Communication (AAC) systems has been a crucial area of research for improving the lives of individuals with speech and language disorders. Over the years, various studies have explored a range of technologies aimed at addressing communication barriers. A notable contribution to the field is the focus on symbol-based communication systems, which have been shown to provide effective support for people with limited verbal communication abilities (Beukelman & Mirenda, 2013). Symbol-based AAC systems, often utilized in both text and picture forms, offer a bridge for non-verbal individuals to convey their thoughts, needs, and emotions, greatly enhancing their quality of life.Further studies have explored the use of multimodal communication strategies, combining voice, gesture, and gaze. This approach caters to users with severe motor impairments by offering them multiple interaction methods. For example, research by Miskolczi et al. (2014) demonstrated the potential of combining eye-tracking technology with speech synthesis to allow users with limited mobility to engage in real-time communication. Similarly, advancements in brain-computer interface (BCI) technologies have opened new frontiers for those unable to use traditional forms of AAC due to more severe disabilities (Lebedev & Nicolelis, 2006).The social impact of AAC systems has also been an area of significant focus, especially in helping users interact more meaningfully within their communities. A study by Sigafoos et al. (2007) explored how AAC devices enable children with autism spectrum disorder (ASD) to better participate in social interactions and classroom activities. These findings emphasize the role of AAC in inclusive education settings, where it helps bridge communication gaps, making educational and social integration possible for students with disabilities.

The recent research highlights the role of machine learning in enhancing the personalization of AAC systems. By analyzing patterns in a user's communication, machine learning algorithms can anticipate and suggest words or phrases, significantly reducing the cognitive load for users and increasing communication speed (Horner & McGee, 2018). This approach offers promise for improving the ease and efficiency of AAC systems in everyday use, allowing for a more adaptive and dynamic interaction model.

3. EXISTING METHODOLOGIES

The process for gesture-based AAC systems typically utilize sensor-integrated wearable devices like smart gloves. These systems incorporate accelerometers to measure hand orientation and movement in three dimensions. Flex sensors are attached to fingers to detect bending angles, while Force Sensitive Resistors (FSRs) identify applied pressure levels during gestures. Data from these sensors are collected using microcontrollers such as Arduino or Raspberry Pi. Predefined thresholds or machine learning classifiers are applied to recognize gesture patterns. Some systems use Bluetooth or Wi-Fi modules for wireless communication with mobile devices or speech output units. Sign language recognition systems like "SignAloud" use similar sensor arrays combined with neural networks for high-accuracy gesture translation. Open-source platforms and embedded programming play a vital role in implementation. These methodologies form the basis for developing more advanced, user-adaptive AAC solutions.

4. PROPOSED METHODOLOGIES

The proposed AAC-Assistive Technology System (AAC-ATS) aims to develop a high-tech wearable communication aid using state-of-the-art motion sensor technology. This system integrates an accelerometer, Force Sensitive Resistor (FSR), and flex sensor to detect various hand gestures and finger movements. Each sensor captures different physical parameters: the accelerometer measures hand motion and orientation, the flex sensor detects finger bending, and the FSR senses applied pressure. These sensors deliver analog outputs corresponding to real-world movements. The signals are processed by a microcontroller, such as Arduino or Raspberry Pi, and mapped to specific commands using machine learning or threshold-based logic. The output can be displayed as text or converted to speech via a text-to-speech module. The system operates on a low-power DC source and is designed to be compact, portable, and user-friendly. Custom gestures can be defined and trained, improving flexibility for users with varying disabilities. Real-time feedback, calibration routines, and wireless connectivity enhance system responsiveness and ease of use. Compared to traditional AAC systems, this model offers intuitive, gesture-based interaction. The overall goal is to empower users with limited motor functions to communicate independently and effectively. The prototype can also be expanded for multilingual or regional language support in future versions. In AAC-Assistive Technology System (AAC-ATS) adopts a sensor fusion approach to translate hand gestures into speech output. The system incorporates a wearable glove embedded with multiple sensors, including flex sensors to monitor finger bending, force-sensitive resistors (FSRs) to detect pressure, and an accelerometer to measure hand orientation and motion. These sensors work collectively to capture detailed gesture dynamics. The analog outputs from these sensors are fed into a microcontroller (e.g., Arduino Uno), where they are digitized and processed. The gesture recognition mechanism is built using a combination of threshold-based logic and predefined gesture patterns.To enhance reliability, sensor calibration is conducted during initial setup, ensuring consistent output across different hand sizes and force variations. Each identified gesture is mapped to a text string stored in memory, which is then displayed on an LCD screen. Additionally, a text-to-speech (TTS) module converts the text into voice output, enabling auditory communication. The system is designed to be wireless, using Bluetooth or Wi-Fi modules to interface with mobile devices or external audio systems.Power efficiency is maintained by using low-voltage components and enabling sleep mode during inactivity. The glove design is ergonomic and lightweight, ensuring user comfort for extended use. Real-time feedback and customizable gesture training options allow users to personalize the system according to their abilities. This methodology emphasizes accessibility, portability, and scalability for a wide range of physical disabilities.

5. GESTURE TO SPEECH COMMUNICATION: ‘

The AAC-ATS (Augmentative and Alternative Communication - Assistive Technology System) follows a systematic algorithm that transforms physical gestures into audible speech in real time. The system begins by initializing all sensors and setting up threshold values through calibration. Once active, the wearable glove detects user gestures using a combination of accelerometers, flex sensors, and force-sensitive resistors (FSRs). These sensors capture analog signals based on hand orientation, finger bending, and pressure exerted by the user. The microcontroller reads these analog signals and converts them into digital values using its built-in ADC (Analog to Digital Converter). The system then compares the real-time sensor values with predefined patterns to identify the gesture. After successful recognition, it maps the gesture to a corresponding word or phrase stored in the system’s memory. The identified text is then displayed on an LCD screen and simultaneously sent to a text-to-speech module, which generates the voice output.

Fig 3: Proposed architecture

6. EXPERIMENTAL FOUNDATIONS

The experimental aspect of the proposed AAC-ATS system is based on the integration of sensor technology for real-time gesture analysis and communication. The hardware setup includes an accelerometer (e.g., MPU6050), flex sensors, and Force Sensitive Resistors (FSRs), each interfaced with a microcontroller such as Arduino Uno. These sensors are attached to a wearable glove to detect hand motion, finger bending, and pressure respectively. During the experiment, analog data from the sensors are captured and converted into digital values using the inbuilt ADC of the microcontroller.

The system is programmed using embedded C or Arduino IDE to interpret sensor outputs based on threshold levels or trained gesture patterns. Each gesture is mapped to a corresponding phrase or word, which is displayed on an LCD and optionally converted to voice using a text-to-speech module. Calibration tests were conducted to ensure accurate gesture detection under varying conditions such as hand size and motion speed. Data collection involved multiple trials for each gesture to improve system reliability. Experimental validation showed that combining three types of sensors improved overall gesture recognition accuracy. This foundation allows the prototype to be scalable, and adaptive for individual

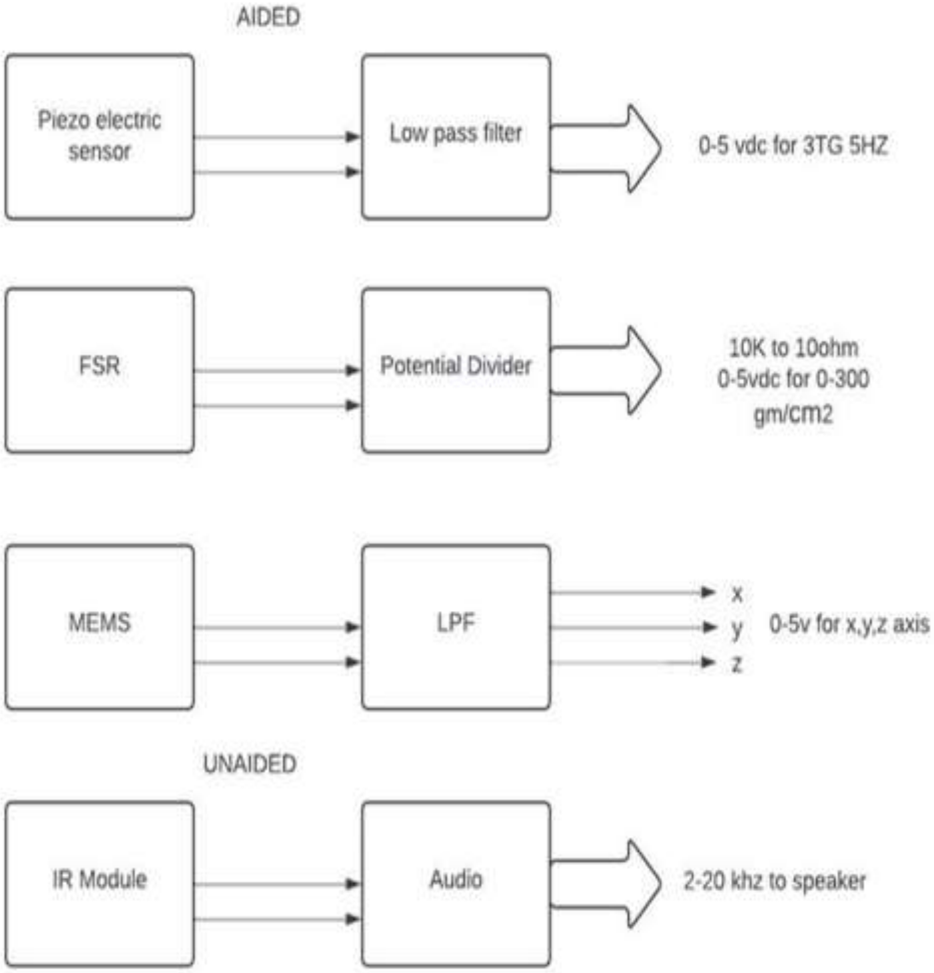

Fig 4 : design for alternative communication

7. CONCLUSION

We have designed a multi-parameter device for the treatment of all types of speech impaired patients. Using the Augmentative and Alternative Communication Technology (AAC), we have made possible a simple and user-friendly device.The main thing is the easy comprehension we have provided for the patients regardless of age or literacy. i.e., people from children to aged and people from skilled to unskilled can learn the working of this device conveniently in a short period.A speech impaired patient must have some part of his body that are functioning. These functioning parts of are utilized and analyzed by various sensors (MEMS sensor, Flex sensor, Force sensing resistor, Piezo-electric resistor) individually according to the condition of the patient from the movement action.This information is taken as the input in transmitter part and an audio output is provided in the output in receiver part. Hence the patient could communicate through his/her gestures. There is a chance of psychological improvement of the patient since he/she thinks and act without the help of a care-taker.Augmentative and Alternative Communication (AAC) devices play a crucial role in improving communication for individuals with speech and language difficulties. These devices are designed to supplement or replace spoken language with various forms of communication, such as symbols, pictures, gestures, or text.

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