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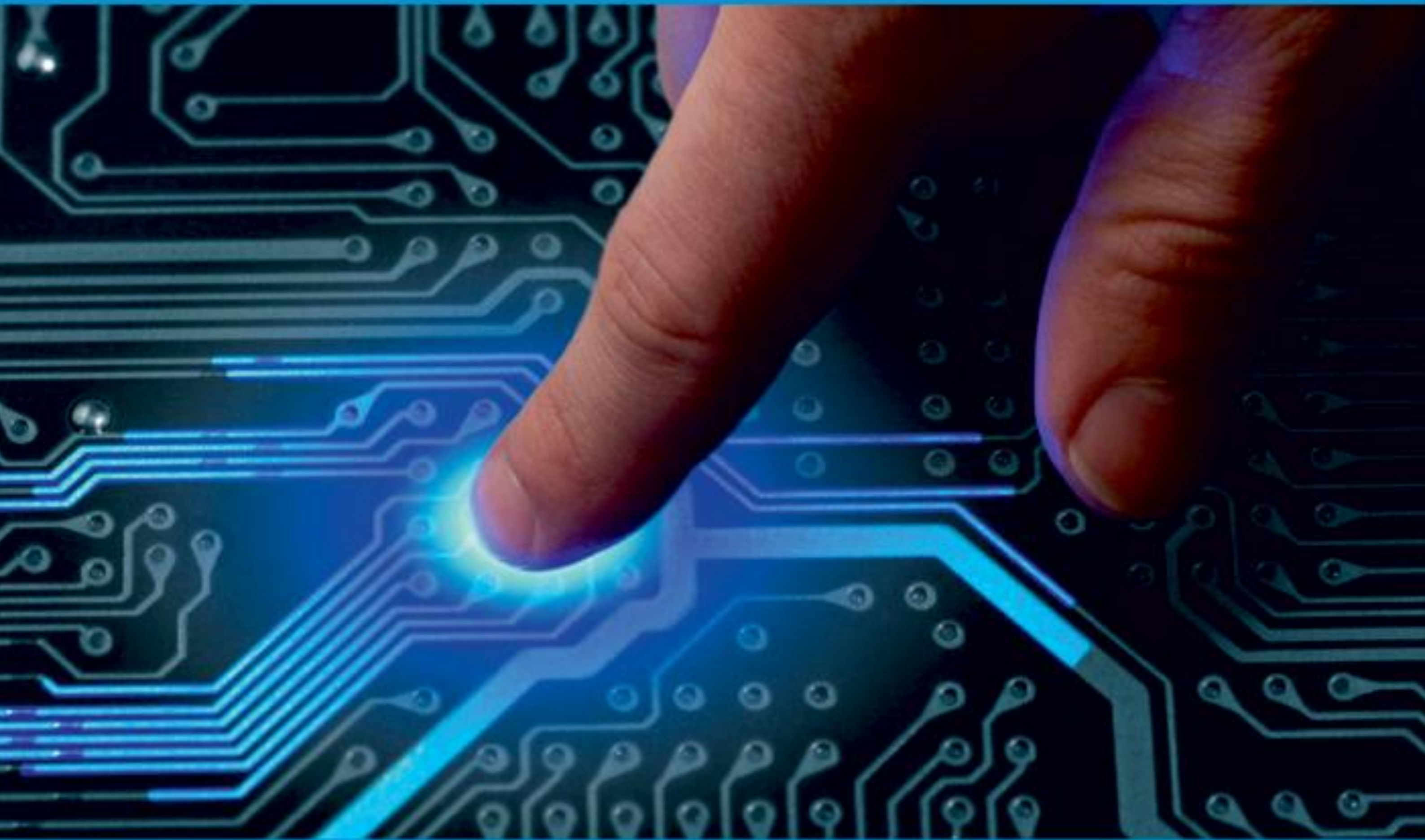

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IoT based Exoskeleton Arm

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ABSTRACT: Today, Stroke is a leading cause of paralysis, affecting millions of individuals worldwide. Over 60% of stroke survivors will either suffer from paralysis of limbs or restricted physical abilities. Hence this study addresses the above challenge by proposing a IoT based motorized exoskeleton arm. The proposed model aimed at providing remote rehabilitation monitoring and assistance for individuals with upper limb impairments. The design integrates motors and actuators for motion assistance and feedback, while leveraging IoT technology to enable seamless data transmission and remote control capabilities. The blynk application serves as the user interface, allowing users to interact with the exoskeleton arm via a smartphone or tablet. The design focuses on light weight materials, ergonomic considerations and intuitive control mechanisms to enhance user comfort and usability. The control architecture incorporates adaptive algorithms to tailor assistance levels according to the user's capabilities and therapeutic goals. Experimental validation conducted on healthy participants and individuals with upper limb impairments demonstrates the efficacy of the motorized exoskeleton arm in facilitating rehabilitation exercises and promoting functional recovery. The proposed system hold promise for individuals with upper limb disabilities and has potential applications in clinical settings for therapeutic interventions.

KEYWORDS: Blynk app, Exoskeleton arm, Light weight, Upper limb impairements

I. INTRODUCTION

The field of Rehabilitation has been under study for decades and remains ongoing. Recent assessments conducted by the World Health Organization (WHO) indicate that approximately 15% of the global population faces some form of disability, with more than half unable to afford healthcare services. Due to various factors, there is a growing number of individuals experiencing general and limb disabilities. Worldwide, there are over 10 million people with disabilities, of which 30% involve arm impairments. Numerous individuals have been diagnosed with various injuries, and new cases continue to be diagnosed. Nearly half of these cases result in some degree of sensory or motor loss in the arms and hands[2]. The number of individuals experiencing their first stroke and stroke-related fatalities has seen a significant rise over the past three decades, particularly in developing nations. Stroke ranked as the second leading cause of death in 2013, resulting in 6.4 million deaths globally. Impaired hand function is a common consequence of stroke. Consequently, enhancing hand function to facilitate functional recovery constitutes a primary objective in stroke rehabilitation. Nevertheless, given the intricacy and precision required, the recuperation of hand function proves challenging and sluggish throughout the entire rehabilitation journey[6].

The concept of exoskeleton was first suggested in 1883, with the initial design emerging in 1936. In 1961, "Hardiman" created a full-body exoskeleton robot utilizing multiple hydraulic actuators. These exoskeletons offer significant assistance to paralyzed individuals and the elderly. Treatment for such conditions often relies on intensive physiotherapy, demanding meticulous attention from skilled medical professionals[4]. Therapeutic interventions frequently incorporate the use of assistive devices, like inflatable balls for muscle strengthening or supportive braces for mobility improvement. Yet, these tools often lack personalized options for individual patients. Additionally, technologically advanced solutions with smart capabilities tend to be expensive, restricting access to a wider demographic. Thus, there is a pressing demand for affordable and dependable solutions that can be customized to address the specific requirements of each patient[6-7]. Exoskeletons are portable gadgets crafted to offer physical support, enhancing the user's strength, endurance, or precision of movement. Nonetheless, traditional exoskeletons frequently encounter issues with being cumbersome and are constructed with weighty metal parts containing motors to actively aid the user's movements[5]. The goal of upper extremity prosthetics research is to develop a motorized

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prosthetic arm that functions fully, with synchronized speed and strength. Presently, prosthetic arms and associated techniques fall short of achieving this objective. An exoskeleton, an external framework worn on a biological arm, is propelled by actuators and capable of either assisting or augmenting the strength of the biological arm, contingent upon the actuator's power[1].

Through interdisciplinary collaboration and advancement, the exoskeletons designed for hand rehabilitation have made significant progress. Some companies now boast mature technology and products in this field, such as Ottobock's WaveFlex, a commercially av ailable continuous passive movement (CPM) device for hand physical therapy utilizing an electric motor for activation. Similarly, Gloreha, developed by IDROGENET in Italy, offers a commercial CPM device for hand rehabilitation. This glove-like device, along with other modules, facilitates flexible and personalized passive hand motor exercises tailored to each patient's specific needs. Festo's ExoHand serves as an active manual orthosis and when combined with a brain-computer interface, enables the establishment of a closed feedback loop[6].

This study focuses on the development of an lightweight exoskeleton integrated with lightweight modules. By 2 leveraging the advantages of both lightweight actuators and exoskeleton components, it aims to create a wearable system that offers enhanced user comfort and minimal discomfort during use[5]. The proposed exoskeleton is suitable for everyday use due to its affordability, uncomplicated design, and minimal upkeep requirements. This model comprises a power source, sensors, microcontrollers, actuators, and diverse gearing mechanisms. It represents an effort to enhance the utility and dependability of wearable robotics[3].

SCOPE AND OBJECTIVES:

The scope of this project is to design, develop, and evaluate an IoT-based motorised exoskeleton arm for individuals with mobility impairments and developing intuitive control mechanisms for users to operate the exoskeleton comfortably and efficiently.

The objectives of this project include,

• Designing a mechanical framework that provides optimal support and range of motion.
• Integrating IoT technology for real-time monitoring, data collection, and remote control.
Implementing motorized actuators to provide powered assistance and adaptive support.
• Reduce the size and weight of the device to prevent the fatigue of the user.
• Preserve the comfort of the user and to prevent any injuries or discomfort.
• Evaluating the performance and usability of the exoskeleton arm through user trials and feedback.

II. HARDWARE COMPONENTS USED

A. Node MCU ESP8266

Node MCU plays a pivotal role in the development of an exoskeleton arm, serving as the central nervous system that orchestrates its various functions. As a versatile microcontroller platform, Node MCU enables seamless integration of sensors, actuators, and communication modules, laying the foundation for a sophisticated control system. It facilitates wireless communication, allowing the exoskeleton arm to receive commands remotely and transmit data about its status, enabling seamless interaction with users and external devices. Through Node MCU, developers can implement advanced control algorithms, user interfaces, and data logging functionalities, empowering users with intuitive control and real-time feedback while facilitating research and development efforts. Overall, Node MCU serves as the backbone of the exoskeleton arm, enabling seamless integration, intelligent control, and enhanced user experience.

The Node MCU ESP8266 has 17 GPIO pins as shown in Fig.1 can be assigned to function like PWM, LED light, button, and IR Remote Control. These pins can be configured to pull-up, pull-down, or high impedance.

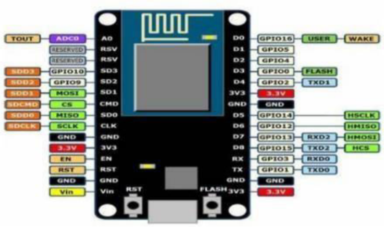

FIG.1 NODE MCU PIN CONFIGURATION

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B. DC Geared Motor:

Geared DC motor shown in Fig.2 play a crucial role in the functionality and movement precision of an exoskeleton arm. These motors are specifically designed to provide high torque output at low speeds, making them ideal for applications where precise control and strength are required, such as in exoskeletons. The gearing mechanism allows for the conversion of high -speed, low-torque input from the motor into slower, high-torque output, which is essential for powering the joints and movements of the exoskeleton arm. Overall, geared DC motors are indispensable components of exoskeleton arms, providing the necessary power, torque, and control for enabling natural and effective movement assistance to users.

Fig.2 Geared DC motor(5V, 60rpm)

C. Relay:

The 4-channel relay shown in Fig.3 plays a critical role in the exoskeleton by serving as a versatile switching mechanism for controlling various electrical components and systems. One primary application of the 4-channel relay in an exoskeleton is the control of motors responsible for joints movement. By using relays exoskeleton can execute precise and coordinated movements, enhancing user mobility and assisting with tasks that require strength and dexterity. Overall, the 4-channel relay serves as a fundamental component in the control and operation of the exoskeleton, enabling precise, coordinated movement and providing essential safety features to enhance user experience and functionality.

Fig.3 Relay

D. Aluminium Flats:

Flat aluminum bars are commonly used as structural components to form the framework or skeleton of the exoskeleton arm. Due to their lightweight yet sturdy nature, aluminum flats provide excellent strength-to-weight ratio, making them ideal for supporting the weight of the arm while minimizing overall bulk and inertia. In the construction of an exoskeleton arm, aluminum flats are often used to create the main frame or chassis, which serves as the backbone to which other components such as motors, actuators, sensors, and control systems are attached. The flat profile of aluminum flats allows for easy attachment of these components using screws, bolts, or adhesive, enabling precise assembly and customization of the exoskeleton according to the user's specific needs and anatomical dimensions.

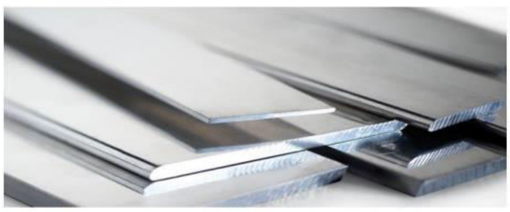

Fig 4:Aluminium Flats

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E. Power supply (Adapter):

The adapter for power supply serves as the lifeblood of the exoskeleton arm, providing the necessary electrical energy to power its various components and systems. This crucial component converts alternating current (AC) from a wall outlet into the direct current (DC) required to operate the arm's motors, sensors, control systems, and communication modules. By supplying a stable and regulated voltage, the adapter ensures consistent and reliable performance of the exoskeleton arm, essential for its safe and effective operation.

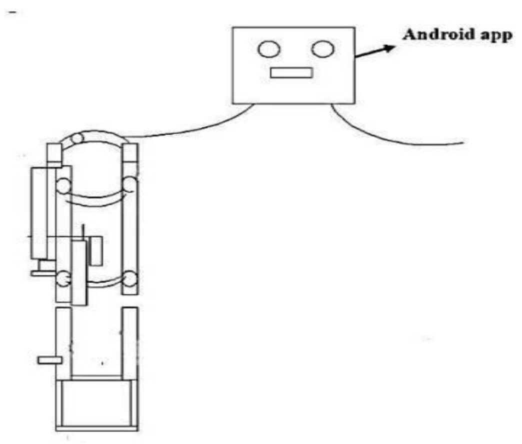

Fig 5: Power adapter

Fig.6 and the proposed model with software and hardware implementation is shown in Fig..7.

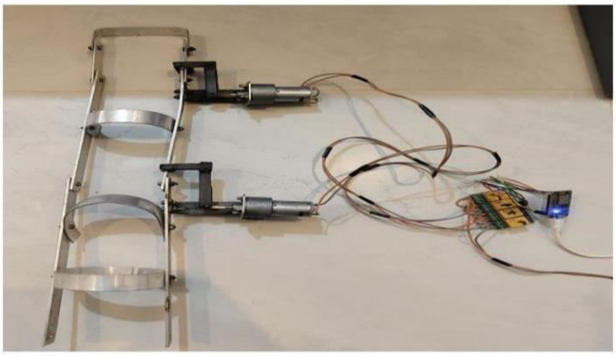

Fig.7 Hardware Implementation

On integration of above hardware components the fabrication of exoskeleton arm have been made whose 2D diagram is shown in

III. METHODOLOGY

A. Block diagram:

An ideal method for development of an IoT based exoskeleton arm is described in the proposed work whose block diagram is as shown in Fig.8. The proposed model of exoskeleton arm incorporates IoT components like the blynk app, motors, relay, and Node MCU which establishes a streamlined communication pathway for efficient control and operation. At the core of this system lies the blynk app, serving as the interface through which users interact with the exoskeleton arm[1]. By sending commands and adjusting parameters via the app, users initiate actions that are relayed to the Node MCU, a versatile microcontroller equipped with Wi-Fi capabilities. The Node MCU acts as the central hub, receiving instructions from the blynk app and translating them into motor control signals. These signals are then transmitted to the relay modules, which regulate the power supply to the motors responsible for the arm's movement which specially focuses on Elbow and wrist movement. Whether it's adjusting joint angles or executing specific

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motions, the Node MCU orchestrates the precise activation and coordination of the motors through the relay modules, ensuring seamless operation in response to user input. This interconnected network of IoT components not only enhances the versatility and functionality of the exoskeleton arm but also facilitates remote accessibility and real-time monitoring, marking a significant advancement in assistive technology and human-machine interaction.

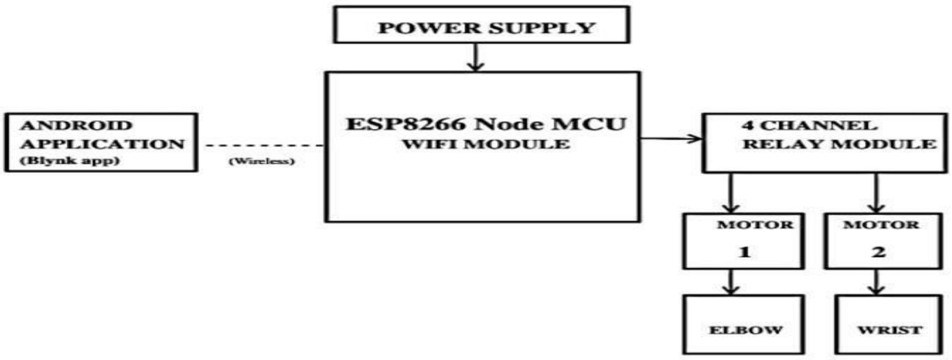

FIG.8 BLOCK DIAGRAM

B. Working principle:

The operational concept of an exoskeleton arm incorporating IoT, a blynk app, a motor, Node MCU, 4-channel relay, and power supply is a symbiotic fusion of hardware and software elements geared towards enhanced functionality and user interaction.

The Node MCU acts as the brain of the system, connecting the exoskeleton arm to the internet. It communicates with the Blynk app via Wi-Fi. The 4-channel relay is used to control the motors of the exoskeleton arm. Each channel of the relay corresponds to a specific motor or joint of the arm. The Node MCU triggers the relays based on commands received from the Blynk app. The Blynk app provides a user-friendly interface for controlling and monitoring the exoskeleton arm remotely. Users can send commands to move specific joints of the arm or adjust settings such as speed and intensity. The Node MCU sends real-time data to the Blynk app, allowing users to monitor the status of the exoskeleton arm, including motor positions, battery levels, and sensor readings.

Hence, Users can remotely control the exoskeleton arm using the Blynk app from anywhere with an internet connection. This enables convenient operation and adjustment of the arm without the need for physical interaction.

C. Flow chart:

The work flow of the project is as follows,

The process begins with initializing all system components, including the Node MCU, relay, sensors, and Blynk app connection. The system establishes a Wi-Fi connection to enable communication between the Node MCU and the Blynk app. The system listens for commands from the Blynk app interface, which includes the touch instructions sent by the user. Once commands are received, they are interpreted by the system to determine the desired action, such as moving a specific joint or adjusting the arm's speed and intensity. Based on the interpreted commands, the system triggers the appropriate channels of the 4-channel relay to control the motors responsible for moving the exoskeleton arm's joints. The motors are then actuated accordingly, executing the desired movement or adjustment as instructed by the user via the Blynk app. The entire sequence of reading data, receiving commands, and executing actions is repeated continuously in a loop to maintain real-time operation and responsiveness of the system. Finally, the flowchart ends, representing the completion of the system's operation until further commands or interactions are received.

The flowchart as shown in Fig.9 provides a visual representation of the sequential steps involved in the operation of the IoT-based motorized exoskeleton arm, illustrating the flow of data and control between its various components.

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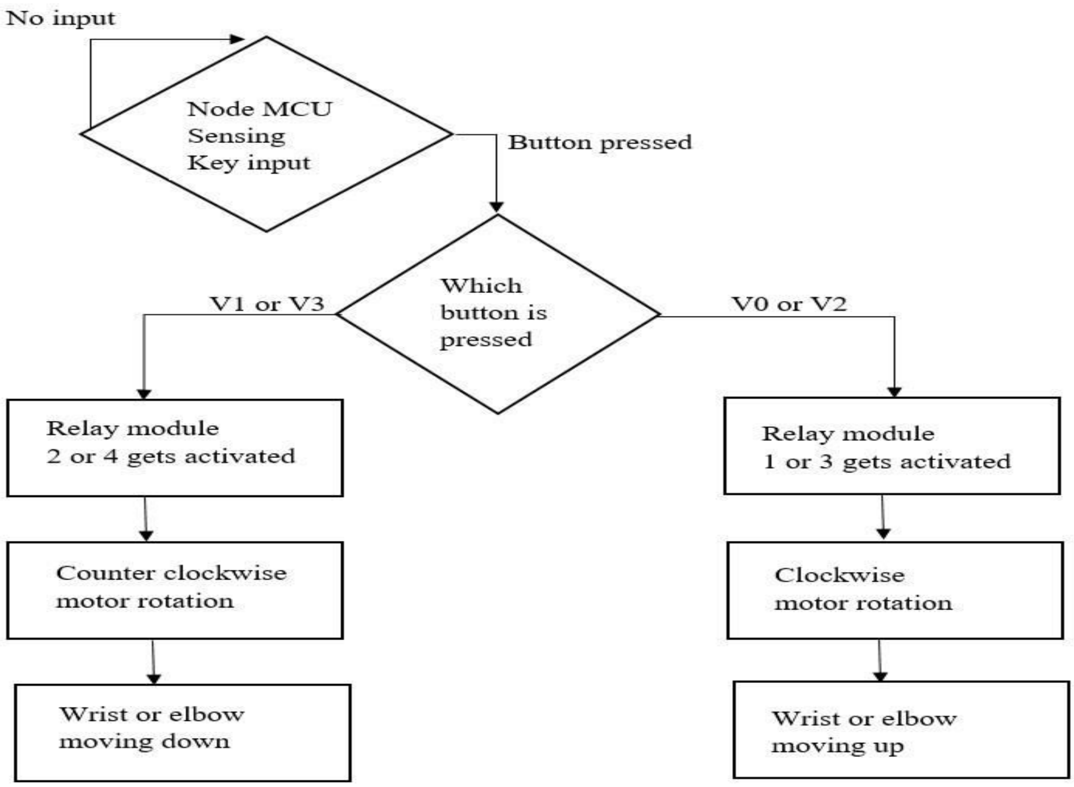

Fig. 9 :Flow chart

IV. RESULTS AND DISCUSSION

A. Performance evaluation:

The exoskeleton arm demonstrated precise movement control and responsiveness to commands sent via the Blynk app as depicted in Table.1. It executed movements accurately and efficiently, showcasing its ability to perform tasks effectively. Additionally, the system operated reliably with minimal latency, ensuring smooth operation in realworld scenarios. The graphical representation of time versus operation of exoskeleton is as shown in Fig.10

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Table.1 The table represents each commands used with its corresponding operation and its required time.

Sl	Commands(Blynk app)	Operation	Time Required
1	V0 - ON	Wrist moves upwards	3sec
2	V1 - ON	Wrist moves downwards	3.4sec
3	V2 - ON	Elbow moves upwards	6sec
4	V3 - ON	Elbow moves downwards	5sec

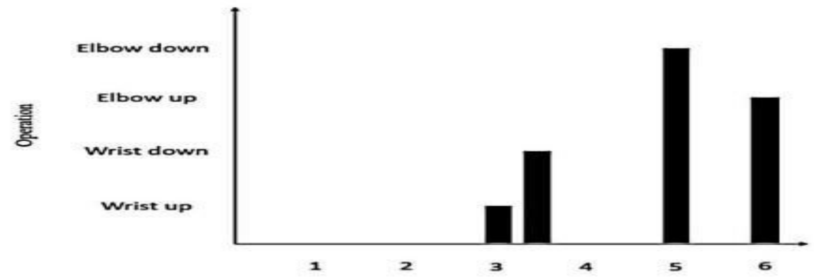

Fig.10: The figure exhibits the graphical representation of time versus operation of the exoskeleton arm

B. Usability assessment:

The Blynk app shown in Fig.11 provided an intuitive interface for users to interact with the exoskeleton arm, enabling seamless control and real-time monitoring. Users easily navigated through different features and functionalities, contributing to a positive user experience. The proposed system has been proven for its simplicity of putting on and taking off. The model even evaluated for its comfort due to the even distribution of weight.

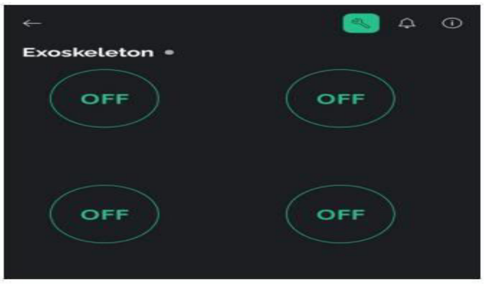

Fig.11: Blynk application

C. Functionality assessment:

The exoskeleton arm successfully integrated IoT technology, allowing for remote control and monitoring via the Blynk app when experimented on user. The users commanded the arm which successfully performed various movements and actions, which enhanced the convenience and accessibility as shown in Fig.12 and Fig. 13. This proposed system has proven to be cost-effective and has shown resistant to corrosion.

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Fig.12: PROPOSED MODEL
(User interface-wrist moving upwards)

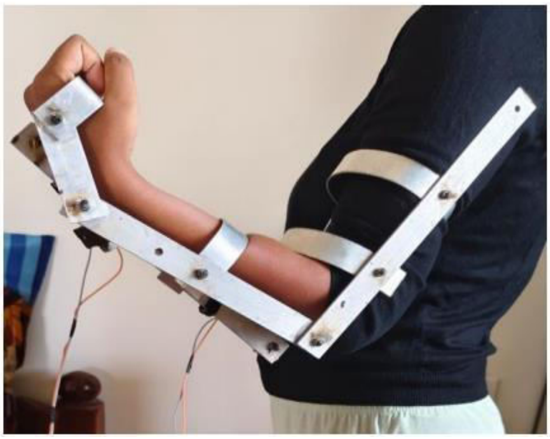

Fig.13: PROPOSED MODEL
(User interface-elbow moving upwards)

V. CONCLUSION

The IoT-based motorized exoskeleton arm represents a significant advancement in the realm of wearable robotics. Through its integration with IoT technology, this innovative device offers a myriad of benefits across various industries. In healthcare, it provides individuals with mobility impairments newfound independence and improved quality of life. In manufacturing and logistics, it enhances worker productivity and safety by reducing strain-related injuries and fatigue. Real-time data monitoring capabilities allow for remote supervision and optimization of performance, further augmenting its utility. However, the widespread adoption of IoT-based exoskeleton arms necessitates addressing several challenges. Security concerns regarding the transmission and storage of sensitive data must be meticulously addressed to safeguard user privacy and prevent potential cyber threats. Seamless integration with existing infrastructure and workflows is paramount to ensure smooth deployment and maximize efficiency gains. Additionally, prioritizing user comfort, ergonomics, and safety in the design and development process is crucial to foster widespread acceptance and adoption. In conclusion, while IoT-based exoskeleton arms hold immense promise in revolutionizing various sectors, their successful implementation hinges on overcoming technical, security, and usability challenges. With careful consideration and strategic planning, these devices have the potential to transform how we work, live, and interact with technology.

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REFERENCES

1. Arun Kumar, R. Chandrasekhar, S. Hrithik Raj, U.V. Sravan Kumar and M.D. Khaja “Fabrication of Voice Operated Motorised Exo Skeleton Arm” June 2022 IJIRT Volume 9 Issue 1 , ISSN:2349-6002 .
2. Chalana.V, Christy Rockey, Shifa Fathima.N and AlMubashir.P.M “Development of Voice Operated Exoskeleton Arm Using Solar” INTERNATIONAL JOURNAL ON ADVANCED SCIENCE HUB Volume 02
3. Issue 06 June 2020 e-ISSN:2582-4376.
4. Pooja Jha, Kinjal Salva and Dishant Shah “Exoskeleton Arm”.
5. JOSHUA HULL, RANGER TURNER, ATHULYA A. SIMON and ALAN T. ASBECK “A NOVEL METHOD
6. AND EXOSKELETONS FOR WHOLE-ARM GRAVITY COMPENSATION” IEEE Access Received July 27,
7. 2020, accepted August 1, 2020, date of publication August 5, 2020, date of current version August 17, 2020.
8. Daniel George , Sadao Kawamura, Member, IEEE, Ying Zheng, and Yoshikatsu Hayashi “Design and Validation of a High DOF Origami Inspired Soft Actuated Assistive Exoskeleton Arm and Spine” IEEE TRANSACTIONS ON MEDICAL ROBOTICS AND BIONICS, VOL. 5, NO. 4, NOVEMBER 2023.
9. Duojin Wang , Qingyun Meng, Qiaoling Meng, Xinwei Li, and Hongliu Yu “Design and Development of a Portable Exoskeleton for Hand Rehabilitation” IEEE TRANSACTIONS ON NEURAL SYSTEMS AND REHABILITATION ENGINEERING, VOL. 26, NO. 12, DECEMBER 2018.
10. Le Dinh Phong, Vu Ngoc Long, and Le Hoai Quoc “Development of IoT based lower limb exoskeleton in rehabilitation” 017 14th International Conference on Ubiquitous Robots and Ambient Intelligence (URAI) June 28 - July 1, 2017 at Maison Glad Jeju, Jeju, Korea.

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