DESIGN AND MAKING OF EXOSKELETON

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Abstract-The purpose of this paper and project is to understand the basic fundamental of the design of Exoskeleton. Exoskeleton is a wearable electromechanical device to overcome limits of human body with the help of modern technology and person's ability to decisive thinking and control. The designed exoskeleton provides an arm support with 3-degrees of freedom for wrist to rotate freely and a mechanism to help lift weights. The aim is to reduce muscle strain during work, thereby enhancing the wearer's ability to lift heavy objects. Essentially, it increases the user's arm strength by providing external torque to counteract load forces. Although exoskeletons have various applications, their high-cost limits widespread use. Developing an affordable solution would be beneficial across industries, medical technology, and military operations. The proposed design will be based on average human dimensions and, once successful, could be expanded for broader and domestic use.

Key Words: exoskeleton, degree of freedom.

1. INTRODUCTION

Exoskeletons are wearable electromechanical devices that amplify human capabilities and to overcome the limits of the human body. The user can experience enhanced strength, working capacities, and mobility while simultaneously reducing the work strain, resistance to the body and much more. These functions and applications of the exoskeleton depend upon the requirements needed by the engineer. Before actually creating an exoskeleton, it is very important carefully study the degrees of freedom of various human joints, movement patterns, so it can closely replicate the kinematics of human body.

With the development of modern technology numerous studies conducted in this domain, the exoskeletons can now be integrated with sensors, better materials, programmable devices, artificial intelligence and machine learning. This has made the control of the exoskeleton easier than ever. The exoskeleton technology holds significant importance in various disciplines some of its applications are military activity, rehabilitation, training, transport, construction and repair, rescue work, provide support for people with disabilities.

2. AIM

The aim of developing mechanical exoskeletons is primarily to enhance human capabilities and improve quality of life in various contexts. These wearable robotic devices are designed to augment strength, endurance, and mobility, thereby assisting individuals in performing physically demanding tasks more efficiently and with reduced effort. In industrial settings, exoskeletons help prevent worker fatigue and reduce the risk of injuries related to repetitive tasks or heavy lifting. In healthcare, they support rehabilitation efforts by aiding patients recovering from injuries or surgeries to regain mobility and muscle strength. Additionally, exoskeletons hold promise in military applications for enhancing soldiers' endurance and reducing the physical strain of carrying heavy loads over long distances. Overall, the goal is to leverage technology to empower individuals, whether in work environments, healthcare facilities, or military operations, by minimizing physical limitations and maximizing human potential through the innovative integration of mechanical assistance.

3. LITERATURE REVIEW

Positive effects of robotic exoskeleton training of upper limb reaching movements after stroke Antonio Frisoli, Caterina Procopio, Carmelo Chisari, Ilaria Creatini2, Luca Bonfiglio, Massimo Bergamasco, Bruno Rossi and Maria Chiara Carboncin

This study focused on nine chronic stroke patients with right-side hemiparesis undergoing a six-week robotic-assisted rehabilitation program using an upper limb exoskeleton. The training aimed to restore motor function in spatial reaching movements. Assessments included kinesiologic measurements through motion and electromyographic analysis of reaching tasks before and after training, compared to a control group of healthy volunteers. Clinical evaluations using the Fugl-Meyer Assessment (FMA), Modified Ashworth scale (MA), and active range of motion were also conducted. Results indicated significant improvements in kinesiologic parameters such as movement time and smoothness, alongside clinical measures like increased FMA scores (4.6 ± 4.2 points) and decreased MA scores (3.2 ± 2.1 points). These improvements correlated with enhanced active ranges of motion and improved shoulder joint coordination. The training effects were influenced by the direction of movement and target position within peri personal space. Specifically, the training facilitated regained single joint movements and improved interjoin coordination between elbow and shoulder joints. Overall, the robotic-assisted rehabilitation effectively promoted motor recovery in chronic stroke patients, enhancing both kinesiologic and clinical outcomes. The study underscores the potential of robotic exoskeletons to aid in functional recovery and improve movement capabilities in individuals with hemiparesis post-stroke.

Kinematic, Dynamic Analysis and Control of 3 DOF Upper limb Robotic Exoskeleton Akash Gupta, Amit Kumar Mondal, Mukul Kumar Gupta1 University of Petroleum and Energy Studies, Dehradun 248007, India Manipal Academy of Higher Education, Dubai 345050, UAE

This paper explores the comprehensive kinematics, dynamics, and joint position analysis of a 3-degree-of-freedom (DOF) upper-limb robotic exoskeleton. Designed after studying human upper-limb biomechanics, the exoskeleton aims to assist in activities of daily living and rehabilitation for stroke or spinal cord injury patients. It enables shoulder abduction/adduction, extension/flexion, and elbow extension/flexion movements, mirroring the natural range of a human arm. Parameters for the exoskeleton are tailored to resemble those of a typical human upper limb. A key focus of the study is the application of computed torque control (CTC) to achieve precise joint positioning. CTC effectively minimizes error between desired and actual joint positions, demonstrating its feasibility as a control strategy for the exoskeleton. The paper also visualizes the exoskeleton's workspace using MATLAB, highlighting its operational range and capabilities. Overall, the research contributes to advancing robotic exoskeleton technology for enhancing quality of life and serving as a rehabilitation tool. By integrating detailed kinematic and dynamic analyses with CTC control, the study validates the exoskeleton's ability to accurately replicate human arm movements, essential for effective daily use and therapeutic applications in rehabilitation settings.

What Are User Perspectives of Exoskeleton Technology? A Literature Review Article in International Journal of Technology Assessment in Health Care · August 2017

This study aims to address current limitations in exoskeleton technology by examining user perspectives through a comprehensive literature review. Despite significant advancements in robotics and mechatronics, existing exoskeletons face challenges in affordability, size, weight, speed, and efficiency, potentially limiting their utility for individuals with neurological impairments who could benefit most from these devices. A thorough search of healthcare databases yielded 912 articles, with 893 excluded based on abstract reviews. Further analysis of references led to the inclusion of seven additional articles. Notably, no studies specifically focusing on user perspectives of exoskeleton technology were found. However, nine articles emphasized the critical role of user involvement in the design of assistive technologies more broadly. From this literature, it is clear that involving end users in the development process of assistive technologies is crucial to meeting their complex needs effectively. Therefore, the study concludes that further research is essential to identify the expectations and challenges faced by potential users of exoskeleton technology. Such insights are necessary to guide the future design and technical advancements of exoskeletons, ensuring they align closely with user aspirations and improve functional capabilities for individuals with disabilities.

Universal compact lower limb turning module intended for use in orthotic robots Mateusz Janowski1, Danuta Jasińska-Choromańska1, Dymitr Osiński1, Marcin Zaczyk1 Faculty of Mechatronics, Warsaw University of Technology, Boboli 8, 02-525, Warsaw, Poland.

The paper presents a novel model for a lower limb rotation system in orthotic robots, specifically designed for applications like the 'Veni Prometheus' System developed at Warsaw University of Technology. It addresses the current landscape of orthotic robots, emphasizing the scarcity of systems capable of executing pivoting turns. The focus is on a two-stage pivoting turning movement, meticulously analyzed with detailed insights into operational conditions and limitations of the system. The innovation lies in introducing an additional degree of freedom to orthotic robots by enabling rotation along the thigh link's lengthwise axis. A comprehensive three-dimensional model is presented, demonstrating how the design facilitates essential movements of the lower limb and torso for individuals with mobility impairments. Importantly, the system is engineered to be compact, facilitating its integration into various orthotic robot designs. Overall, the paper contributes a significant advancement in enhancing maneuverability and functionality in orthotic robots, crucially benefiting rehabilitation and mobility assistance technologies.

Past, Present and Future of Assistive Robotic Lower Limb Exoskeletons Ramesh Narina, Marek Iwaniec and Swapnil Arawade AGH University of Science and Technology, Al. Adama Mickiewicza 30,30 - 059 Kraków, Poland Vishwakarma institute of technology, Pune, 411037 Maharashtra, India

This chapter provides a comprehensive overview of advancements in assistive robotic exoskeletons for human lower limbs, consolidating fragmented knowledge from various research efforts. It acknowledges the rapid technological progress in recent years, which has led to disparate publications focusing on specific aspects like mechanical design, control interfaces, or simulation techniques. The aim of this work is to synthesize these aspects into a cohesive framework, encompassing popular exoskeleton types. The discussion spans mechanical design considerations, electrical control systems, and their respective algorithms. Analytical simulations such as forward and inverse kinematics, as well as dynamic simulations using ADAMS and Open Sim, are explored in depth to evaluate system behaviors like multibody dynamics. The chapter not only proposes improved solutions but also addresses ongoing challenges in each facet of exoskeleton development. By integrating these diverse insights, the paper aims to contribute to a more holistic understanding and advancement of assistive robotic exoskeleton technology for enhanced human mobility and rehabilitation applications.

4. METHODOLOGY

To design an exoskeleton arm that fits a wide range of user's data is collected focusing on key measurements such as arm length, forearm length, wrist circumference, and elbow-to-wrist distance. These measurements are analysed to determine average values and standard deviations, which are then used to establish baseline design parameters. The exoskeleton arm's necessary degrees of freedom (DoF) include 1 DoF for the elbow, and 2 DoF for the wrist, which are simulated using kinematic modelling tools.The wrist design, created in Solid-Works, incorporates actuators and uses materials that are weight durable and provides the user comfort. The overall framework supports the wrist and other components, with a modular design for ease of assembly and future upgrades are provided. Fabrication involves procuring materials like lightweight alloys and composites, using manufacturing techniques such as 3D printing, fabrication processes such as welding and drilling, and conducting thorough inspections and initial functional tests. Testing includes assessing the range of motion, load-bearing capacity, followed by usability trials with target users to adjust the fit and gather feedback on comfort and performance. The methodology concludes with a summary of key findings, discussing the design's implications and suggesting areas for future research and development. This structured approach provides a comprehensive overview of the exoskeleton arm's development process, from initial design to final testing and evaluation.

Fig-1: MS Steel Arm Frame

Fig-2: 3D Printed Wrist Frame

Fig-3: Working model

Fig-4: Final product

5. FUTURE APPLICATION

The future of robotic exoskeletons is promising across various sectors due to ongoing technological advancements and broad potential applications. In healthcare, these devices enhance rehabilitation and offer personalized care through customization and integration with monitoring systems, benefiting both patients recovering from injuries and elderly populations seeking improved mobility and quality of life. In industrial contexts, exoskeletons reduce physical strain, boost productivity, and ensure safer working conditions. Future developments could include autonomous functionalities, energy-efficient designs, and integration with collaborative robots, expanding their utility in space exploration, education, and beyond. However, ethical considerations, regulatory frameworks, and societal acceptance are crucial for ensuring safe and equitable global adoption of exoskeleton technology.

6. CONCLUSION

In conclusion, exoskeleton technology represents a groundbreaking innovation with the potential to revolutionize multiple industries and improve the lives of individuals with mobility impairments. As research and development in this field continue to progress, we can expect to see even more advanced and versatile exoskeletons that offer enhanced functionality and accessibility. The future of exoskeletons holds great promise for transforming the way we work, move, and interact with the world around us.

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