DESIGN AND DEVELOPMENT OF ANTI-TREMOR SOFT-ROBOTIC EXOSKELETON FOR DAMPING HAND TREMORS FOR ELDERLY AND PHT PATIENTS

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Introduction:

Hand tremors are involuntary rhythmic oscillations of one or both hands, affecting millions worldwide. These tremors can result from various medical conditions. Parkinson's disease patients and the elderly are frequently affected by hand tremors, which severely reduce their quality of life and ability to perform daily tasks. Non-invasive solutions are needed because traditional treatments like medication and surgery have drawbacks and possible adverse effects. This project intends to design and build a soft-robotic exoskeleton to decrease hand tremors, boosting the user's ability to do everyday chores. By producing a lightweight, comfortable, and user-friendly technology, the exoskeleton offers a promising alternative to improve the quality of life for those suffering from terrible tremors. Soft robotics has the potential to completely transform healthcare, especially in the areas of assistive technology and rehabilitation. Soft robotics, as opposed to traditional rigid robots, is the creation and application of malleable and flexible materials that replicate the suppleness and natural movement of biological beings. This new discipline combines engineering, materials science, and biomechanics concepts to develop gadgets that are safer and more pleasant for human contact while also demonstrating improved adaptation to challenging conditions.

Objectives: To design and develop of a lightweight, pneumatically actuated soft-robotic exoskeleton that,

1. fits comfortably to the hand and wrist anatomy,
2. minimizes tremor amplitude and improve hand steadiness during daily activities,
3. is designed for durability and reliability for everyday use,
4. uses readily available inexpensive biocompatible materials to make the exoskeleton accessible to a wider range of users.

Methodology:

1. Discussion with Doctors on PHT.
2. Literature Review: Comprehensive analysis of existing research and technologies related to anti- tremor gloves and soft robotics.
3. Research Methodology: Outline of the systematic approach and methods used for developing the anti-tremor glove system.
4. Concept Design of the Entire Anti-Tremor Gloves System: Initial design blueprint detailing the components and functioning of the anti-tremor gloves.
5. Detailed Design of Single Finger Mould: Specific design parameters and CAD modelling for creating a single finger mould.
6. Fabrication of the 3D Printed Single Finger Moulds: Production of single finger moulds using 3D printing technology.
7. Fabrication of the Soft Robotic Finger from the Mould: Creating the soft robotic finger using the fabricated mould.
8. Testing of the Soft Robotic Finger with Solenoid Valve Actuation: Evaluation of the robotic finger's performance using solenoid valve actuation.
9. Establishment of Optimized Soft Robotics Fabrication Parameters: Identifying and optimizing the key parameters for soft robotics fabrication.
10. Repeat Steps 5, 6, 7 for Other Fingers: Production, creation, and testing of other four robotic fingers following the established process.
11. Detailed Design of Pneumatic Circuit and Electronic Control Circuit: Engineering design of the pneumatic and electronic control circuits for the glove.
12. Fabrication of the Pneumatic Circuit and Electronic Control Circuit: Building

the designed pneumatic and electronic control systems.

13. Testing of the Pneumatic Circuit and Electronic Control Circuit: Performance testing of the fabricated pneumatic and electronic control systems.
14. Hardware Integration: Assembling of the Soft Robotic Fingers, the Pneumatic Circuit, and Electronic Control Circuit for Complete anti-tremor glove prototype.
15. Testing and Validation of the Final Prototype: Comprehensive testing to validate the functionality and effectiveness of the final prototype.
16. Design Optimization: Refining design based on testing feedback to enhance the performance and usability.
17. Discussion: Analyzing the results and implications of research and development process.
18. Conclusion: Summarizing the findings and overall success of the project.
19. Patent Filing: Selecting Intellectual property rights for the developed technology.
20. Dissemination of the results in Research papers: publishing the research findings in scientific journals and conference.

Result and Conclusion:

The proposed Anti-tremor Soft-robotic glove will:

- Significantly decrease the amplitude and frequency of hand tremors, improve precision and steadiness in hand movements.
- Enhance ability of patients to perform daily activities such as writing, eating, and dressing independently.
- Be a design that is comfortable to wear for extended periods and ensures patient safety without causing discomfort.
- Be simple, intuitive controls and have ease of wearing and removing the exoskeleton, facilitating use by elderly patients with minimal assistance.
- Be lightweight design ensuring the device is portable and does not cause additional strain on the user's arm.

• Wearing this robotic exoskeleton will not obstruct the tactile sensing of the hands.

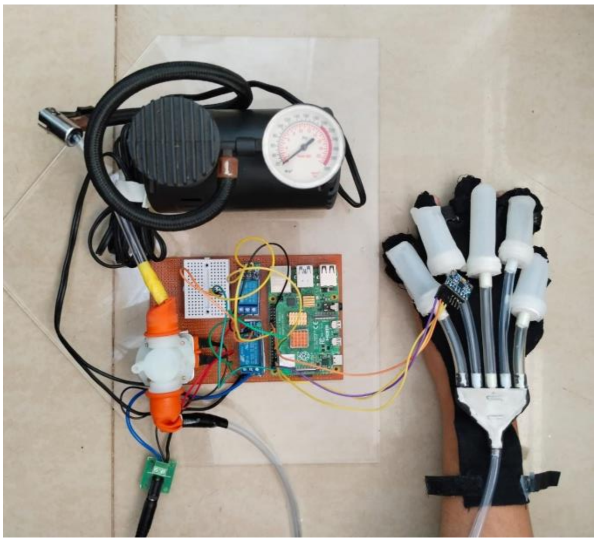

Figure 1: Prototype

After completing the project on a rehabilitation soft robotic exoskeleton for hand tremors using a pneumatic system, we conclude that it shows great potential in aiding individuals with tremor disorders. Our testing indicates that the exoskeleton effectively reduces hand tremors, enhancing quality of life for users. The exoskeleton comfortably conforms to the hand and wrist anatomy, minimizing tremor amplitude and enhancing hand steadiness during daily activities. Built with durability and reliability in mind, it is well-suited for everyday use. Ongoing improvements have addressed technical issues and user comfort, establishing the device as a non-invasive and accessible option that complements traditional therapies.

The anti-tremor soft robotic exoskeleton offers a groundbreaking solution to mitigate hand tremors in elderly individuals and PHT patients, improving their quality of life by restoring fine motor control. The technology guarantees real-time tremor detection and exact dampening without obstructing voluntary movements by combining soft robotics, sophisticated sensors, and AI-driven algorithms. Its lightweight, flexible design prioritizes user comfort and wearability, making it suitable for extended use while maintaining safety. Through a multidisciplinary approach involving robotics, biomedical engineering, and healthcare, the exoskeleton is designed to be both effective and user-friendly. This innovation not only empowers users to regain independence in daily tasks but also serves as a significant step forward in assistive robotics, paving the way for future advancements in addressing motor impairment.

Future Scope:

The future scope of this project includes:

1. Enhanced AI Algorithms: Developing more sophisticated machine learning models to improve tremor detection, classification, and adaptive control for various tremor types and severities.
2. Integration with Wearable Technology: Incorporating additional sensors, such as physiological monitors (e.g., heart rate, skin temperature), to provide a comprehensive health monitoring system alongside tremor control.
3. Customization and Scalability: Designing modular or adjustable components to cater to different age groups, hand sizes, and specific user needs, enhancing the device’s accessibility and usability.
4. Energy Efficiency Improvements: Innovating energy-efficient actuators and optimizing battery technology to extend operational time and reduce the device's overall weight.
5. Wireless Connectivity and IoT: Enabling wireless communication for real-time data tracking and sharing with healthcare professionals, facilitating remote monitoring and personalized therapy.
6. Material Innovations: Exploring advanced soft materials with self-healing or shape-memory properties to improve durability, comfort, and adaptability to user movements.
7. Integration with Rehabilitation Protocols: Expanding the device's applications to support physical therapy, aiding patients in regaining strength and dexterity through guided exercises.
8. Clinical Trials and Validation: Conducting extensive trials across diverse patient demographics to validate the exoskeleton’s effectiveness, safety, and comfort, and to gather data for iterative design improvements.
9. Cost Reduction Strategies: Focusing on affordable materials and manufacturing processes to make the device accessible to a broader audience, particularly in low-resource settings.

10. Adaptation for Other Tremor Disorders: Modifying the device for use in other conditions, such as Parkinson’s disease or multiple sclerosis, to broaden its application and impact.