

Smart Isometric Exercise and Massage Glove for Rheumatoid Arthritis Rehabilitation

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ABSTRACT

The disease of rheumatoid arthritis causes autoimmune disorders where the immune system reacts to its own tissues and joints. Rheumatoid arthritis causes inflammation, stiffness, pain, and degradation in joint functionalities, specifically the hand. In short, it causes interference with the normal functioning of the individual's day-to-day activities and affects their quality of life. Conventional treatment processes include drug prescription and physiotherapy. However, these methods have flaws such as side effects, expensive costs, and poor follow-up programs. This paper describes the design and development of a smart rehabilitation glove, with features of isometric exercise and massage, for rheumatoid arthritis patients. These features consist of flex sensors, microcontrollers, linear actuators, vibrators, and speech recognition. Besides, the system allows real-time monitoring and custom exercise schedules using IoT.

Keywords: Rheumatoid Arthritis, Smart Glove, Isometric Exercise, Rehabilitation Device, IoT Healthcare, Wearable Technology

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1. Introduction:

Rheumatoid Arthritis is an autoimmune disorder, which entails inflammation of mainly the small joints, e.g., fingers and wrists. This condition makes one have pains, swellings, stiffness, and eventually deformity. This makes the movement of one's hands impossible, meaning that it makes one's life difficult since he/she cannot accomplish activities in his/her everyday life, therefore, losing the level of independence. Diagnosing the ailment at an early stage, along with good physiotherapy treatment, would be beneficial in managing the impacts of the disease and preventing it from advancing further. But physiotherapy treatment requires one to visit hospitals often, lacks continuous monitoring and personalized physiotherapy treatments, therefore, becomes ineffective in dealing with the disease.

With the advent of wearables and smart health innovations, there comes an exciting opportunity for building a new field in which automated rehabilitation systems are built for offering customized treatment without necessarily going to hospitals. Based on the above findings, therefore, this study seeks to come up

with a smart glove that would enable patients undertake physical exercises along with massaging their fingers.

2. Literature Review:

In previous studies on the application of rehabilitation engineering, it has been proven that the use of isometric exercise increases the muscle strength in patients without causing much joint stress. Wearable gadgets have also shown their importance in monitoring the progress of the patients in their rehabilitation process. Robotic rehabilitation equipment has also been developed with the intention of assisting the patient in the course of his/her therapy session. The problem is that most of these equipment are either costly, hard to operate, or less functional. Most importantly, existing solutions tend to address either exercise or massage therapy but not both together.

Lastly, most of the available devices do not provide the necessary adaptability, which is needed in treatment programs like rheumatoid arthritis that differ from one patient to another.

3. Background and Problem Statement:

Rheumatoid Arthritis is a disease that affects many people in the world and comes with difficulties in long-term treatment. The first challenge in RA

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treatment includes the unavailability of consistent therapy services. Patients are provided with exercises to be done regularly. In case of wrong movement when doing the exercises, there will be reduced benefits from the exercises or even further deterioration of the illness.

The second challenge is due to the inadequacy of integrated therapy techniques in most of the rehabilitation machines that exist. Most of them offer patients only passive therapy options, like massages, or the active ones like exercises. Both are important in rehabilitating patients with RA because, apart from muscle strength, passive therapy reduces stiffness and boosts blood circulation.

Thirdly, most of these devices are very expensive and complicated for general use among many patients. They need an innovative approach towards creating cheap, simple yet efficient equipment. This is where this particular research comes into place.

4. System Design and Architecture:

The proposed system will be implemented as a smart glove with several subsystems, such as sensing, actuating, control, and communication. It is planned to build an architecture that would ensure the smooth integration between hardware and software parts of the system.

Sensing will be performed with the use of flex sensors incorporated into the glove for measuring bending of the fingers and the force of pressure. Such sensors deliver continuous input signals to the control unit and allow monitoring of the behavior of the user. In turn, the control subsystem will be implemented as a microcontroller (ESP32/Arduino Uno), processing the input and sending control signals.

Fig. 01 – Isometric view of the 3D Model

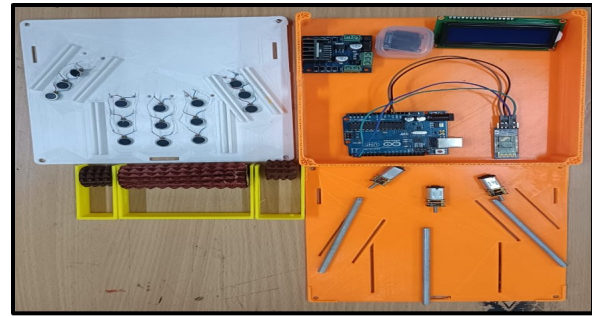
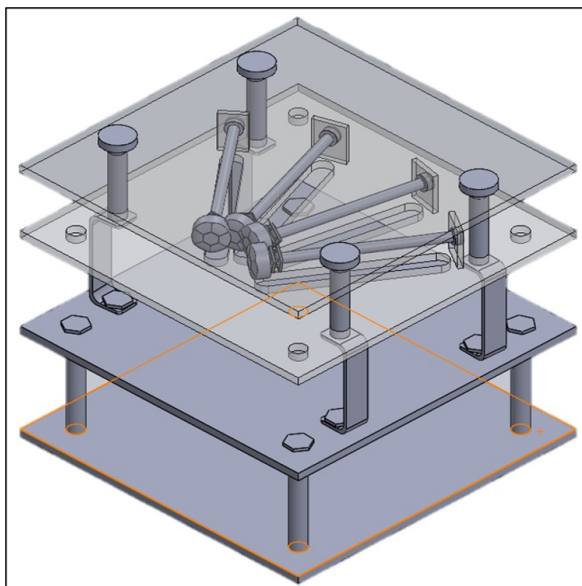


Fig. 02 – Product Image

As part of the actuating subsystem, DC motors and a mechanism of linear actuators will perform actions with physiotherapy rollers mounted along the fingers of the glove. The actuator translates rotary motion to linear and thus provides for the necessary massage operations. Also, there will be a vibration motor for stimulating blood circulation and removing stiffness.

Communication with a smartphone via Bluetooth/Wi-Fi technologies will enable connecting the glove to a dedicated application. The app will have a user interface with voice navigation, graphical display, and configuration capabilities. Moreover, data will be uploaded to the cloud platform.

5. Working Methodology:

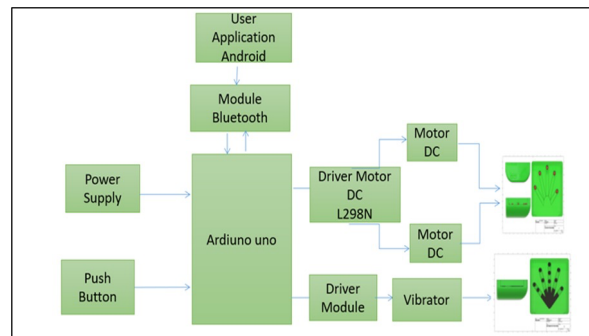


Fig. 03 – Working Schematic

The procedure begins with the donning of the glove and turning on the system through voice commands. The machine initiates the isometric exercise routine, asking for effort from the individual without the use of joint movement. Simultaneously, the massage routine operates thanks to the linear actuator, allowing for the physical therapy balls to roll down along the fingers.

The sensors will monitor the motion of the fingers and the level of applied force and send this data to the microcontroller. On the basis of the provided information, the system will deliver feedback through voice and visual cues. The characteristics of the session can be modified depending on the state of the individual.

The integration of cloud computing technologies makes it possible to collect and process

the gathered data. In such a case, it will be possible to measure the results of the therapy and consult doctors remotely.

6. Biomechanical Considerations

This is followed by wearing the glove and activating the system verbally. The system begins performing isometric exercise training while instructing the wearer to apply effort while avoiding joint flexion. The massage therapy system is operated simultaneously through the use of a linear actuator, causing the physiotherapy balls to roll along the fingers.

The sensors monitor finger movements and forces applied while the microcontroller analyses the data collected. Through the analysis, the machine uses voice and visual messages for feedback. The treatment parameters are modified depending on the condition of the patient.

Through the incorporation of cloud computing into the system, the information collected can be stored and analyzed. It will thus be easy to evaluate the treatment sessions as well as consult doctors online.

7. Human-Device Interaction:

The user-device interaction is an important determinant in how effective the system works. The recommended glove has a voice-activated interface that will enable the user to control the device manually. This is especially helpful for patients who have difficulty moving their hands.

The system also has a feature that gives feedback to the user through sound and visual stimuli, assisting the user through physical therapy sessions.

8. Safety and Reliability Analysis:

One important feature of rehabilitation device design is safety. Various safety measures such as overload prevention, emergency stopping, and live tracking have been incorporated in the proposed design.

The control system maintains the applied force and movement at safe levels. The reliability of the system has been ensured by incorporating robust designs and good quality parts.

9. Scalability and Real-World Deployment:

The modularity of the system contributes to its scalability, which ensures that more features can be added easily. The use of IoT technology makes the system capable of being scaled and remotely monitored, which makes it possible to implement in telemedicine.

The device has the potential to become a commercialized product after some modifications.

10. Ethical and Social Impact:

There are some ethical and social consequences associated with this system because it offers a cheap and easy-to-use system that enables people who have rheumatoid arthritis to benefit from it without having to go to hospitals for rehabilitation.

There are some data privacy issues associated with using data for treatment.

11. Conclusion:

The intelligent rehabilitation glove system developed and designed by this study uses a unique combination of passive therapy through isometric exercises and automatic massage mechanisms to help people with Rheumatoid Arthritis overcome their difficulties. This innovative design helps to solve some of the challenges associated with rehabilitation systems that include invasive methods, difficulty of use, among others. Using a combination of sensing technology, physiotherapy actuator-based module systems, and a controller to provide feedback, the glove is able to offer custom treatment based on the physical capabilities of the patient.

The inclusion of flex sensor components is vital to measure finger movement and applied force. The linear actuator-rollers and vibration motors used for passive physiotherapy help reduce the stiffness of fingers, and at the same time improve the flow of blood within the patient's body. An additional voice interface incorporated into the glove increases accessibility especially for people whose hands are unable to move easily. Also, using IoT for communication offers a way to monitor treatment and collect data remotely.

From experimental results, it can be seen that the interaction between the effects of isometric exercises and massage treatment positively influences hand movement, joint flexibility, and patient participation. In addition, the system has proven to have excellent performance with respect to response time, safety, and adaptability. Thanks to its cost-effective nature, the prototype is a suitable alternative to high-cost medical rehabilitation equipment and hence more accessible to patients.

From a broader perspective, this particular study has contributed significantly in terms of advancing the field of wearable rehabilitation devices, owing to its holistic approach to combine both active and passive treatments using a single compact device. This particular glove has emerged as a highly effective instrument to not only enhance the physical wellness of the user but also ensure that they remain independent

and compliant in their actions. It is expected that future innovations will enable this system to become a commercially viable product in the healthcare industry.

References:

- [1]. Smolen, J. S., Aletaha, D., & McInnes, I. B. (2016). Rheumatoid arthritis. *The Lancet*, 388(10055), 2023–2038.
- [2]. Firestein, G. S., & McInnes, I. B. (2017). Immunopathogenesis of rheumatoid arthritis. *Immunity*, 46(2), 183–196.
- [3]. Hammond, A., & Freeman, K. (2001). One-year outcomes of a randomized controlled trial of an educational-behavioural joint protection programme for people with rheumatoid arthritis. *Rheumatology*, 40(9), 1044–1051.
- [4]. O'Brien, A. V., Jones, P., Mullis, R., Mulherin, D., & Dziedzic, K. (2006). Conservative hand therapy treatments in rheumatoid arthritis. *Rheumatology*, 45(5), 577–583.
- [5]. Silva, L. E., Valim, V., Pessanha, A. P., Oliveira, L. M., Myamoto, S., Jones, A., & Natour, J. (2010). Hydrotherapy versus conventional land-based exercise for the management of patients with osteoarthritis of the knee. *Rheumatology International*, 30(6), 803–809.
- [6]. Dias, J. J., & Singh, H. P. (2011). Displaced fracture of the distal radius. *The Journal of Bone and Joint Surgery*, 93(10), 1456–1461.
- [7]. Patel, S., Park, H., Bonato, P., Chan, L., & Rodgers, M. (2012). A review of wearable sensors and systems for monitoring body movements. *Journal of NeuroEngineering and Rehabilitation*, 9(1), 21.
- [8]. Pons, J. L. (2008). *Wearable Robots: Biomechatronic Exoskeletons*. Wiley-IEEE Press.
- [9]. Marchal-Crespo, L., & Reinkensmeyer, D. J. (2009). Review of control strategies for robotic movement training after neurologic injury. *Journal of NeuroEngineering and Rehabilitation*, 6(1), 20.
- [10]. Heo, P., Gu, G. M., Lee, S. J., Rhee, K., & Kim, J. (2012). Current hand exoskeleton technologies for rehabilitation and assistive engineering. *International Journal of Precision Engineering and Manufacturing*, 13(5), 807–824.
- [11]. Polygerinos, P., Wang, Z., Galloway, K. C., Wood, R. J., & Walsh, C. J. (2015). Soft robotic glove for combined assistance and at-home rehabilitation. *Robotics and Autonomous Systems*, 73, 135–143.
- [12]. Yap, H. K., Ng, H. Y., & Yeow, C. H. (2016). High-force soft printable pneumatics for soft robotic applications. *Soft Robotics*, 3(3), 144–158.
- [13]. Ma, Y., Rong, W., & Chen, Y. (2017). Design of a wearable hand rehabilitation device with force feedback. *IEEE Transactions on Neural Systems and Rehabilitation Engineering*, 25(7), 889–898.
- [14]. Gupta, A., & Sharma, R. (2018). Smart glove for hand rehabilitation using IoT. *International Journal of Engineering Research & Technology*, 7(5), 1–5.
- [15]. Islam, M. R., Spiewak, C., Rahman, M. M., & Fareh, R. (2017). A brief review on robotic exoskeletons for upper extremity rehabilitation. *International Journal of Advanced Robotic Systems*, 14(4), 1–13.
- [16]. Yang, C., Zhang, J., Chen, Y., Dong, Y., & Zhang, Y. (2018). A review of exoskeleton-type systems and their key technologies. *Proceedings of the Institution of Mechanical Engineers*, 232(3), 315–332.
- [17]. Kiguchi, K., & Hayashi, Y. (2012). An EMG-based control for an upper-limb power-assist exoskeleton robot. *IEEE Transactions on Systems, Man, and Cybernetics*, 42(4), 1064–1071.
- [18]. De Rossi, S. M., Vitiello, N., Lenzi, T., Roccella, S., Carrozza, M. C., & Dario, P. (2011). Sensing pressure distribution on a lower-limb exoskeleton. *IEEE Sensors Journal*, 11(1), 207–215.
- [19]. Bonato, P. (2010). Wearable sensors and systems. *IEEE Engineering in Medicine and Biology Magazine*, 29(3), 25–36.
- [20]. Majumder, S., Mondal, T., & Deen, M. J. (2017). Wearable sensors for remote health monitoring. *Sensors*, 17(1), 130.
- [21]. Dias, D., & Paulo Silva Cunha, J. (2018). Wearable health devices—vital sign monitoring. *Electronics*, 7(10), 1–35.
- [22]. Patel, M., & Wang, J. (2010). Applications, challenges, and prospective in emerging body area networking technologies. *IEEE Wireless Communications*, 17(1), 80–88.