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Robot-Assisted Therapy For Stroke Rehabilitation

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Abstract
The current study aims to create a hybrid exoskeleton robotic manipulator for stroke patients' upper limb rehabilitation. A hybrid manipulator made up of two parallel manipulators coupled in series makes up the robot. It combines the capabilities of a bottom 2-SPR (Spherical-Prismatic-Revolute) parallel manipulator and an upper 3-SPS (Spherical-Prismatic) parallel manipulator. This robot is four-degree-of-freedom (d-o-f) based on rehabilitation motions it will provide. The intention is to offer two motions for wrist joints and two motions for elbow joints as robot therapy. Wrist flexion/extension, ulnar/radial deviation, elbow flexion/extension, and pronation/supination are among the actions that the robot is made to enable. End-effector and exoskeleton technologies have the potential to improve hand motor function in chronic stroke patients, producing outcomes that are on par with or better than those of conventional therapy. As a potential strategy to improve recovery results, robot-assisted therapy is becoming more widely acknowledged as a beneficial addition to traditional rehabilitation techniques for enhancing motor function in stroke patients.
Keywords: *Hybrid Exoskeleton, Robotic, Stroke Rehabilitation,*

INTRODUCTION

Technological developments in the field of intelligent automation have evolved Robotics as a multidisciplinary science that integrates various scientific disciplines. It is a convolution of Mechanical Engineering (that investigates the anatomy of the robot), Electrical and Electronics Engineering (which is involved in the design and development of appropriate drives and controls), Control Systems Engineering (which identifies appropriate sensing and accurate control of the system), and Information Technology Engineering (which develops hardware, software and process information)[1]. The advancements in networking technologies, has brought a significant transformation in the use of computing facilities by the erudite and the common man, alike. A similar transformation in the area of intelligent automation is also anticipated imminently [2].

Robots have significant effects in industries. Industry manufacturings are based on intelligent automations. In the beginning, serial robots were introduced into industrial manufacturing, which had an end-effector attached to the manipulator. Productivity and accuracy were the reasons for using these robots in industries. Since industries required better force mobility and accuracy for improving the manufacturing technology, parallel robots were the new solution for many applications than serial robots [3]. Closed-loop kinematic chains with a stationary base and a moving platform comprised parallel robots. The base platform would be connected to the moving platform, which would serve as the end-effector, via a number of separate kinematic chains. Every limb has a minimum of one joint. The type of joints and the number of joints decide their degrees of freedom. Usually prismatic, universal and spherical joints are used [4]. The scope of the study is the design of a hybrid robot structure, its kinematics and workspace analysis. Exoskeleton manipulator/robots are mechanical manipulators that are meant to be worn by a human. The present research worldwide in this field is creating exoskeleton manipulators that are reprogrammable and multifunctional with an autonomous intelligent system that needs less therapist intervention. This powered exoskeleton is applied to enhance the muscle strength of the paralyzed patients. Rehabilitation is a routine and repetitive physical exercise that is performed with assistance from a physiotherapist [5]. A patient's physical abilities as well as sensory and mental abilities can be restored to normal conditions through rehabilitation. It is the treatment by which stroke paralyzed patients can learn to use their limbs in the best way and become independent again. It is a highly time-consuming training program as well as quite costly. Rehabilitation therapy is successful only if done immediately after stroke. Regardless of the therapist's level of expertise or weariness, this robot exoskeleton provides rigorous rehabilitation continuously for a long time.

METHODOLOGY

In order to address unimanual and bimanual arm activities, our group developed nine robotic treatment tasks that addressed feedback, intensity, challenge, and subject involvement. Subacute stroke patients were randomized to either the robotic therapy group (N=9) or the control group (N=10) using a matched-group design. For ten days, in addition to their usual therapy, the robotic therapy group received an extra hour of robotic therapy every day, while the control group just received conventional care. Both before and after the intervention, clinical and robotic evaluations were carried out [6]. Clinical tests such as the Functional Independence Measure (FIM), Action Research Arm Test (ARAT), and Fugl-Meyer Assessment of Upper Extremity (FMA UE) were employed in the study. Arm Position Matching and Visually Guided Reaching were among the robotic testing tasks. Both clinical and robotic evaluation scores were compared before and after the intervention using paired sample t-tests [7].

3. 1 Data analysis

The formula d = (M1-M2)/SD pooled, where M1 and M2 are the means of the two groups, was used in the study to compute between-group effect sizes (ESs). The formula SD pooled = √((SD1^2 + SD2^2)/2 was used to estimate the pooled standard deviation (SD pooled), which allowed comparison of effects across various time points after the intervention. In order to account for variation in the use of instruments, the study used random effects models to estimate pooled effects [16]. The results were presented as standardized mean differences (SMDs) with 95% confidence intervals (CIs). The formula SD = SE√n was used to approximate missing standard deviations (SDs) when needed. To prevent unit of analysis mistakes in three-arm RCTs, the outcomes of two intervention groups were aggregated and compared to the control group. SMDs are classified as small (0.2), medium (0.5), or big (0.8) in size. Additionally, we used the I2 statistic to analyze the heterogeneity among RCTs; a substantial and considerable heterogeneity between studies is indicated by an I2 > 50% with $p < .05$. The software program RevMan 5.3 was utilized to carry out the aforementioned analyses. We removed studies from meta-analyses if they included exoskeleton data with bias, such as medians and interquartile ranges, or if there were ≤2 RCTs per outcome [17].

3.2 Exoskeleton-Type Robot Devices

Four randomized controlled trials that employed exoskeleton-assisted robot therapy to enhance upper limb motor function in stroke patients were included in the study. Patients in the chronic phase of stroke recovery were the focus of all trials [8]. Among these, one study discovered that the robot-assisted therapy group had a noticeably better impact on spasticity than the group receiving traditional therapy. On the other hand, the traditional therapy group, which received the same dosage of treatment, saw a greater improvement in ADL function. The remaining three studies found no distinction between traditional therapies and robot-assisted therapy using exoskeleton equipment. The use of exoskeleton devices in robot-assisted rehabilitation for subacute stroke patients has also not been the subject of a randomized controlled experiment [9]. It is difficult to make firm judgments regarding the impact of exoskeleton-based robot-assisted therapy on upper limb function in stroke patients due to a lack of evidence, underscoring the need for more investigation [10].

IV RESULT AND DISCUSSION

The pilot study was finished by subacute stroke patients (39.8 days after the stroke). There were not many side effects throughout the intervention, and it was feasible to continue robotic therapy for an extra hour. At baseline, there was no significant difference in clinical or robotic scores across groups [11]. The FMA UE, ARAT, FIM, and Visually Guided Reaching scores, as well as the results of robotic therapy, significantly improved in the robotic intervention group. However, throughout the same time period, the control group only showed gains in FIM and Arm Position Matching scores. During our search, 321 records in all were found. There were 186 abstracts to screen after duplicates, brief reports, and non-English studies were eliminated. Reference lists turned up two more articles. Following the removal of studies that did not meet the requirements of the Critical Appraisal Skills Programmed and those that reported methods and/or results that were deemed flawed [12].

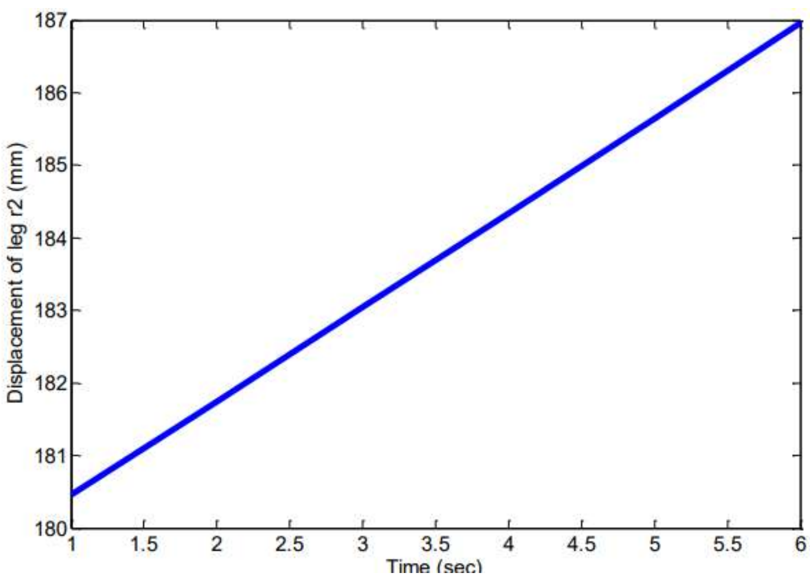

Figure 1. Displacement of Leg r2 during Wrist Flexion Motion to Wrist Extension Motion

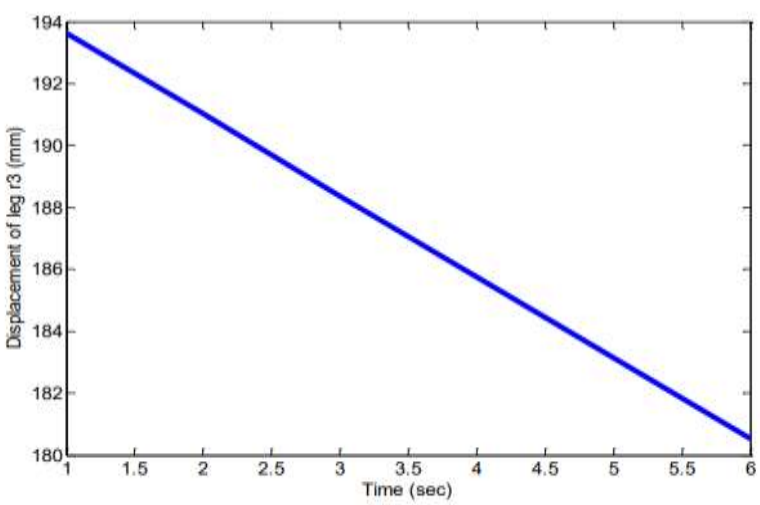

Figure 2. Displacement of Leg r3 during Wrist Flexion Motion

The graphs (Figures 1 and 2) show that during wrist flexion to extension motion, the leg displacements (r1, r2, r3) change smoothly across a wide range as the center (o2) displacement of the top platform varies gradually. This implies that the top parallel manipulator (PM) has advantageous kinematic properties that are advantageous for hybrid/parallel robots [13].

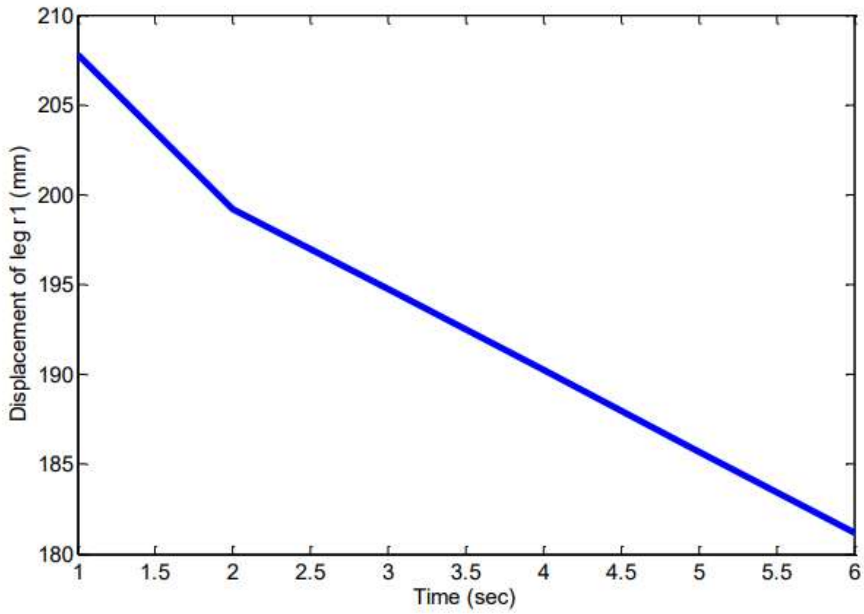

Figure 3. Displacement of Leg r2 during Wrist Ulnar Deviation Motion to Wrist Radial Deviation Motion

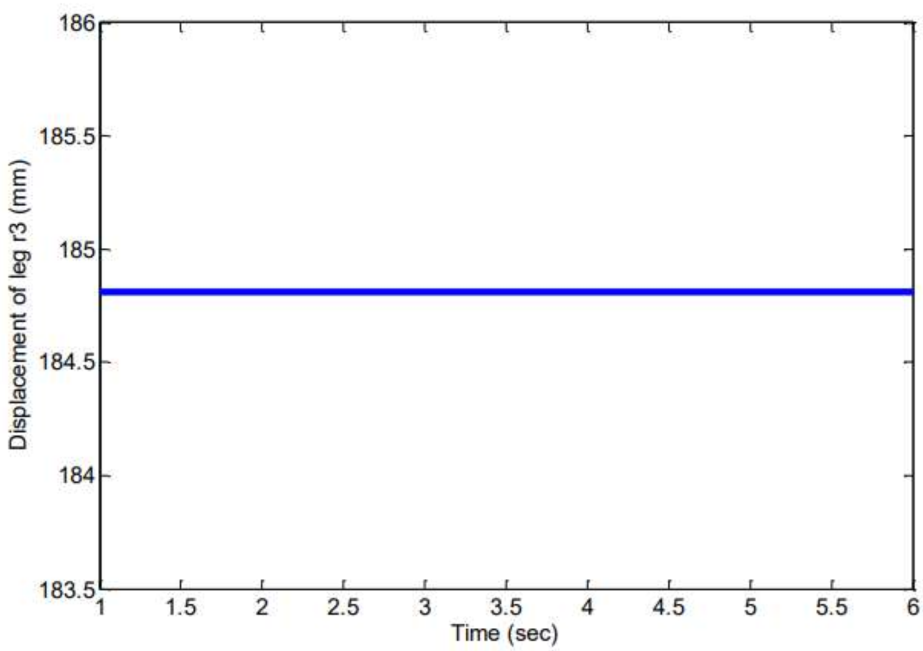

Figure 4. Displacement of Leg r3 during Wrist Ulnar Deviation Motion to Wrist Radial Deviation Motion

The graphs (Figures 3-4) demonstrate that during wrist ulnar deviation to radial deviation motion, the leg displacements (r1, r2, r3) change smoothly across a broad range as the center (o2) displacement of the top platform varies gradually [14]. This suggests that for these particular wrist motions, the upper parallel manipulator (PM) has good kinematic features. In Figures 3 to 4, time is represented in the x-axis and the leg displacement is represented in y-axis [15].

CONCLUSION

In short, robot technology is responsible for important functions in motor and cognitive post-stroke recovery. Rehabilitation robots' application can spare clinicians from intense training duties. With their accuracy and reliability as leverage, rehabilitation robots provide an efficient solution for improving stroke patient outcomes. Future research should concentrate on developing adaptive training technology for rehabilitation robots, standardizing and uniformly applying rehabilitation robots to stroke treatment, and exploring the integration of rehabilitation robot training with telemedicine and virtual reality. For robot-assisted therapy to become a vital component of stroke rehabilitation, well-controlled studies with a large number of patients that demonstrate improved efficacy for motor recovery are required. Analysis of the financial impact and functional advantages of robot-assisted therapy is required. After a stroke, robot-assisted therapy is still in its early stages of development and has advanced remarkably. Robotics technology will continue to advance, improving efficiency and lowering costs. These advancements will elevate robot-assisted therapy to a recognized therapeutic procedure in stroke rehabilitation.

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