



R Tool Analysis of Gripper Motor Rehabilitation for Post Stroke Therapy

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Abstract: Today, cerebral stroke issues are one of the most terrifying disorders in the clinical era, in which the most common people are highly affected. Worldwide, more than 20,00,000 individuals are exposed to stroke problems like hemiplegia, consistently, where 70% of them pass away at the instance of stroke. Among the survival group after the treatment, more than 85% of them are exposed to long term permanent disability. The affected community practice themselves to survive along with disability due to financial instability and reachability. While comparing with western standards, developing nations like India need keen attention to improve the medical standards. In order to treat the affected at the instance of stroke, home based methodologies shall be introduced for better performance and to improve the standard of daily living. This project involves a gripper motor based regulator for wrist and fingers incorporated with Arduino 328P. This device is a textile fabric tailored with 5 gripper motors to actuate each fingers as a part of post stroke rehabilitation.

Keywords: Gripper Motor, Rehabilitation, Post Stroke Therapy

Introduction and Epidemiology

In general, stroke disorders are classified into Ischemic and Haemorrhagic. The impact of stroke is dependent on the location of injury and its severity [1]. According to World Health Organization (WHO), the global statistics of stroke accounts to 60 to 90 % of disability [2,6]. With reference to the developing nations have higher strike rate of stroke and the prevalence rate in international sides are 500-900/100000 and in India it is 100-300/100000[3]. The number of death rates are 6-7 Million globally and 1.3 million in India. The DALY (Disability Adjusted Life Year) rates are 30000000 globally and 6000000 in India [4]. Over the recent decades,

standards of stroke cases are decremented by 2% in global map whereas there is an incremental rate of 6% in developing countries [5]. The global and Indian Scenario is listed in the Table 1.

Table 1 International and Indian Scenario of Incidence and Prevalence of Stroke

S. No.	International Scenario			Indian Scenario		
	Country	Incidental	Prevalence	State	Incidental	Prevalence
1	America	0.9 Million	4.8 Million	Mumbai	0.2 Million	1.4 Million
2	Africa	0.7 Million	1.6 Million	Kolkata	0.1 Million	1.2 Million
3	South East Asia	1.8 Million	4.5 Million	West Bengal	1.1 Million	1.5 Million
4	Western Pacific	3.3 Million	9.1 Million	Tamil Nadu	1.3 Million	1.6 Million

Design Methodology

The device integrates a reflexive exercise machine with kinetic exercise. The general block diagram is shown in Figure 1. The rehabilitation device consists of a battery, Arduino microcontroller, servo gripper motors, nylon threads and a textile based glove. The battery used to power the whole system is lead acid type. The control is programmed in high performance lower power Arduino Uno microcontroller chip, ATMEGA 328. Five servo gripper motors that rotate to up to 180 degree is used to actuate the fingers. The motor is connected to the fingers using strong nylon threads tailored to the cotton fabric glove. The force is transmitted through the strings to cause the flexion and extension of the fingers. The microcontroller is programmed to operate the motors in both individual and combination modes to attain different functionalities. The functioning of this system shown in Figure 1 is involved in the actuation of the fingers responding to extension and flexion of the hand movement. The movement of the fingers is based on the signal received from the ports of Embedded code which drives the circuit and the control circuit is shown in figure 1. The servo-gripper motor acts as an actuator which facilitates with self-lock mechanism to set with position, speed and force. The switch, when turned on, enables the servo-gripper motor to facilitate each finger with on and off control i.e flexion and extension, providing the essential torque at different angles even to hold a small object.

When the motors are rotated at specific speed at one direction, a linear pulling force is transmitted through the strings to cause the flexion of fingers and when they are rotated in the opposite direction, it causes release of the threads and thereby making the fingers to extend. The threads are selected to be of desired length and strength and are mounted on a textile based glove so as to provide support and comfort to the patient. This on and off control is extended to all the fingers thereby enabling the patient to hold and release an object in grip.

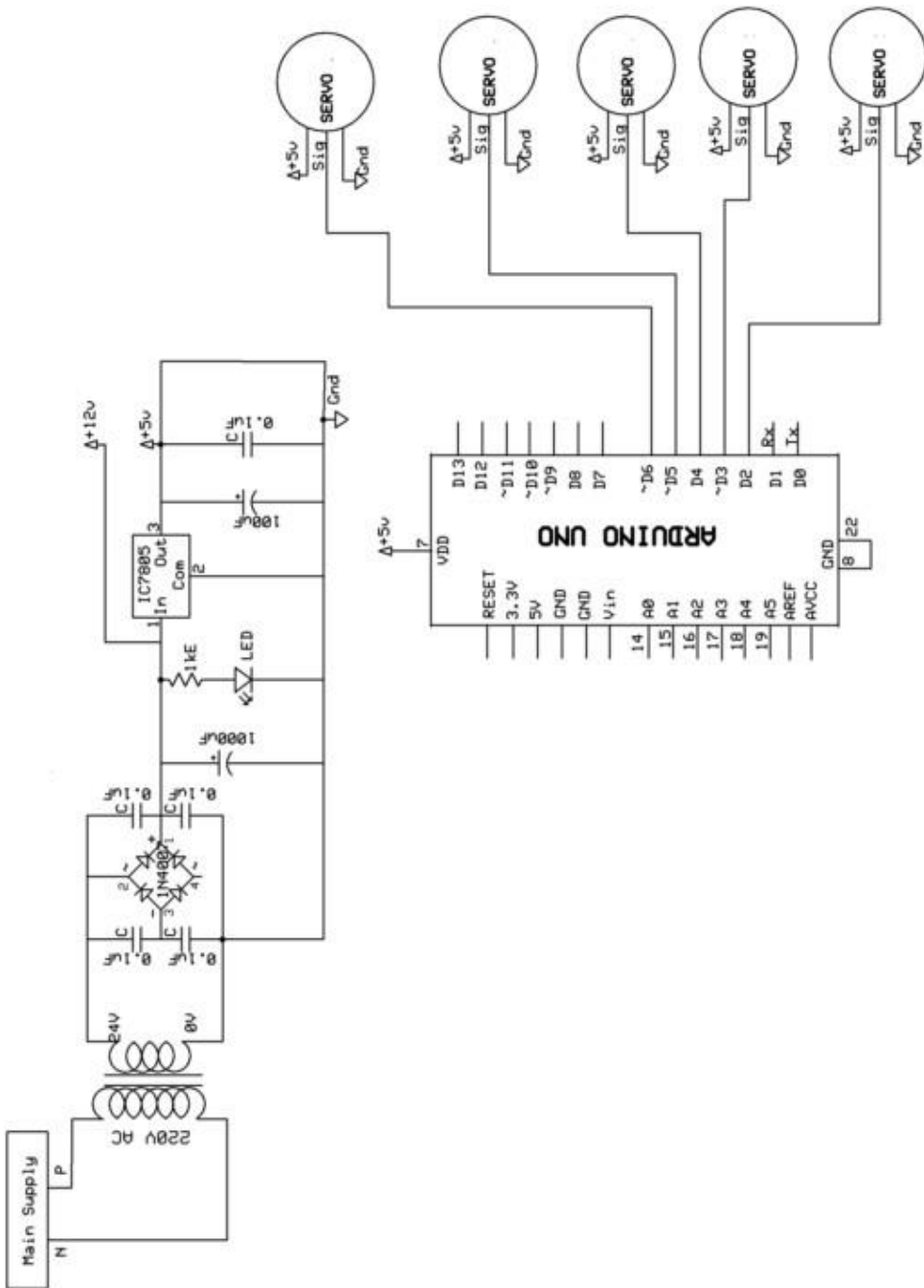


Figure 1 Control circuit of the Gripper motor for motor based rehabilitation

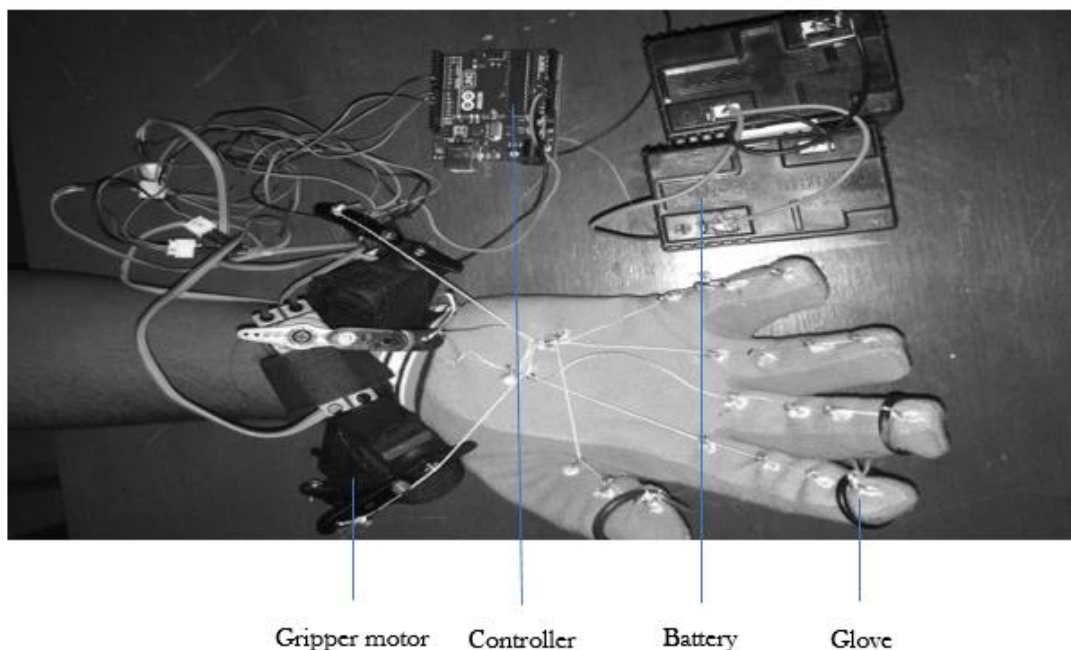


Figure 2 Experimental setup of Rehabilitation using Gripper Motor

Result Analysis and Discussion

A patient was reported with a known case of HTN (Hypertension). A periodic treatment was given over a period of 1 year to stabilize his blood pressure. On course of this treatment he was presented with complaint of numbness of left upper and lower limb. The patient was diagnosed with posterior circulation Cerebral- Vascular Accident (CVA) due to hypertension in the areas of Left Cerebellar bilateral occipital / Pons / midbrain / left thalamic infract. The patient was hospitalized and given adequate medical assistance for improving his health care status. Adequate physiotherapy measures were provided to him based on his condition during the course of hospital treatment. The patient developed some state of sense in his upper and lower limb and was able stand and walk with the support of two attenders, yet the tasks of holding and lifting objects for the accomplishment of daily living was a challenge for the patient. Hence the patient was assisted with the physiotherapy at the hospital. After a period of stay at the hospital the patient had developed some distress and was willing to move home. Considering his conditions, and after consultation from the physiotherapists the patient opted for home based rehabilitation therapy

A. Fugl Meyer Assessment report using Gripper Motor Actuated Rehabilitation systems

With reference to the assessment criteria set, the results displayed in table 2 were obtained from the patient after the experimental trial using the motor actuated rehabilitation system (gripper motor) with proper consent

Table 2. Fugl Meyer Assessment report for a patient using Motor Actuated Rehabilitation systems (Gripper motor)

Parameter	Null	Partial	Full	Assessment		
Assessment	Scores			Pre	Mid	Post
Upper Extremity						
Flexors	0	1	2	0	0	0
Extensors	0	1	2	0	1	1
I. Reflex activity	0	2	4	0	1	1
Shoulder retraction	0	1	2	1	1	2
Shoulder elevation	0	1	2	1	1	1
Shoulder abduction	0	1	2	0	0	0
Shoulder external rotation	0	1	2	1	1	1
Elbow flexion	0	1	2	0	0	0
Forearm supination	0	1	2	1	1	1
Shoulder adduction	0	1	2	1	1	2
Elbow extension	0	1	2	1	1	2
Forearm pronation	0	1	2	1	1	1
II. Volatile motion within synergies	0	9	18	7	7	10
Hand to lumbar spine	0	1	2	0	0	0
Shoulder flexion	0	1	2	1	1	1
Pronation-supination	0	1	2	0	0	0
III. Volitional motion mixing synergies	0	3	6	1	1	1
Shoulder abduction	0	1	2	1	1	1
Shoulder flexion	0	1	2	1	1	2
Pronation-supination	0	1	2	0	1	2
IV. Volitional motion with no synergies	0	3	6	2	3	5

V.Normal reflex activity	0	1	2	1	1	2
TOTAL A (Upper Extremity)	0	18	36	11	13	19
B. Wrist						
Stability at 15% dorsiflexion	0	1	2	0	1	1
Repeated dorsiflexion	0	1	2	0	0	2
Stability at 15% dorsiflexion	0	1	2	1	2	2
Repeated dorsiflexion	0	1	2	1	1	2
Circumduction	0	1	2	1	1	2
B.Wrist	0	5	10	3	5	9
C. Hand						
Mass flexion	0	1	2	0	2	2
Mass extension	0	1	2	1	1	2
Flexion in PIP and DIP	0	1	2	0	2	1
Thumb adduction	0	1	2	0	1	2
Opposition	0	1	2	0	1	2
Cylinder grip	0	1	2	1	1	1
Spherical grip	0	1	2	1	1	1
C.Hand	0	7	14	3	8	11
D. Coordination speed						
Tremor	0	1	2	1	1	1
Dysmetria	0	1	2	1	1	1
Time	0	1	2	1	1	1
D.Coordination speed	0	3	6	3	3	3
Total A-D	0	33	66	20	30	42
H. Sensation						
Light touch upprarm,fore arm	0	1	2	0	1	2

Light touch palmer surface of hand	0	1	2	0	1	1
Position Shoulder	0	1	2	0	0	1
Position Elbow	0	1	2	1	1	2
Position Wrist	0	1	2	0	0	0
Position thumb	0	1	2	0	1	2
H.Sensation	0	6	12	1	4	8
I. Passive Joint Motion						
Shoulder	0	4	8	3	3	4
Elbow	0	2	4	2	3	4
Forearm	0	2	4	1	2	3
Wrist	0	2	4	2	3	3
Fingers	0	2	4	2	2	2
I.Passive Joint Motion	0	12	24	10	13	16
J. Joint Pain						
Shoulder	0	4	8	3	3	3
Elbow	0	2	4	2	2	3
Forearm	0	2	4	2	3	4
Wrist	0	2	4	2	3	3
Fingers	0	2	4	2	3	3
J. Joint Pain	0	12	24	11	14	17

B. Graphical representation in terms of Scatter plot and Box plot

Table 3 figures out the consolidated report of the results obtained from the table 2. The consolidated scores obtained during pre, mid and post phases of assessment were consolidated in the table.

The scatter plot shown in figure 3 infers how the major parameters of Fugl Meyer Assessment are affected over the period of assessment. The x-axis predictor variable represents the number of weeks of assessment and the y-axis response variable represents the motion

parameters of Fugl Meyer Assessment. The linear scatter plot obtained across the weeks demonstrates a linear model of data with no outliers.

Table 3 Consolidated Statement

Parameter	Pre-assessment	Mid-assessment	Post-assessment
A. Upper extremity	12	16	19
B. Wrist	3	5	9
C. Hand	3	8	11
D. Coordination Speed	3	3	4
Total A-D	21	32	42
Sensation	1	4	8
Joint pain	10	13	16
Passive Joint Motion	11	14	17

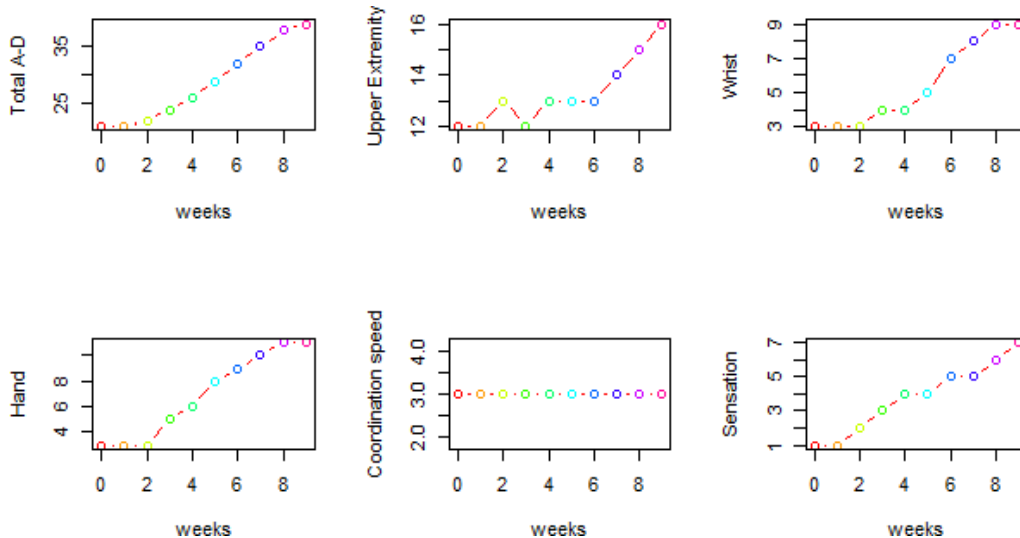


Figure 3 Scatter plot for Motor Actuated Rehabilitation system (Gripper motor)

The corresponding boxplot shown in figure 4 also proves the evidence for a normalized, clean data with no outlier extremes. The factors of Sensation, coordination speed, Hand, Upper Extremity, Wrist proves to vary normally across the weeks and hence the predictor and response variables prove to be in a linear modelling. Thus, the plots ensure reasonable linear improvements over the scale.

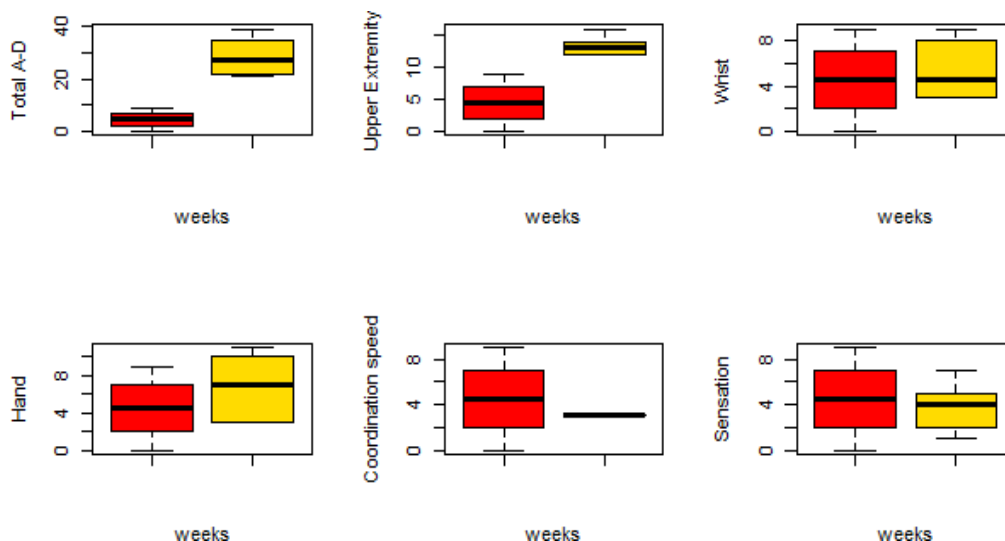


Figure 4 Box plot for Motor Actuated Rehabilitation system (Gripper motor)

C. R-Tool Analysis of The Proposed Systems

In order to deduce the computational complexity and human errors, the data obtained using Fugl Meyer Assessment is subjected to be analysed using R-tool. The data obtained from each patient is converted into an Electronic Health Record (EHR) and subjected to data cleansing. The cleansed data is converted into a Comma Separated Value (.CSV) format. Each dataset is imported into the R-tool workspace using the command “read.csv”. On execution of the code, the values of t,p, DoF (Degrees of Freedom), Mean Difference is extracted and it is listed in the table 4

Table 4 Statistical analysis results

S. No.	Pre	Post	t value	P value	DoF	Mean Diff
1	21	44	1.8	0.11	6	5.348
2	22	43	1.8	0.11	6	5.751
3	22	42	2.3	0.08	6	5.825
4	18	36	1.8	0.14	6	4.715
5	19	37	1.9	0.16	6	4.587

From the table 3, it is observed that, the difference between the pre assessment status at week 0 and the post assessment status at week 10 shows a reasonable improvement in the Kinematics of motion of the patients subjected to trial. Also, the obtained t- values from all the five experimental trials seem to be positive. The p-values have confirmed that there exists a mean

difference between the two vectors „m“ and „n“ since they are greater than 0.05. The mean difference is said to be positive from the observed positive „t“ values.

Even in this case of the assessment performed by therapist, the datasets favor alternate hypothesis that signifies there is a change in the assessment made across the weeks. This positive change thus drives the functionality of the product in improvising the patients motion control .Thus according to the various assessments done with the help of R tool the stability of the product is recognized. Hence the product proves to be helpful in bringing about the movements of the upper arm of the patient thus bringing about noteworthy changes in the lifestyle of the stroke survival group. After the execution of the above mentioned models and implying on various patients on home restoration premise, different parameters were estimated and looked at. The correlations depended on development, outline, and executions are listed in Table 5 which briefs the examination of different parameters acquired from the results of the device.

Table 5 Result Analysis of the proposed systems for Upper Arm Hemiplegia

S. No.	Parameter	Result
1	Energy Source	External
2	Power Supply	Single phase
3	Storage	Lead Acid battery
4	Diversity	Good
5	Hand Kinematics	Wrist & Fingers
6	Cost of a supply source	Low
7	Actuators	Gripper motor
8	Force	Medium
9	Loss	Minimum
10	Control	Yes
11	Portability	Good
12	Reliability	Good
13	Size	Medium
14	Weight	Less
15	Large force capabilities	Medium
16	Design Cost	Low
17	Controller	Arduino

Conclusion

The outcome obtained from all the trial preliminaries adds that the rehabilitation device can be utilized for home based rehabilitation. The major advantages of this device are it is readily available, less time consumption and adequacy. The clinical professionals can also use the device for treatment purpose. On the other hand, this device can be extended to be used for Lower Arm Hemiplegia (LAH). The device can be developed with electromechanical frameworks which would help the patients to their lost motion skills.

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Conflict of interest :

The Authors have no conflicts of interest to declare that they are relevant to the content of this article.

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