This full-text paper was peer-reviewed and accepted to be presented at the IEEE ICCSP 2015 conference

Mechanical Movement Aid to Nerve Damaged and Parkinson's using Pressure & frequency detection (Pseudo Arm Controller)

Eram Khan and Ashish Panchal

Abstract: **This paper proposes a novel method of using external helping mechanism for increasing interactivity of human arm for paralytic patients. Restricting unwanted movements in a Parkinson's patient will also be possible. This external helping mechanism was constructed using pressure sensor for detection of minuet muscle pressure applied by the user. DC coreless motor to control the movement of metallic finger frame, which in turn are connected to the user's arm. Fast and reliable responses, low power consumption pseudo arm controller. MCU is used to acquisition and processing data of the piezoelectric pressure sensors. The device can be worn as a glove by the user. The second part of this arm is a claw designed to give mechanical restriction to the hand of a Parkinson's patients preventing unwanted movement. A MEMS accelerometer and a MEMS gyro in a single chip. The sensor uses I2C bus to interface with MCU. By activation of the claw if frequency of hand movement is above 1-2Hz it is possible to restrict unwanted movement.The frequency of a normal hand tremor is 9-25Hz, of an essential tremor is 4-12Hz and of a Parkinson's patient is 3-8Hz.**

***Keywords*-External helping mechanism; Microcontroller; Pseudo arm controller; Pressure sensor; Parkinson's; Paralytic;**

I. INTRODUCTION

Pseudo arm controller, can be worn like a glove, amplifying the week signals given by paralytic patients into meaningful mechanical movement. The speculated cost of the completed product is $150. The approximate cost of operating on the nerve impairments such as radial nerve palsy, tendon damages, Peripheral neuropathy, Distal median nerve dysfunction, Nerve Compression Syndromes of the Hand, Ulnar nerve dysfunction is about $50,000, with a very low success rate.[1][2]

Artificially intelligent prosthetic arms have been developed. Only 5% of these operations are successful in terms of usage. Furthermore, these type of equipment are not durable and prone to infection. As generally happens in cases of nerve damage and impairment, not all the neurons are affected [1]. In some cases although the controlling signals reach from the brain to a body organ say a hand, but the hand is not able to perform

Eram Khan,is with the department of Electronics and telecommunication, Army Institute of Technology, Pune, India.
Ashish Panchal, is with the department of Electronics and telecommunication, Army Institute of Technology, Pune, India.

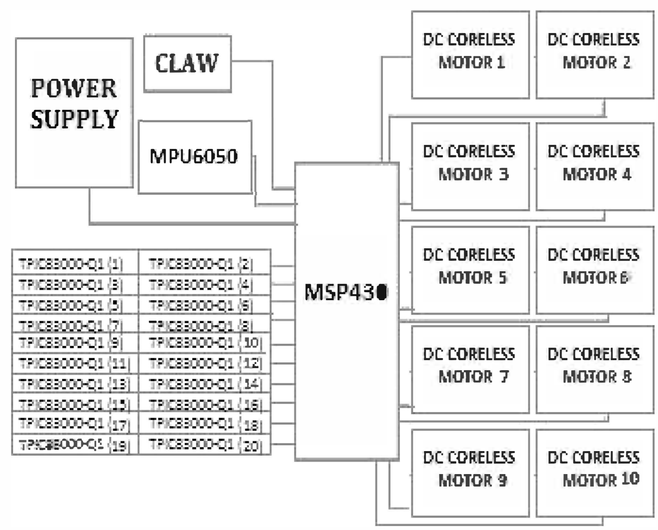

Fig. 1. Representation of basic apparatus of Pseudo Arm Controller (PAC).

required task. Feeble hand movement is possible in 35% cases [2]. PAC essentially performs the task of amplification of these feeble hand movements converting them into meaningful ones. By the detection of a feeble stimulus, the hand enclosed in a glove-like structure with the frame of metallic caps will be able to contort or expand (Whether to contort or expand will be decided on the basis of the direction of the feeble movement) to 60 degrees. If the stimulus is detected again, it will again contort or expand by the specified angle. This contortion or distortion provides the patients with a movement that can help them perform everyday tasks like sipping a cup of coffee, picking up the telephone, hold something in their hand. The second part PAC caters to the need of Parkinson's patient. In early states of Parkinson's, patients have uncontrolled "shivering" experienced primarily in their hand [3]. The frequency of hand movement is way beyond any regular voluntary movement. This frequency is detected. At the base of the glove-like structure of PAC, there is a mechanical claw, restricting the movement, ultimately nullifying it. The detection of minor stimulus provided by the patient was a key factor. Using the piezoelectric pressure sensors this requirement is satisfied.[4][5][6][7]

II. APPLICATIONS

This arm will be instrumental for people with nerve damages such as radial nerve palsy, tendon damages, Peripheral neuropathy, Distal median nerve dysfunction, Nerve Compression Syndromes of the Hand, Ulnar nerve

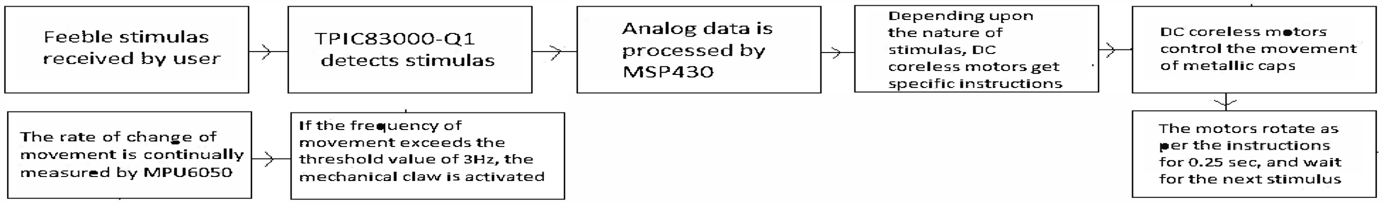

Fig. 2. Flow chart depicting the functioning of proposed system.

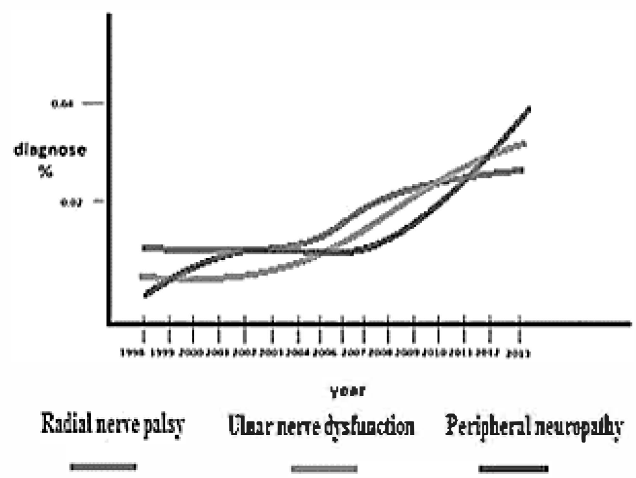

Fig. 3. Average human strength employed for usual tasks.

Dysfunction as well as for Parkinson's patients of the first degree. 12 in 100 people with one risk factor develop peripheral neuropathy. Radial nerve palsy occurs in 8.5% to 12% of humerus fractures. People challenged with these kind of nerve injuries will be most benefited by the solution. The idea is to make the product affordable for common people and thus increases its market.

Also, as per current statistics, about 7-10 million people in the world are living with Parkinson's disease. The burden is expected to double in a single generation. No other form of external support for these patients has yet been devised. The uniqueness, affordability and mere simplicity will make this a popular gadget. The medical procedures are very expensive and time consuming; therefore a simpler solution is always welcome. This gadget will be potentially popular all over the world. $150 will be the cost of one complete product. 4, 7450000 is approximately the average cost of operating on the nerve impairments such as radial nerve palsy, tendon damages, Peripheral neuropathy, Distal median nerve dysfunction, Nerve Compression Syndromes of the Hand, Ulnar nerve dysfunction. 67% operations are not successful.[4]

III. Experimental Apparatus

Microcontroller MSP 430 along with its in built ADC is required to process the data from piezoelectric pressure sensors. Also, to monitor the rotation of motors to suit the desired movement. DC coreless motor is required for the movement of the arm. The direction and speed of its rotation will control the overall movement of arm.TPIC83000-Q1, piezoelectric pressure sensors are used to detect slight stimulation by nerve damaged patient and pass on the data to MSP430 for possessing. HS-64MG Servo motor is an integral part of claw used to control shivering of hand. The InvenSense MPU-6050 sensor which contains a MEMS accelerometer and a MEMS gyro in a single chip. The sensor uses I2C bus to interface with MSP430.The frequency of a normal hand tremor is 9-25Hz, of an essential tremor is 412Hz and of a Parkinson's patient is 3-8Hz. By activation of the claw if frequency of hand movement is above 1-2Hz it is possible to restrict unwanted movement. Other essential parts for implementation include machine screws, to integrate various mechanical components Square Tube, 6063AL, 1/2 In Inside Sq, 6 ft, for making cap like structure on fingers, Extension Springs, for connecting metallic caps on to the gear, Metallic Sheet of 1.25sqm, for making metallic caps[8][9][10][11].

IV. Hardware

The MPU6050 was studied under different conditions.[12][13] For stimuli from user the response of accelerometer and proper calibration to detect feeble gyros was studied in

The figure below is simulation diagram of the PAC. In the place of MPU6050 simulation is performed using a frequency generator.[14]

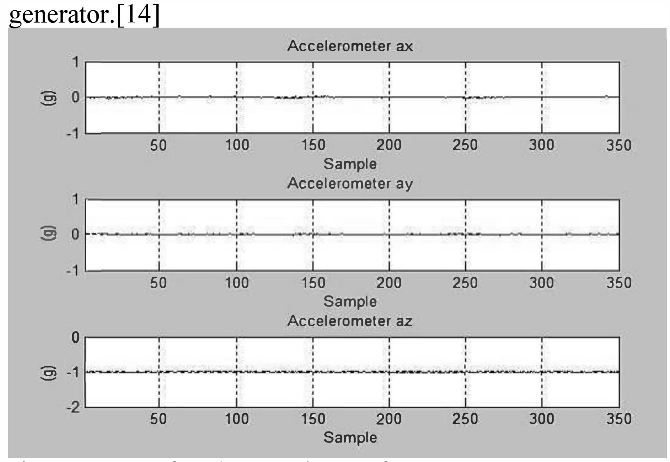

Fig. 6. Response of accelerometer in case of a movement.

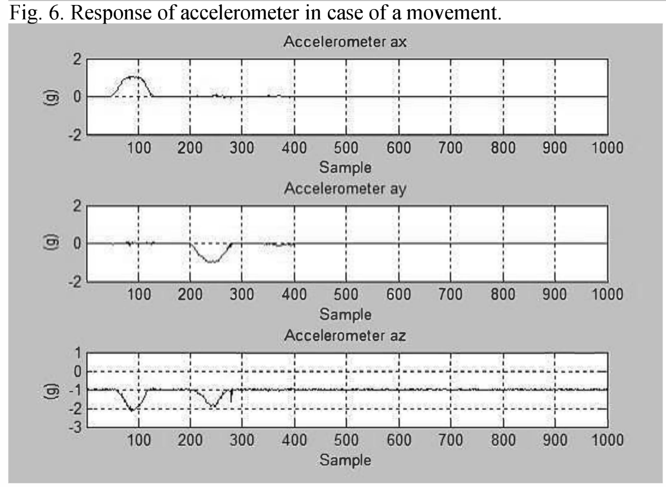

Fig. 7. Response when it is rotated.

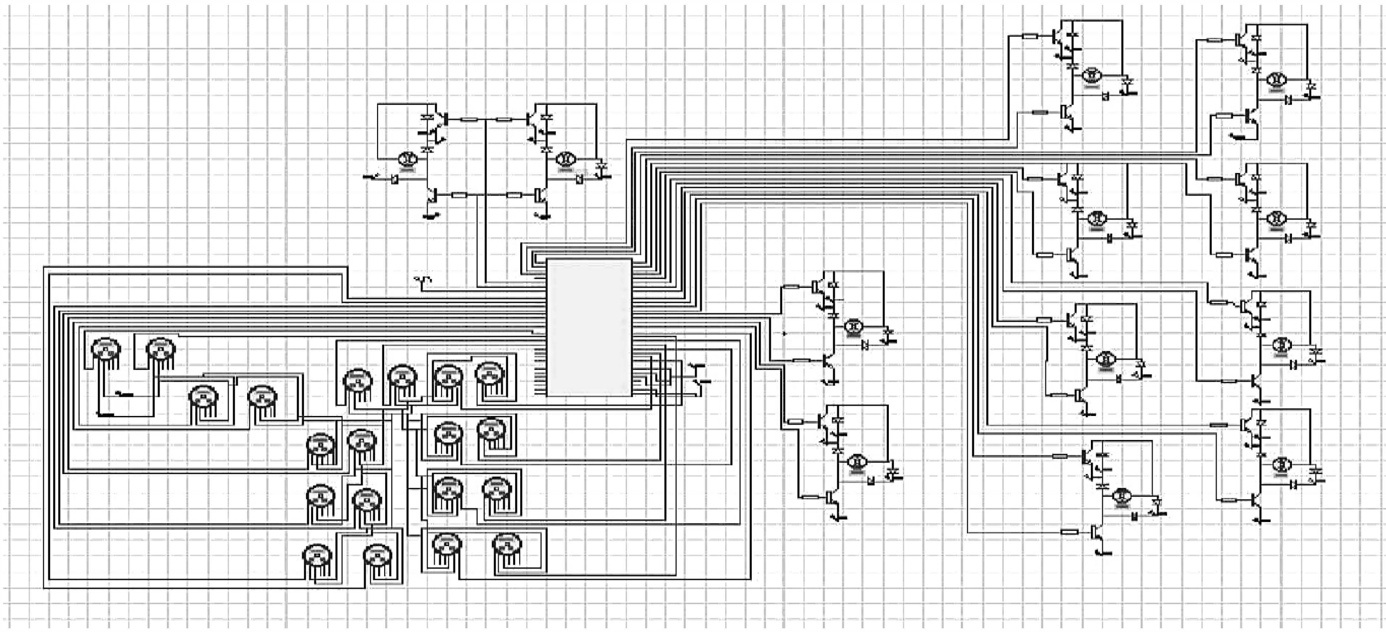

Fig. 5. Simulation of basic apparatus of Pseudo Arm Controller (PAC).

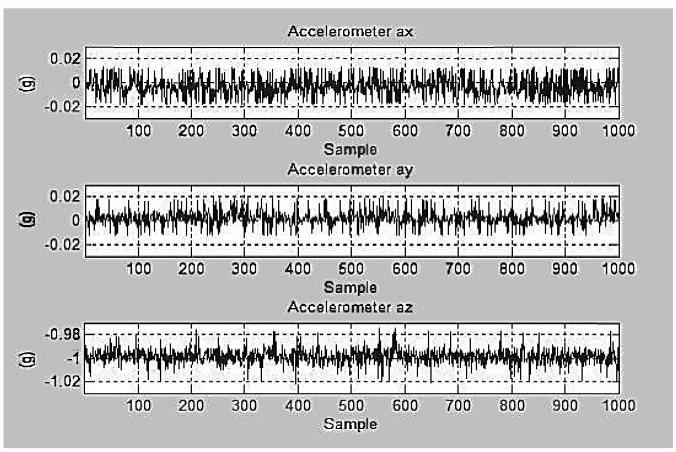

Fig. 8. Response if it is stationary

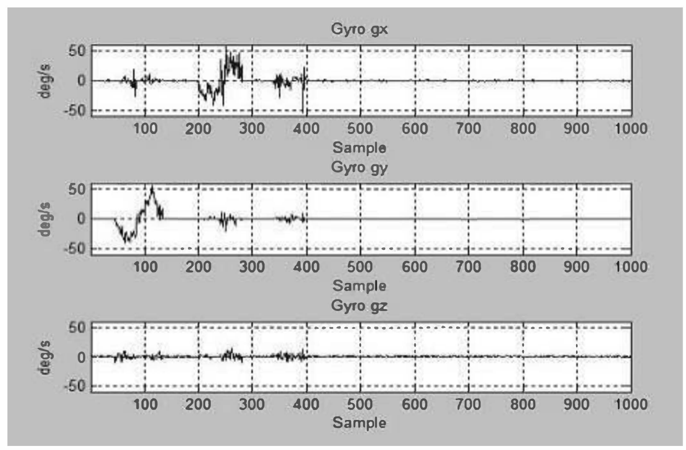

Fig. 10 . Response when it is stationary.

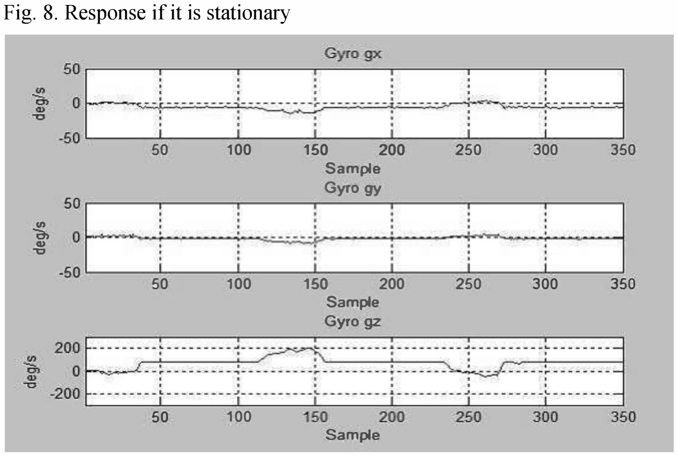

Fig. 9. Response of accelerometer in case of a movement.

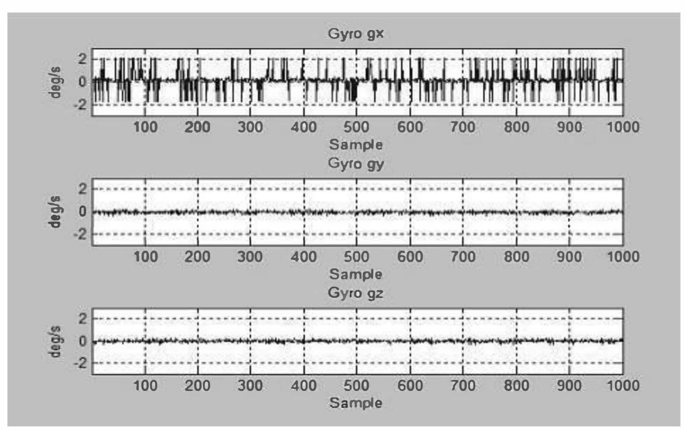

Fig. 11. Response in case of rotation.

In the design of the PAC, metallic caps are worn by user. These are connecting via extensible springs to the DC coreless motor. Pressure sensors reside over these metallic caps. An MPU6050 is at the center of the palm. Also, a mechanical claw is attached. All these components form a glove-like equipment to be worn by the user. Each finger will contain two dc coreless motors, four pressure sensor TPIC83000-Q1 and an extensible string as a connection between them. TPIC83000-Q1, MPU6050, the mechanical claw and the dc coreless motors are all connected to and controlled by the microcontroller MSP430.[15][16]

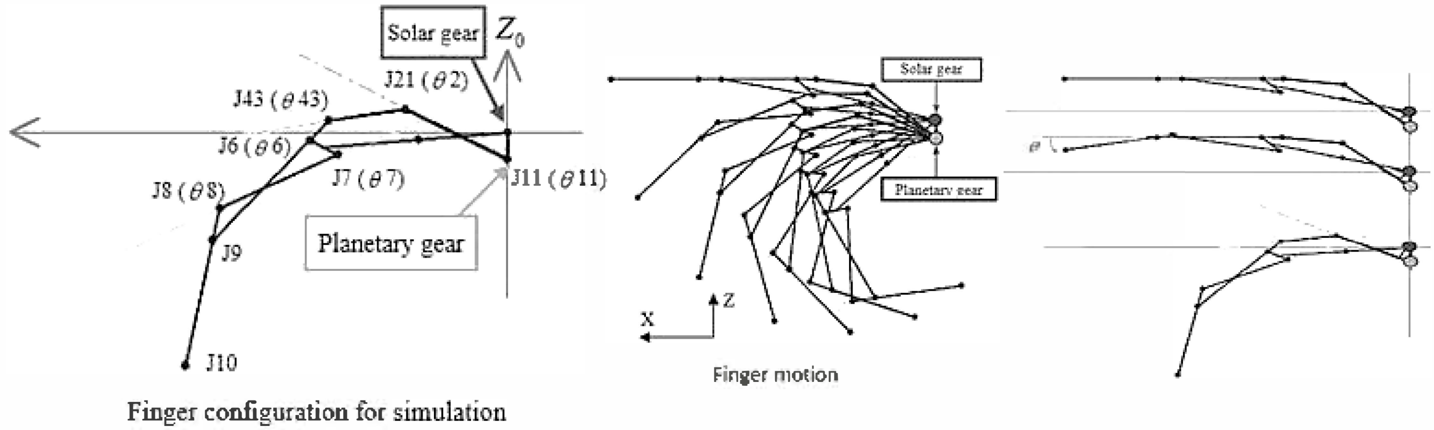

Fig. 13. The movement of the finger controlled by the motor, with the help of gears is represented. [5]

V. WORKING

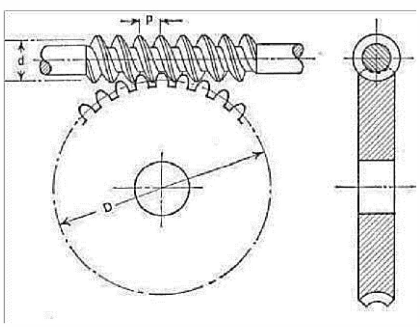

Fig. 11. Demonstrates the interaction of motor with coreless motors of the particular finger, from the extensible spring. Where the stimulus is detected.

The basic steps performed by the PAC are as follows:

1) Metallic caps shown in Fig.4. are worn by the user.
2) These caps are connected to extensible springs.
3) On the feeble stimulus by the user (as nerve damaged patients cannot perform a complete movement by themselves), the piezoelectric pressure sensor TPIC83000-Q1 detects the stimulus.
4) This analog data is processed by MSP430.
5) For each localized detection by TPIC83000 user's movement Q1, a set of instructions is given to the DC coreless motors of the particular finger, from where the stimulus is detected.
6) These motors, via the extensible fingers control the movement of the metallic cap, in turn controlling the user's arm.
7) The motors rotate as per the instructions for 0.25 sec, and wait for the next stimulus.
8) The rate of change of movement is continually measured by the MPU6050.
9) If the frequency of movement exceeds the threshold value of 3Hz, the mechanical claw is activated by the MSP430, to restrict the user's movement.

According to the varying torque of the DC coreless motor, the angle of the finger is varied. The metallic caps exert a normal force to the fingers in order to mimic the movement of the metallic cap. These metallic caps which in turn are controlled by the motors on each finger.[17][18][19]

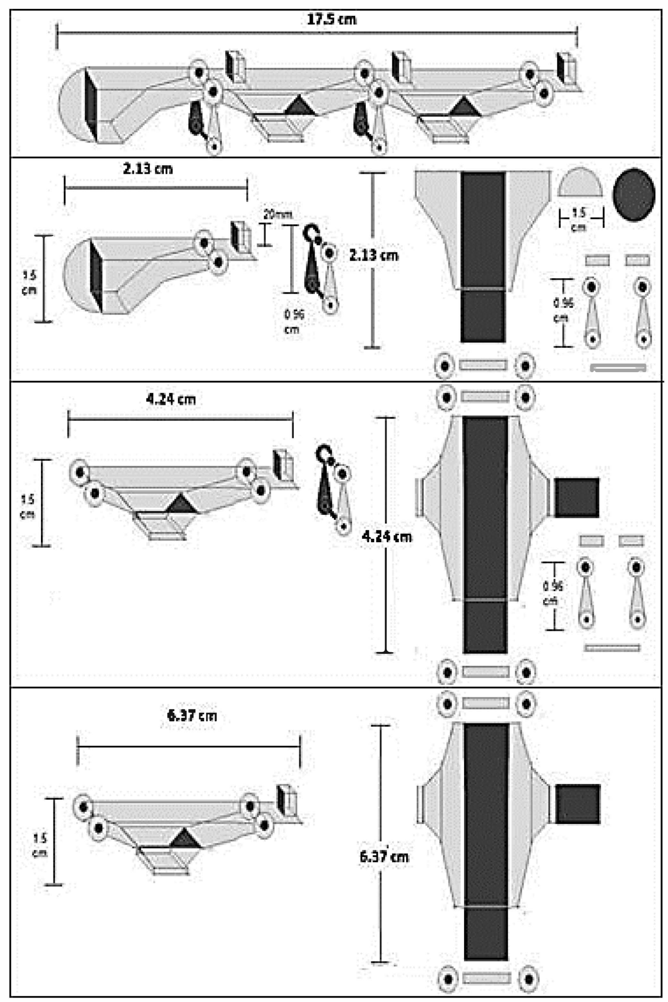

Fig. 4. The metallic sheet is cut into these parts. These are the finger caps movements to be worn by the user so that can be forced on to the arm. The dimensions for an average human hand are indicated standard environments.

VI. CONCLUSION

The sensitivity of TPIC83000-Q1 allows it to detect 0.1% of pressure generally employed by humans. [20] This makes the PAC detect even the feeble pressure exerted by any nerve damaged patient. Also, the threshold for activation of mechanical claw to restrict involuntary movements is set is 3Hz. The MPU6050 keeps track of this frequency and sends data for processing to MSP430.[21][22][23]

We are addressing around 20 million people when we talk about people having Parkinson's and partial nerve injuries. Our controlling arm makes these patients self-reliant.

Simplicity is the uniqueness of this project. All we have to do is convert the partial movements of these patients and convert it into meaningful mechanical movements. It is almost like having full control of their arm, without any kind of risky as well as expensive surgical procedures.

REFERENCES

[1] Webb Haymaker, Barnes Woodhall, *Peripheral nerve injuries: Principles of Diagnosis,* 1998

[2] *Wikipedia.org*

[3] Ph D Robert Rodgers, *Road to Recovery from Parkinson's disease,* 26-Nov-2009

[4] The end of Hardware 3rd Edition, 2009

[5] http://en.wikipedia.org/wiki/Median_nerve

[6] Birglen, Lionel, Laliberté, Thierry, Gosselin, Clément M., *Underactuated Robotic Hands,* 11-Mar-2008

[7] Mark E. Rosheim, *Robot Evolution: The Development of Anthrobotics*, John Wiley & Sons, 11-Aug-1994

[8] Peter Cork, 2011, Robotics, Vision and Control: Fundamental Algorithms

[9] Parvej Ahmad Alvi, 12 December 2012, *MEMS Pressure Sensors: Fabrication and Process Optimization,* International Frequency Sensor Association

[10] Michael Miloro (Ed.) 2013, *Trigeminal nerve injuries*

[11] Calif Med. May 1954, *Peripheral nerve injuries: Principles of Diagnosis*

[12] John Davies, Glasgow University, August 2008, *MSP430 Microcontroller Basics*

[13] C Nagy, 03 Sep 2003, *Embedded Systems Design Using the TI MSP430 Series*

[14] Grigorie, T.L., "*The Matlab/Simulink modeling and numerical simulation of an analogue capacitive micro-accelerometer. Part 2: Closed loop",* Perspective Technologies and Methods in MEMS Design, 2008. MEMSTECH 2008. International Conference, 21-24 May 2008.

[15] Rong-Jyue Wang, Nat. Formosa Univ., Huwei, Taiwan ; Jun-Wei Zhang ; Jia-Ming Xu ; Hsin-Yu Liu *"The multiple-function intelligent robotic arms"* Fuzzy Systems, 2009. FUZZ-IEEE 2009. IEEE International Conference, 20-24 Aug. 2009.

[16] Micera, Senior Member, IEEE, Jacopo Carpaneto, and Stanisa Raspopovic, *"Control of Hand Prostheses Using Peripheral Information"*, 2010-ieee-rbme VOL. 3, 2010.

[17] Seon-ju Lim , Kyung-Jin You , Schieber, M.H. , Thakor, N.V. , Hyun-Chool Shin, "*Single and multi-finger movements are correlated in neuronal population activities as well as in natural behaviors"* , Intelligent Signal Processing and Communications Systems (ISPACS), 2011 International Symposium , 7-9 Dec. 2011

[18] Kerr,M.S.D. ,Kahn,K. ; Hyun-Joo Park ; Thompson, S. ; Hao, S. ; Bulacio, J. ; Gonzalez-Martinez, J.A. ; Gale, J. ;Sarma, S.V., *"High frequency activity correlates of robust movement in humans",* Engineering in Medicine and Biology Society (EMBC), 2014 36th Annual International Conference of the IEEE, 26-30 Aug. 2014

[19] Hussein, M., As'arry, A., Zain, M.Z.M., Mailah, M., Abdullah, M.Y., *"Experimental study of human hand-arm model response",* Mechatronics and its Applications, 2009. ISMA '09. 6th International Symposium, 23-26 March 2009.

[20] Acernese, F., De Rosa, R., Giordano, G., Romano, R., Vilasi, S., Persichetti, G., Barone, F., "A new architecture for the implementation of force-feedback tunable mechanical monolithic horizontal sensor", Real Time Conference (RT), 2010 17th IEEE-NPSS, 24-28 May 2010.

[21] Junjie Zhang, Jiangcheng Fang, *"Research of Mechanical Arm Control Based on Data Glove",* Information Science and Engineering, 2008. ISISE '08. International Symposium (Volume:1), 20-22 Dec. 2008.

[22] *"Mechanical vibration and shock— Hand-arm vibration— Measurement and evaluation of the vibration transmissibility of gloves at the palm of the hand",* ISO 10819:2013, 2013-07-15.

[23] Jacobsen, S., et al.*"Design of the Utah/MIT dextrous hand. in Roboticsand Automation. Proceedings.*" 1986 IEEE International Conference, 1986. IEEE.