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Continuous Passive Motion Device for Hand Rehabilitation

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Abstract- In today's computing world 1 in 50 people have been diagnosed by some form of paralysis, temporary or permanent ,so the need for the physical reformation treatment for paralyzed patients is getting increased day by day. It is highly impossible to therapist and doctors to assist each patient for the purpose of treatment, thus the problem is getting more and more serious in coming future and also physician experiences may not be sufficient to achieve high quality medical results. So that's why CPM machine is being developed and used in foreign country. This continuous passive motion device is very expensive and barely available in our country. The purpose of the project is to define standard and 100 percent accurate therapy treatment methodology that specifies better settings of the continuous passive motion device could decrease the overall treatment time and may improve patient's outcome, and also to make continuous passive motion affordable to common people.

Index Terms- CPM, Rehabilitation, Actuators, Physiotherapy, PIP, MIP.

1. INTRODUCTION

This theory presents a development of a machine used for recovering hand injuries ,active resistance and haptics. Many common procedures and postoperative treatments are applied to the paralyzed patients or after joint surgery. This was traditionally done by using rubber balls, applying the force externally with the help of therapist, springs or many other techniques[1]. Some treatments methodology gives better outcomes and some methodology had many drawbacks. But in medical cases the output of the treatment should be 100 percent accurate .Thus Continuous Passive Motion is postoperative therapy which was designed to aid recovery after joint surgery which is given with help of a device called CPM machine[2].
However day's passes the use of continuous passive motion machine is increased to recover paralysis of patient's finger and also helps to reproduce sense in between those fingers and wrist[4]. But the current machine available in the market is intended for use within the clinic itself and also cannot be operated without the help of a therapist . The device which we have design has overcome these disadvantages .The major disadvantage of intervention is overcome by

providing a touch screen LCD input screen with easy options and can be operated by common wealth.The device is capable of moving the metacarpophalangeal joint(MCP) and Proximal Interphalangeal joint (PIP) through a range of 0degree to 180 degree and can be used for both the hands(Right as well as left)[1]. The device is also capable of controlling speed, angle as well as end delay which was demanded by almost 9 out 10 people using the CPM device.

2. LITERATURE SURVEY:

- **Current Machines:** There are numerous WaF CPM Devices in the market, few of which are shown here for the purpose of comparison[8][9][10].

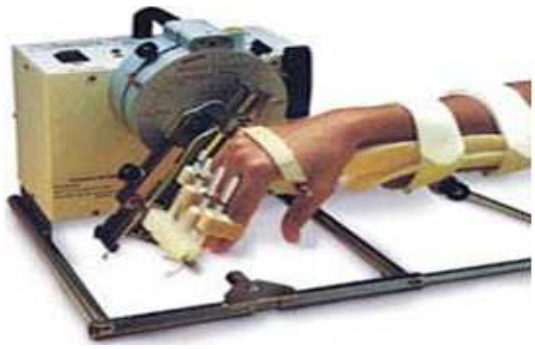

Fig. 1 KINETEC Maestra Hand and Wrist CPM Machine

Fig. 2 ABREXIS Wrist Cpm Device

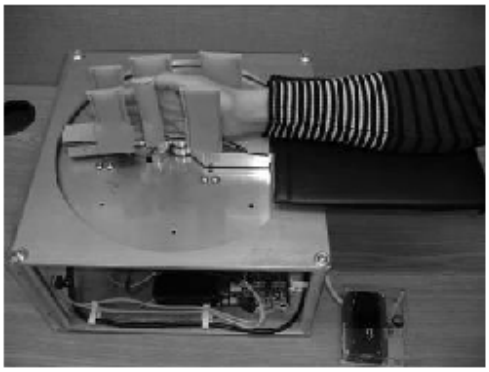

Fig. 3 Brich thesis.

- **Accessories needed for the operation of these Machines :**

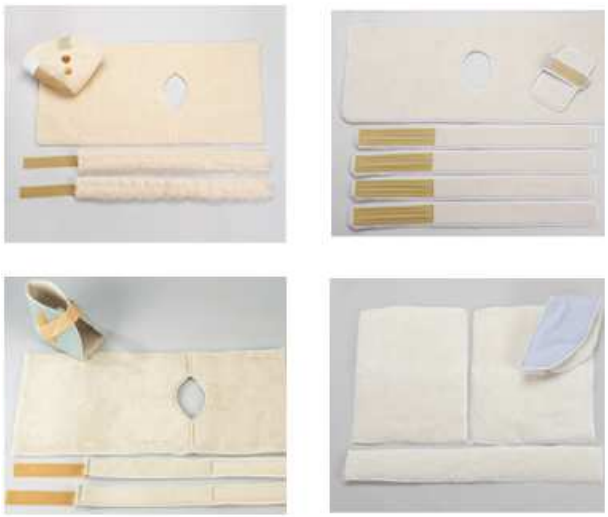

Fig. 4 Accessories needed for the operation

2.1 Features of the Current Machine

- Anatomical motion :Increases patient compliance and decrease joint stress.
- Horizontal Abduction/Adduction: Unique passive mode to address this critical functional motion.
- Enables focused treatment on specific fingers as opposed to the whole hand[6].
- Useful for neurorehabilitation.
- Independent motion of both MIP and PIP points of the fingers.
- 'Stand Alone' and desktop mounted Device.
- Adaptable for various sized hands with a quick setup time.

2.2 Drawbacks of the current machine

- As it evident from the images shown above that these machines have one thing in common which is they are excessively bulky.
- These devices have complex mechanical (Button Operated) User Interfaces which are most of the times incomprehensible for the patients using them.
- Also they need numerous components for their operation and hence this increases the complexity of their use[3].
- Most of these existing devices use wall outlets as their power source which in turn implies that they are not portable.
- Because of their weight and excessive complexity they are not operable by the patient on his/her own.
- Of all these disadvantages the one that is most significant and hasn't been mentioned yet is 'Each and every one of these devices are excessively expensive which keeps them out of reach of the common folk.

3. OTHER OPTION WE TRIED AND PROBLEMS DURING TRAILS:

3.1 Trials

3.1.1 The other option we considered had strings attached to the fingers which were being pulled by motors. The motors were placed on the same side of the palm. The fingers closed by the force of motors and retracted by the force of springs on the backside of the fingers.

3.1.2 *General Purpose PCB Based Test Board:*

- Used the Atmega128 (TQFP) soldered on a general 16-64 pin breakout board and Atmega8 DIP
- Successfully tested the working of motor with the help of Atmega8 and Atmega128 working in synchronization.

3.1.3 *Beta Version :*

- Made two separate single sided boards and made connections between them using burg pins to make a double sided board.
- Tested the Atmega128 and command uplink and downlink with computer on the board.
- Also did the same test for Atmega8.

3.1.4 *Version 1.0:*

- This was the first double sided printed circuit board and was made with most the components inbuilt on it.
- Added the feature of inbuilt power supply.
- Despite countless hours spent in the development of this board, it wasn't ever used in reality. It just provided ideas for the next version of the board.

3.2 Problems During trials:

3.2.1 The strings when pulled could not close the fingers further after a certain Deadlock Angle which was not satisfying the requirements if the device operation. So this idea was rejected.

3.2.2 General Purpose PCB Based Test Board :

- The LCD could never be driven from this board because there were so many connections and they were interfering with each other.
- So it was decided to continue the further trials on the printed circuit boards.

3.2.3 Beta Version :

- The connections of the two boards were not matching perfectly, resulting in oddly asymmetrical alignment and hence using it was really difficult.
- The pin outs for programming were interfering with each other and it also lacked an on board power supply.

3.2.4 Version 1.0 :

- The ratnest on both sides of the boards were not identical resulting in unequal expansion of the connections when being printed.
- The connections for some ports were inverted (i.e. mirrored), rendering them useless.
- All the burg connections were from above increasing the difficulty faced in soldering them.

Fig. 5 The LCD showing options

4. STATEMENT OF CONTRIBUTION

The device consists of the following component:

4.1 Touch Screen Graphical Input LCD

- The JHD12864e LCD which is used for intervention with the patients and enables them to input the data according to their need.
- The options provided are:
- Speed which can be incremented or decremented.
- Angle which has maximum or minimum angle.
- End delay which also has maximum and minimum angle.

4.2 The Brain of our Device(Atmega Controller)

- The AVR is a single-chip microcontroller which was developed by the Atmel in 1996.The major reason for choosing the AVR microcontroller was for their incredible features like flash memory,i.e. a memory that can retain its data in the absence of the power supply, one time programmable Rom, EEPROM.

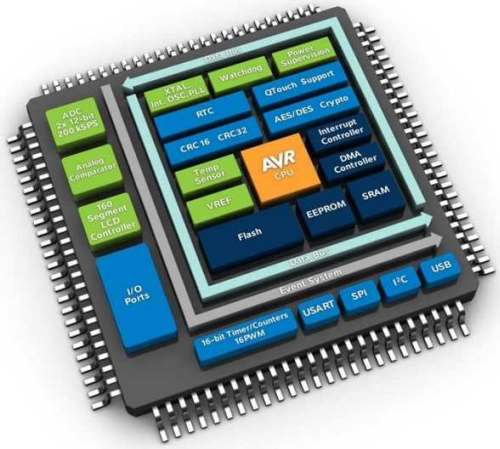

Fig. 6 Architecture of controller

- One of the major advantage of these controller is its cost and availability i.e. it is available from any manufacturer.
- One more advantage is of speed, most of the AVR's are capable of 20MHz(even really cheap ones like the Attiny25/45/85 and ATmega48) and actually run at near 20 MIPS.
- In addition, with the better addressing modes and registers of the AVRs, most operation can be done in only one instruction, where it often takes more than one instruction to do the same thing on a PIC[5].
- Peripherals: Many Atmel AVR µcontrollers, like many Microchip PIC µcontrollers, have a built-in 10 bit ADC. Some have LCD or USB drivers."One big advantage of AVRs is that they are supported by the GNU Compiler Collection (GCC)."

4.3 Linear Actuators: As the name suggests this motor gives to n fro motion i.e. in the straight line and is used in our device to give motion to wrist as well as to the fingers.

4.4 Linear Voltage regulator: A linear voltage regulator is used to maintain a steady voltage. It is made to act like a variable resistor which adjusts the voltage divider network to maintain its constant o/p voltage by dissipating the difference in the form of heat.

4.5 Copper Wires: Copper is been used for the transmission of electric and is used to connect various components. The wires that we are using are 4mm thick.

4.6 Lithium Polymer Batteries : These batteries are rechargeable batteries and is of Lithium-ion technology which packed in the pouch format. We will be using the batteries in the Configuration of 2s4p and wattage of 10 AH.

5. PROPOSED MODEL

The block diagram and working of the device is described below respectively:

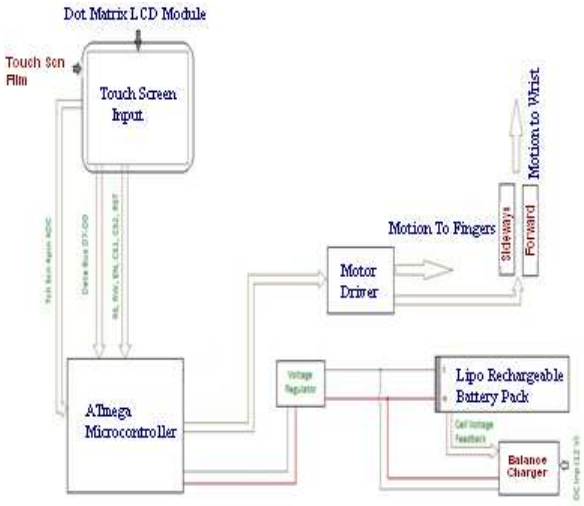

Fig. 7 Block Diagram

- The LCD which is attached to the controller has a touch screen which enable the user to give its appropriate input.
- Attached to the controller are the motors drivers which driven by the instructions of the controller which indeed are responsible for the driving the actuators which gives the motion to the wrist and the fingers.
- Also a voltage regulator is attached to the controller which is responsible for maintaining a constant voltage.
- Also balance charger is available for protecting the battery cell with the lowest capacity as well to avoid the overcharging discharging of the cell. This balance charger is attached to the battery pack of Lipo Rechargeable Battery Pack[7].

Working:

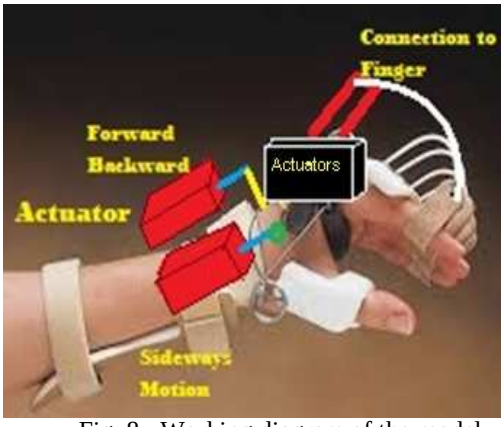

Fig. 8 Working diagram of the model

- The Motor drives a U-Bend frame to move in 180^{o} across the back of the hand.
- The frame in turn drives a Curved Finger Joint which moves the fingers in accordance to the motion of motor.
- The Curved Finger Joint is Removable to provide motion to only those fingers which need it.
- There are also two actuators, one on the back of the palm and one on the side of it.
- The Actuator moves the Wrist To and Fro or Sideways.
- The motors are driven by an Atmega Controller according to the choices entered in Touch Screen Input.
- The Available Choices include : Max and Min Angle of motion, Speed of motion, time duration of operation, etc.

6. MATHEMATICAL MODEL

- After plotting the movement of the fingers of the normal human hand, we were able to find that the centre of the curve traced by the tips of the fingers is located slightly above the backside of the palm.
- Also the tips of the fingers are in a curve relative to one another and are joined in that fashion only.
- The Radius of curve traced by the pinkie finger of an average person is approximately 10 cm and that of the longest middle finger is approximately 13 cm.
- The torque required to move a single finger is in the order of 1.5 to 2.5 Kg/cm so we have used a servo with more than required torque of 11 to 14 Kg/cm.

7. CONCLUSION AND FUTURE SCOPE

Because CPM therapy increases the joint mobility ,increases Range of motion, helps in decreasing the complications such as joint stiffness and adhesions and also reduces the length of post operative hospitalization and so builds the confidence the patients, hence convincing us to take in such project for the implementation. We referred many devices and their working ,studied their drawbacks which was helpful for us to understand what steps are to be taken and have tried many trail and errors and are at a stage where we have decided a final design for our device and will be implementing it. We hope that we are not only complete our project successfully but also be able to help many poor common wealth people.

The future scope for this project would be to enable the users to set the timings as well along with these other options Ex: Set Angle for 5min.

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