Design of Hand Motion Assist Robot for Rehabilitation Physiotherapy

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<i>Article History</i>	<i>Abstract</i>
<p>Article Submission 10 August 2015</p> <p>Revised Submission 27 October 2015</p> <p>Article Accepted 10 November 2015</p> <p>Article Published 31st December 2015</p>	<p><i>This paper deals about developing a microcontroller based two-axis robot for human hand physiotherapy for the treatment of paralyzed patients. The interactive two-axis motion robot is designed to fit around patient's arm and work with the patient to reestablish movements of hand by gently moving it in desired direction. The robot moves the patients hand up and down, left and right using servo motor interfaced with it. The motor is controlled by switching ON/OFF the stator winding. The microcontroller generates the switching pulses of the motor; the angular distance and movements are programmable through keys. The robot actively moves the non-responsive body parts allowing it to be a useful tool in all steps of rehabilitation.</i></p> <p><i>Note to Practitioners-Compared with cable-driven humanoid arm, a cable less robot is more accurate because a cable driven robot has some drawbacks due to the mismatch of connections. If the connections are mishandled, there is a chance to occur any severe damages. The main drawback is more expensive, very difficult to maintain and clean. This drawback can be rectified by the proposed method. The main feature of this robot is its mobility function.</i></p> <p>Keywords: Humanoid arm, Cable-driven module, self-calibration, two-axis method.</p>

I. Introduction

In the functioning of upper limb, the role of the hand is important. It has different cortical formations that are dedicated to control the sensor motor. Hand dexterity loss is of cortical lesion because of cerebrum-vascular disease. Immediately next to stroke, the main important aspect is paresis which is one side affected in the brain. Upper limb will be recovering is difficult and needs different multi-factorial procedures. Recently, affected arm will be recovered is approximated based on evaluation by the doctors clinically [1]. Here, advanced robotic devices have been employed to do exercises for lost operations of the recovering arm. With the increase in population, patients with disability are at specific part of the body is becoming more and more. Therefore, strokes leads to disability of adults in many countries including India. These disabled patients require lot of time and rehabilitation centers to recoup from their disabilities and be normal in their daily activities. Therapists who are limited will not be possible for long rehabilitation training sessions to the patients to acquire them [2].

Now, we come up with a solution to this problem in which the patients need a rehabilitation system controlled by them to conduct exercises of his/her own. Rehabilitation system employed robots takes control for improvising conventional post stroke treatments. They can furnish treatments for long running time in a good manner without any disturbance. It can be operated in many modes in a simple click. It is also an automated system to perform different functions [3].

A professional doctor employs their senses of touch, smell and hearing to analyze an affected person's health. Employing variety of innovative methods we can move beyond the traditions. Developments in the technology furnish more options to drive the invisible to visible. It provides particularly advanced options for therapy[4].

II. Related Work

Here, proposed 7-DOF humanoid arm by Quanzhu Chen, Weihai Chen, Guilin Yang, and Rong Liu will have a parallel-serial kinematic anatomy in order to develop accuracy of controlling the motion. It has three sequences attached parallel driven by cable nodes. Here, we propose an integrated two-level self-calibration method. Evaluating level one which is a mechanism includes clink age at the centre. Also the other is evaluated based on cable-driven module [5][6].

Rachel Gockley, Maja J Matarić research work is used in achieving hands-on assistance that is physically a robot takes care of the patient [7][8]. Here, we takes the research towards hands-on assistive and interaction with the patient by a robot. The expressions of the robot can be correlated with patient's features. We improvised an automatic robot which is moving to monitor the patient after the stroke and is shown in figure 1.

Fig 1: Block diagram of conventional approach

Scientists named Lillian Y. Chang and Yoky Matsuoka et al stated that in a hand, thumb is the key part in moving the objects. ACT thumb kinematic model is proposed here to combine different studies advances towards biomechanical information. Also, we calibrate operational uniformity between active thumb and data from cadaveric. These gives the geometric relationship of muscle length and joint angles that permits robots to function same as the human muscle. In all the previous methods the main drawback is that the equipment is large and it is very expensive and it is very difficult to maintain and clean [9][10].

III. Proposed Hand Motion Assist Robot for Rehabilitation Physiotherapy

In the proposed system, we develop an embedded based two-axis robot to help the paralyzed persons to undertake the physiotherapy exercises without human intervention. The robot moves the hands of the patients up and down, left and right using the servo motors interfaced in it. The robot is designed with three modules that are fitted at the elbow to move the hand in the left and right direction, shoulder to move in up and down direction and wrist to move it to and fro.

Servo motor's principle is the negative feedback in which a mechanical systems' input is controlled to the initial position that is evaluated by a transducer at the output. If the difference of input and output is increased, then system will drive the robot in a necessary path to remove the bug. The motor is controlled by switching ON/OFF the stator winding. Microcontroller generates the control pulse for the motion of the motor. The motor drivers are used to amplify the control pulses to the current and voltage levels of the motor stator windings. H-bridge driver configuration employs four transistors that are switched in a specific manner to control the direction of the current through the motor. Keys are used to program the angular distance and the movement counts of the robot.

The movement counts carrying out can be viewed via LCD. Rehabilitation employing a professional requires more labor and process takes a lot of time. The main drawback is that it is very costly. In opposite, by employing

a robot, we can simply plug in and get ready for the session. However, it is flexible. It also helps a disabled person to finish the exercises.

Fig 2: Schematic representation of proposed hand motion assist robot

If primary winding is applied by the ac input for a transformer, it steps down or up based on the required DC value. Here, we employ a step down function in which 230V AC is converted to 12V DC around the secondary winding. A small change affects the transformer top to be positive and the bottom becomes negative. Moreover, it is vice-versa for the later change. Specification of the transformer current is 500mA.

Rectifier is the one which converts AC to DC, also known as rectification. It permits current in only single path. Bridge rectifier is a rectifier which contains four diodes in a bridge format helps in attaining full wave rectification. Here, D1,D3 conducts in the first half cycle and in the second half cycle, D2,D4 conducts. 1N4007 is employed in such type of circuits.

IV. Simulation Results

The simulations are performed using Simulink work space. Filters are the circuits that go along with rectifier circuit in general capacitor sweeps limiter. Such a capacitor is also known as bypassing capacitor that not only arrest the ripple but also helps DC frequency to present at the end output. It is key aspect of power supply unit. The main purpose of it takes the help from rectifier and filter circuit in necessitating a DC voltage to the device. If power suppliers are not having regulators, there occurs variation in DC values in the load. May be changes in the AC voltage which is a linear one. When a regulator attaches to DC output, the voltage is in around the tolerant value which generates an exact output. Voltage regulators under the family 78xx have three terminals which are positive and have seven different voltage priorities. These are the ICs implemented as voltage regulators that are fixed. It can release output currents more than 1A with enough heat sinking.

H-bridge motor circuit is used for motor driver. Motor driver is used for amplification. The pulse generated by microcontroller is 5V but to run a motor 12V supply is needed. H-bridge circuit is principally a structure consisting of four switches, which are changed in a different manner to holds the path of current. The pulses are given to the anode and cathode terminals of optocoupler. Optocoupler is a semi-conductor device that allows signal to be transferred between the circuits electrically isolated from each other. When the switches Q1 and Q3 turns on, then the current is directed to motor through Q1 and Q3 causing the motor to run in clock-wise direction. When the switches Q2 and Q4 turns on, then the current is directed to motor through Q2 and Q4 causing the motor to run in

anti-clockwise direction. H-bridge driver can effectively run the motor in both the direction and is shown in figure 3.

Fig 3: The H-bridge circuit for arm action

A servo motor is a rotary actuator that allows for precise control of angular position. It consists of a motor coupled to a sensor for position feedback, through a reduction gearbox. Servo motor's principle is the negative feedback in which a mechanical system's input is controlled to the initial position that is evaluated by a transducer at the output. If the difference of input and output is increased, then the system will drive the robot in a necessary path to remove the bug. Any difference in the value is amplified to eliminate the errors. The motor is controlled ON/OFF by stator winding. It provides a high level of accuracy regardless of the effects of aerodynamics loads or other factors. The Simulink workspace is shown in figure 4.

Fig 4: Simulink workspace for hand motion assist robot

The various motions of the arm are tabulated in table 1. Thus, the up-down movement and right-left movement are shown in two axis. The controls of the movements are programmed in PIC microcontroller. LCD display is used for displaying the number of counts the movement has to be done.

Table 1: Various arm motions

Modules	Position	Movements
1	Shoulder	Up and Down
2	Elbow	Left and Right
3	Wrist	To and Fro

V. Conclusion

Health information technology is the use of computerized systems to manage health information. It is increasingly becoming viewed as the most promising tool for improving the overall quality. Thus the embedded based two axis robots for human hand physiotherapy (Wrist module) for the treatment of paralyzed persons to undertake the physiotherapy exercises without human intervention is developed. The stepper motor uses to move the hands of the patients up and down, left and right. The controlling function of 2 axis robot using microcontroller is verified successfully. So 2 axis robot for Physiotherapy has been using electronic health information technology to achieve improved health care quality like Prevention of health treatment errors, Reduction in health care costs, increased administrative efficiencies and Decreased paperwork for clinicians.

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