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Human Hand Movement Training with Exoskeleton Arm

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Abstract – *The humanoid robots are one of the most important and exciting current research topic in the field of robotics. There are two types of research activities on humanoid. The first is the scientific interest to understand the human behavior in computational scientific ways and the second is simply to develop a humanoid in order to use it practically. A robotic humanoid hand is created to mimic a human user's hand motions in a real time manner. First, the motions of the human hand are captured by a sensor .Then the gesture of the user hand is passed to a arduino microcontroller. Finally, the microcontroller sends the control to wireless sensor networks. Then the original motion of the hand is decoded at the receiver section then the corresponding in action is carried at the developed robotic arm. The commands to the servomotors of the robotic hand to implement the required gesture. In order to ensure that the motion of the robotic hand matches the minimum speed requirements. The robotic model is implemented using the microcontroller and results show that the robotic hand was able to mimic a human user's finger motions successfully in a real time way. In this paper, a robotic humanoid hand was developed and created, which could mimic a human user's finger motions.*

Key Words: **Exoskeleton arm, Micro-Electro-Mechanical System (MEMS), Arduino, Wireless Sensor Networks (WSN), Finger motions, Robotic model.**

1. INTRODUCTION

Stroke can cause deficiency in various neurological areas and mainly it causes disability in the motor system [1]. Most of the stroke survivors suffer from paralysis of one side of the body. Motor rehabilitation research has shown that to speed up the recovery process of the upper limb function, activity dependent interventions can be used to assist the use of paralyzed limb [2]. To be able to understand and repair the hand motor function after a person undergoes stroke has been the major focus of rehabilitation research as human hand play a vital role in the daily life activities. Furthermore, in the rehabilitation of the hand motor function the major concern has been how to achieve the optimum restoration of hand function. While positive outcomes have been obtained from therapies in general, the stroke patients who have undergone harsh, moderate or mild motor deteriorations, an optional therapy known as bilateral movement training has demonstrated positive results. In addition, based on neurophysiologic and behavioral mechanisms an immense assurance in hastening upper limb chronic stroke recovery has been shown by bilateral movement practice [3]. In comparison to the unilateral training patients, the bilateral training indicates better improvement of the upper extremity functions and decrease in movement time of the damaged limb [4]. The major aim of the paper is to design and develop a post stroke remedial system that can assist the stroke patient to flex/extend the impaired hand based on the flexion/extension movement of the healthy hand fingers. By performing bilateral movement training, the hand motor function of the impaired limb of the stroke survivor can be enhanced due to plasticity of the human brain. The robot manipulators are required to have the same number of joints. Their advantages of over fully actuated robots led to many studies to predict their behavior. The advantages such as light weight, low power consumption and low cost automation can easily overcome the failure due to an unexpected accident. Mahindrakar et al. [5] has proposed a dynamic model that takes into account the frictional forces acting on the joints. The results obtained were also verified through numerical simulation. Yet, solutions projected still lack generality and systematization. Artificial Intelligence (AI) was introduced as an alternative solution for many complex and ill-defined problems. AI is implemented in robots for predicting and making the robot systems attribute more intelligence with a high degree of autonomy. Researchers have recommended Artificial Neural Networks (ANN) for learning from examples and predicting from a large number of data [6]. The ANN will learn the target parameters based on weight adoption via reducing the error between the target and the calculated output throughout iteration during the training process. This scheme do not require any prior knowledge about the dynamic model [7]. A real, fabricated model must be formatted with the knowledge of how to operate it for the success of this scheme. Many Neural Networks have been developed for variety of applications. Nowadays, Neural Networks is one of the most successful technique that can be applied to fault detection, automatic control, combinatorial optimization, information prediction, and other fields. In the fault diagnosis area, the encoded weights of a neural network act as the antibody and the network error is considered as the antigen. Shinji Yoshii has proposed a low cost dental diagnostic system that can carry out real-time observation of the interior of the narrow root canals of the teeth. It is quite similar to the research which reduces the arm function for

about three degrees of freedom (DOF) with two active links and one passive link.

2. EXISTING SYSTEM

The need for robots have recently changed from factory automation to human friendly robot system. With increasingly aging societies, the realization of the robot hand that assists human activities in daily environment such as in offices, homes and hospitals are required. In the future, a humanoid robot, which can walk biped ally and perform skillful tasks by dual-arm with hands, would be one of the ultimate robots that have an ability of cooperative co-existence with humans, because of anthropomorphism, friendly design, locomotion, controlled behavior within the human living environment and so on. Over the past few years, a number of robotic hands have been developed should be compact and light weight. They should also be able to move their fingers quickly before grasping an object and be able to exert a large grasp force when grasping the object. To meet these requirements with a fixed reduction ratio, the hand needs to use large motors, which makes the hand large and heavy. The disadvantages of the existing system are there is a wired interface to the robot and it is not automatically controlled.

3. PROPOSED SYSTEM

The proposed system consists of a robotic hand model and human hand with motion signal detector employed in it. The motion signal detector will be placed on the human hand to detect the hand movement. The human hand and the robotic hand interacts through wireless sensor network (WSN). During the training phase, we will train the robot by pressing the switch. After releasing the switch, the hand will move according to the training phase. Each and every changes of the motion signal detector is sent to the robotic hand model through WSN. According to the movement of the human hand, the robotic hand model will also move. Using this system the dangerous situation will be handled by the human without the direct contact. The advantages of the proposed system includes the following:

- It is automatically controlled.
- There is a wireless interface to the robotic arm.
- It is less in weight.
- Inexpensive microcontroller is used.
- Easily programmable.

3.1 Block Diagram

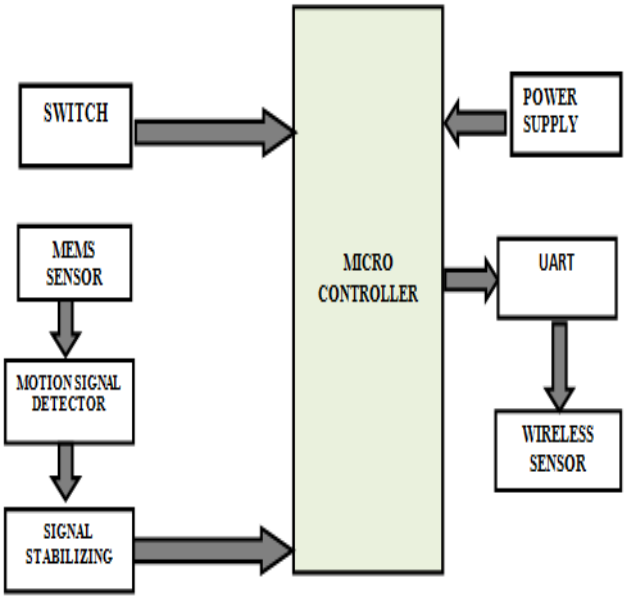

Fig -1: Control section

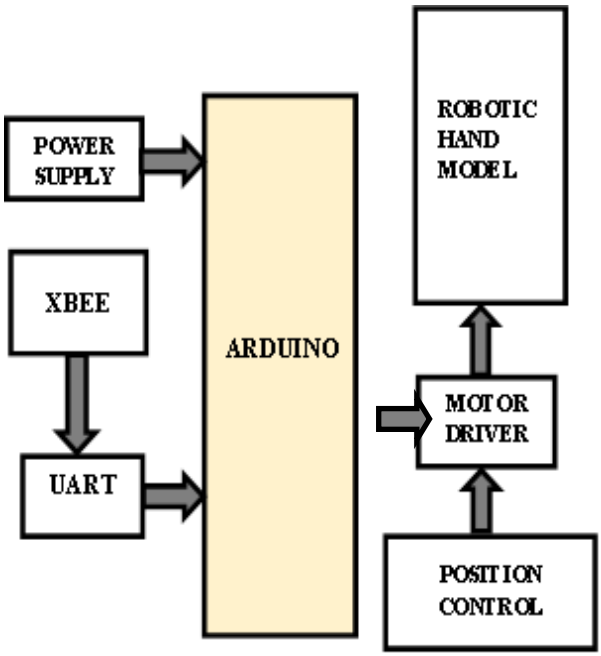

Fig -2: Arm section

3.2 Hardware requirements

- Power supply
- Microcontroller
- Motion signal detector
- Wireless sensor network

- Robotic hand model
- Driver circuit
- MEMS sensor
- Switch

3.3 Software requirements

- Arduino IDE
- Embedded C

4. HARDWARE DETAILS

4.1 MEMS Accelerometer

Micro-Electro-Mechanical System (MEMS) is the integration of many mechanical elements, sensors, actuators, and electronic components on a common silicon substrate through micro-fabrication technology. The electronic components are fabricated using integrated circuit process sequences (e.g. CMOS, Bipolar, or BICMOS processes). The micromechanical components are fabricated using compatible "micromachining" processes in which selected parts of the silicon wafer can be etched. Also, it can add new structural layers to form the mechanical and electromechanical devices.

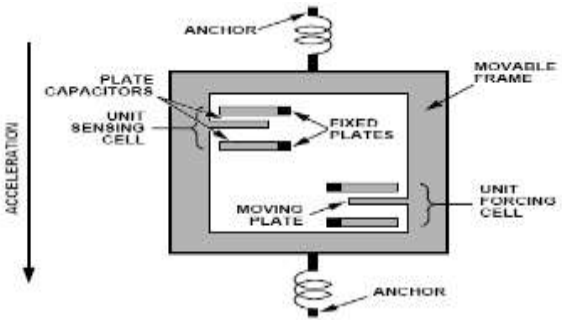

Fig -3: MEMS Accelerometer

An example of commonly used MEMS sensor is an accelerometer sensor that might be used in consumer electronic devices such as game controllers (Nintendo Wii), personal media player /cell phones (Apple iPhone, Nokia mobile phone models, HTC PDA models) and also in a number of digital cameras and other “smart” devices. The principle of capacitance differentiation is mainly used for designing the MEMS accelerometer sensors.

4.2 Driver circuit

The L298 is an integrated monolithic motor driver circuit consisting of both the 15-lead multi watt and powerSO20 packages. It is a high voltage, high current dual full-bridge driver circuit designed to accept the standard TTL logic levels and drive inductive loads such as relays, solenoids, DC and stepper motors. Two enable inputs are provided to the circuit to enable or disable the device independent of the given input signals. The emitter terminals of the lower transistors in each of the bridge circuits are combined together and hence the corresponding external terminal can be connected to the external sensing resistor. An additional supply input will be provided so that the logic works at a lower voltage.

Fig -4: L298

4.3 ZigBee Module

ZigBee is a specification for a suite of high-level communication protocols which can create personal area networks that are built from small, low-power digital radios. Though the low power consumption limits the transmission distance to 10–100 meters line-of-sight, power output and environmental characteristics, ZigBee devices can transmit the data over long distances by passing data through a mesh network of the intermediate devices in-order to reach the more distant ones. ZigBee configuration is mostly used in low data rate applications that require long battery life and secure networking (ZigBee networks are secured by 128 bit symmetric encryption keys). ZigBee has a defined data rate of 250 kbits/s which is best suited for intermittent data transmissions from a sensor or input device. The applications of ZigBee configuration includes wireless light switches, electrical meters with in-home-displays, traffic management systems, other consumer and industrial equipment that require short range and low-rate wireless transfer of data. ZigBee is a new wireless technology which is guided by the IEEE 802.15.4 Personal Area Network standard. It is primarily designed for the wide ranging automation applications and also to replace the existing non-standard technologies. It currently operates in the 868MHz band at a data rate of 20Kbps in Europe, 914MHz band at 40Kbps in USA, and in 2.4 GHz ISM bands worldwide at a maximum data-rate of about 250Kbits/s. The ZigBee specification is a combination of both home RF late and IEEE 802.15.4 Personal Area Network standard.. This specification operates in the 2.4GHz (ISM) radio band which is the same band used for 802.11b standard, Bluetooth, microwave and some other devices. It can connect 255 devices per network. This specification supports data transmission rates of 250 Kbps at a range of up to 30 meters. ZigBee technology is slower than 802.11b (11 Mbps) and Bluetooth (1 Mbps) but it consumes significantly less power. 802.15.4 (ZigBee) is a new standard specially designed for low data rate wireless personal area networks. It provides low data rate, low power consumption and low cost wireless networking. The main goal is to provide a physical-layer and MAC-layer standard

for such networks. When compared with wired networks, the advantages of the wireless networks are deployment, cost, size and distributed intelligence. This technology allows the users to set up a network quickly and also allows them to set up the networks where it is impossible or inconvenient to use wire cables. In general, wireless networks are more cost-effective than wired networks. Bluetooth (802.15.1) was the first well known wireless standard which provided low data rate applications. The effort of Bluetooth to cover more applications and provide good quality of service has led to its deviation from the design goal of simplicity. This deviation makes it expensive and inappropriate even for some simple applications which requires low cost and low power consumption. These are the kind of applications on which the new standard focuses. It is relevant to compare Bluetooth and ZigBee as they are sometimes seen as competitors so that they can show their differences to clarify which application suits each of them. The data transfer capabilities are much higher in Bluetooth which makes it suitable for transmitting audio, graphics and pictures over small networks and is also appropriate for file transfers. ZigBee, on the other hand, is better suited for transmitting smaller packets over large networks, mostly static networks with many infrequently used devices like home automation, toys, remote controls, etc.

4.4 Arduino

Arduino ATMEGA-328 microcontroller consists of 14 input and output analog and digital pins (in which 6 pins are considered to be the PWM pins) out of which 6 are analog inputs and the remaining are digital inputs. Power jack cable is used to connect the Arduino board with the computer. Externally, the battery is connected with the Arduino microcontroller for power supply. Arduino is an open source microcontroller from which there will be no feedback given to the microcontroller. The Arduino board consists of I2C bus that can be able to transfer the data from the arduino board to the output devices. The arduino board is programmed over RS232 serial interface connections with ATMEGA-328 arduino microcontrollers. The operating volt ranges from 5v.

Fig -5: Arduino

The input voltage recommended for Arduino microcontroller is from 7V to a maximum of 12V. The arduino board is given an input DC current in the range of 40mA.

5. CONCLUSION

Development of arm motor function rehabilitation device based on sensor has been developed. The device was able to achieve full flexion/ extension motion of arms. In order to achieve better accuracy, feedback control needs to be developed by MEMS sensor for the prediction of under-actuated systems behavior. Data were collected from sensors fixed on the ARM. Testing of the device on actual stroke survivors and the further discussions with the physiotherapist for suggestions is necessary for future modification of the device.

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