Flex Sensors Based Robotic ARM for Disabled Persons: A Review

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Abstract – In this paper, the studied of gesture recognition using flex sensors for disabled persons. It is used for accurate human hand gesture recognition and tracking. Since a flex sensor is better at tracking rapid movements, while a vision sensor is more stable and accurate for tracking slow movements, a novel adaptive algorithm provides accurate measurement of the robotic arm which is helpful for disabled persons or depending on human needs. The method is capable of reducing the velocity error and position of the robotic arm without any drift using flex sensors because of the high level of sensitivity.

Index Terms – Robotic ARM, Flex Sensors, Gesture Recognition System, Tracking Technique.

1. INTRODUCTION

According to the World Facts and Statistics on Disabilities and Disability Issues, currently, around 15 percent of total world's population lives with a disability. About 80 percent of theses disabled people live in developing countries as declared by United Nations Development Programme (UNDP). The disabled population in India has increased by 22.4% from 2001 to 2011 (2.19 crore in 2001 and 2.68 crore in 2011). Most of the disabled are those with movement disability. 20.3% of disabled are movement disabled followed by hearing disability of 18.9% and 18.8% with visual impairment and 5.6% are mentally challenged. The gesture-based robotic arm acts as a boon for them among various assistive devices. A smart robotic arm like gesture-based is one that helps such disabled people to carry out simple tasks like lifting a glass of water etc. Gesture-based technology in conjunction with Arduino or microcontroller has been used to operate the robotic arm [1].

The term robot was first introduced by Czech Writer Karel Capek in his play Rossum's Universal_Robots, published in 1920. The word "Robota" literally meaning worker or labour is coined from the Slavic word. A definition of the Robot by Robot Institute of America- "A Robot is a programmable multifunctional manipulator designed to move material, parts, tools, or specialized devices through variable programmed motions for the performance of a variety of tasks." A Robot is a mechanical or virtual artificial agent, usually an electromechanical machine that is guided by a computer program or electronic circuitry [2]. Robotics is the branch of technology that deals with the design, construction, operation and application of robots as well as computer systems for their control, sensory feedback, and information processing. These technologies deal with automated machines that can take the place of humans as per safety measuring consideration in dangerous environment or manufacturing processes, or resemble humans in appearance, behaviour or cognition. A gesture-based static/ mobile robotic arm itself requires safety measuring technologies against obstacle avoidance like a ditch, rough surface, wall, crowd etc. in free space. Many robots / robotic arms do jobs that are hazardous to humans such as defusing bombs, mines and exploring shipwrecks and rescue, military battle, mine and bomb detection, scientific exploration, entertainment, hospital care, aid to people disabilities. So robot / robotic arm needs sensor/ gesture-based recognition technology for disabled persons using Arduino /microcontroller.

1.1 Need of Gesture-Based Robotic Arm

A physically disabled person nourishing himself was considered as a great deed in the 19th century. But this age has become an era where talents are considered as the matter of fact in spite of their physical weakness. Today's world comprises of a large variety of people. Some of them depend on others for their living. But in today's fast world, everyone is busy and there are fewer people to care for the increasing number of elderly and the physically challenged people.

Gesture based robotic arms are expected to become increasingly important tools for supporting persons with disabled upper limbs in their daily life activities. Recently, several assistive robotic arms have been developed that are small and functional enough to be installed on hand, a wheelchair or on a bed. If persons with upper limb disabilities were to have access to robotic arms that provide degrees of flexibility similar to healthy arms and hands [3]. They could perform numerous daily life activities by themselves, such as drinking, eating, reading books and letters, operating cell - phones etc. all of which would normally require the assistance of another person. In such situations, the gesture based robotic arms would provide more freedom and independence to disabled users and thus improve their quality of life (QOL) with a lot of safety measures as concerned to a disabled person. So robot / robotic arm needs gesture based recognition technology using different sensors on hand glove for disable persons using Arduino / Microcontroller.

1.2 Basics of Robotic ARM

It is a programmable mechanical arm that has functions similar to human upper limbs and moves the objects spatially. A robotic arm is made up of a chain of rigid links interconnected by movable joints. Links can be considered to correspond to human anatomy as waist, upper arm and fore arm with joints at shoulder and elbow. At the end of the arm, a wrist joint connects an end effecter to the forearm. The links of such a manipulator are connected by joints allowing either rotational motion (such as in an articulated robot) or translational (linear) displacement. The links of the manipulator can be considered to form a kinematic chain and the terminus is called the wrist/end effecter. And analogous to the human hand.

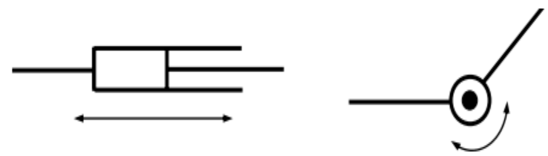
1.3 Configuration of Wrist

The arm configuration carries and position the wrist attached to the end point of the arm. The wrist subassembly movements enable the manipulator to orient the end effectors to perform the task properly. The wrist must possess at least 3 DOF (Degree of Freedom) to give three rotations about three principle axis. Fewer than 3 DOF may be used in wrist depending upon the requirement. A 3 DOF wrist permitting rotation about three perpendicular axis provides motions such as ROLL (motion in a plane perpendicular to the end of the arm), PITCH (motion in a vertical plane passing through the arm) and YAW (motion in a horizontal plane passing through the arm).

1.4 End Effecter

The end effecter may be a tool and its fixture or a gripper or any other device to do the work. The end effecter is similar to a human hand with or without fingers, it is external to the manipulator and its DOF do not combine with the manipulator's DOF. End effecter can be a Gripper or Tools. The gripper is an end effecter to grasp or hold the work piece during the work cycle. The tool can be a drill, a welding torch, a screw driver. Many types of joints can be made between two links like:

Firstly Revolute, secondly Prismatic, thirdly Rotary and fourthly Twist.



(a) (b)

Fig. 1 Types of Joints (a) Prismatic (b) Revolute

But only two basic types (Revolute and Prismatic) are commonly used in the robotic arm as shown in Fig. 1.

Revolute Joint Two links are joined by a pin (pivot) about the axis of which the links can rotate with respect to each other.

Prismatic Joint Two links are so joined that these can slide (linearly) move with respect to each other.

1.5 Human Arm Characteristics

The design of the human arm structure is a unique marvel and is still a challenge to replicate. Certain characteristics of the human arm are a far cry for today's manipulators.

The human arm's basic performance specifications are defined from the zero reference position, which is the stretched right arm and hand straight out and horizontal with the palm in downward direction. The three motions to orient the hand are:

$-120^o <= \text{Roll} <= +90^o$

$-90^o <= \text{Pitch} <= +50^o$

$-45^o <= \text{Yaw} <= +15^o$

Note that to provide the roll motion to the hand, forearm and the upper arm both undergo a twist, while pitch and yaw are provided by the wrist joint. The second part of the human arm consists of an upper arm and fore arm with shoulder and elbow joints. It has 2 DOF in the shoulder and 1 DOF in the elbow joint. The 2 DOF shoulder joint provides an approximately hemisphere sweep to the elbow joint. The elbow joint moves the forearm by approximately 120^o (from -5^o to 125^o) in different planes, depending upon the orientation of two fore arm bones and elbow joint. For zero reference position defined above, the forearm and the wrist can only sweep an arc in the horizontal plane.

Another important feature of human arm is the ratio of the length of the upper arm to that of the fore arm which is around 1.2 any ratio other than these results in performance impairment. The technology has to go a long way to replicate human arm's bone shapes, joint mechanisms, a mechanism to power and move joints, motion control, safety and above all self-repair. The human hand with four fingers and a thumb, each with 4-DOF is another marvel with no parallel. The finger and thumb joints can act independently or get locked, depending on the task involved. In contrast, the robot gripper with two or three fingers has almost no dexterity. The human arm's articulation and to the same extent, the human leg's locomotion are a challenge yet to be met.

Keeping in view the above facts, it is very essential to find the effective techniques for the people with upper arm disability, so that they can become less dependent on others.

1.6 Description of Sensors

A device that responds to physical stimuli (such as heat, light, sound, pressure, magnetism, motion, gesture, etc.) and transmits the resulting signal or data for providing a measurement, operating a control, or both in terms of voltage vs. distances / size/ color/pixel/strain/motion [4, 5]. Sensors order robots to receive information about a certain measurement of the internal components and external environment for performing their tasks like movement with safety measures. They are used for various forms of measurements like shape, distance, colours gesture recognition, voice recognition etc., to give the robots warnings about safety measures or to avoid malfunctions, and to provide real time information of the task it is performing. Several types of sensors are used for robots such as flex sensor, 3 axis accelerometer, infrared range finder, ultrasonic sensors, high image processing cameras, CMOS sensors, colour sensors, distance sensors, touch / non-touch sensors, sonar, gyroscope etc.

1.7 CONTROLLER

A controller is a brain of the robot which controls all the functions of the robot. Controller stores software programmes for specified works using coding or c, c++ and visual basic. Generally, the controller is a microprocessor, microcontroller / Arduino and pc based. Either auxiliary computers or embedded microprocessors are used for the control of almost all industrial robots today. These perform all the required computational functions, as well as interface with and control associated sensors, grippers, tooling and other associated peripheral equipment. The control system performs the necessary sequencing and memory functions for on-line sensing, branching and integration of other equipment. Programming of the controllers can be done on-line or at remote off-line control stations with electronic data transfer of programs.

2. PROPOSED BLOCK DIAGRAM OF THE SYSTEM

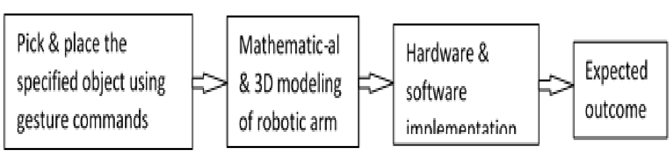


Fig. 2 Block Diagram of proposed System

The main objective of this work is to design and develop a gesture controlled a robotic arm for the mute people with upper limb disability which helps them to perform certain basic activities like pick and place, drink and eat. The proposed system is operated using gesture commands created by the operator. The block diagram of the proposed work is shown in the Fig. 2.

3. GESTURE-BASED RECOGNITION TECHNOLOGY

It is a class of intelligent control techniques or simply sensors based control techniques that use various Artificial Intelligence (AI) computing approaches like Artificial Neural Network (ANN), Bayesian probability, fuzzy logic machine learning, evolutionary computation, intelligent agent and genetic algorithms [6]. Gesture-based recognition technology is an autonomous entity which observes through accelerometer sensors, flex sensors, gyroscope and acts upon an environment using actuators (i.e. it is an agent) and directs its activity towards achieving. Intelligent agents may also learn or use knowledge to achieve their goals. They may be very simple or very complex. A reflex machine such as a thermostat, pick and place robotic arm is an intelligent agent.

Gutta et al. [7], presented a hybrid architecture which consisting of an ensemble of connectionist networks-radial basis functions (RBF) and inductive decision trees (DT). The experimental results, proving the feasibility of our approach, yield (i) 93% accuracy, using cross validation, for contents-based image retrieval (CBIR) subject to correct ID matching tasks, such as 'find Joe Smith with/without glasses', on a data base of 200 images, and (ii) 96% accuracy using cross validation, for forensic verification on a data base consisting of 102 images corresponding to 350 subjects (of whom 102 are duplicates). Cross validation results on the hand gesture recognition task yield a false negative rate of 3.6% and a false positive rate of 1.8%, using a data base of 750 images corresponding to 25 hand gestures. Sigalas et al. [8] have presented a novel approach for hand gesture recognition. The proposed system utilizes upper body part tracking in a 9-dimensional configuration space and two Multi-Layer Perceptron/Radial Basis Function (MLP/RBF) neural network classifiers, one for each arm. Classification is achieved by buffering the trajectory of each arm and feeding it to the MLP Neural Network which is trained to recognize between five gesturing states. Waldherr et al. [9] have described a gesture-based interface for human-robot interaction, which enables people to instruct robots through easy-to-perform arm gestures. Such gestures might be static pose gestures, which involve only a specific configuration of the person's arm, or they might be dynamic motion gestures, that is, they involve motion (such as waving). Results are reported in the context of an interactive clean-up task, where a person guides the robot to specific locations that need to be cleaned, and the robot picks up trash which it then delivers to the nearest trash-bin. Akl et al. [10] have proposed the problem of gesture recognition using the theory of random projection (RP) and by formulating the whole recognition problem. For training, the system employs dynamic time warping as well as affinity propagation to create exemplars for each gesture while for testing, the system projects all candidate traces and also the unknown trace onto the same lower dimensional subspace for recognition. A dictionary of 18 gestures is defined and a database of over 3700 traces is created from seven subjects on which the system is tested and evaluated. The system achieves almost perfect user-dependent recognition, and mixed-user and user-independent recognition accuracies that are highly competitive with systems based on statistical methods and with the other accelerometer-based gesture recognition systems available in the literature. Zhou et al. [11], presented an algorithm for hand gesture tracking and recognition based on the integration of a custom-built micro-electromechanical systems (MEMS) based inertial sensor and a low resolution imaging sensor. The experimental results verify that the proposed method is capable of reducing the velocity error and position drift in an MEMS-based inertial sensor when aided by the vision sensor. Compensating for the time delay due to the visual data processing cycles, a moving average filter is applied to remove the high frequency noise and propagate the inertial signals. The reconstructed trajectories of the first 10 Arabic numerals are further recognized using dynamic time warping with a direct cosine transform for feature extraction, resulting in an accuracy of 92.3% and individual numeral recognition within 100 ms. Lee et al. [12] have presented a new method for spotting and recognizing whole body key gestures at the same time on a mobile robot. In this regard, both of execution speed and recognition performance should be considered. For efficient and natural operation, we used several approaches at each step of gesture recognition; learning and extraction of articulated joint information, representing gesture as a sequence of clusters, spotting and recognizing a gesture. In addition, constructed a large gesture database, with which authors verified proposed method. As a result, proposed method is successfully included and operated in a mobile robot. Corke et al. [13], designed MATLAB Toolbox for robotics which is very useful for simulation, visualization and 3D modelling of robot. The robotics toolbox provides many functions that are required in robotics and addresses such areas as kinematics, dynamics, and trajectory generation. The Denavit and Hartenberg (D-H) parameters of the robot and can be created by the user for any serial-link manipulator. A number of examples are provided for well-known robots such as the Puma 560 and the Stanford arm. Saha et al. [14], developed Roboanalyzer software for learning concepts of robotics. Roboanalyzer perform kinematic and dynamic analyses of serial robots. “Visualization of DH Parameters and Transformations”, “3D CAD Model Importer” and “Inverse Kinematics” are explained and illustrated. Fei et al. [15], presented six degrees of freedom industrial robot. The author has used the DH method to do the forward kinematics analysis and inverse kinematics analysis for robot, establishes the kinematics model, and uses Lagrange method for robots’ dynamics analysis, and then builds the relational model among mechanical arms and their force (or Design and Development of an Intelligent Robotic Arm Page 10 torque). Roboanalyzer has been used to illustrate the above to prove the correctness and rationality of the models. Farman et al. [16], presented modeling and control issues of a simple robot arm design. Mathematical, Simulink models and MATLAB program have been developed to return maximum numerical visual and graphical data to select, design, control and analyze arm system. The proposed models and program has been tested for different input values and control strategies for showing the accuracy and applicability of derived models. The proposed model is intended for education and research purposes. Patil et al. [17], presented the position control of pick and place robot arm. The author has develop algorithms for controlling movements. The robotic arm was designed using AutoCAD drawings and simulation was carried out by EdgeCAM software. Servo motors has been used for joints movement. Intelligence behind the robotic arm is 8051 Microcontroller. Kinematic modeling has been used to find position and orientation of the end effector with respect to base. Salvucci et al. [18], experimentally analyzed and compared the six most significant actuation redundancy resolution approaches 1-norm, 2-norm, ∞ -norm, phase different control (PDC), nonlinear phase different control (NLPDC), and linear programming (LP). Among these six approaches, three have been proposed by the authors, namely ∞-norm, NLPDC, and LP. Biarticular actuation has been mainly implemented in robotic limbs, by means of pneumatic actuators. The resolution of actuator redundancy is a fundamental problem in the control design for such robots, as it strongly characterizes the robot arm performance. ∞ -norm approaches minimize the necessary joint actuator torques to produce a desired force. The NDLPDC avoid the calculation error from end-effector force to input torques caused by the linearization process in the PDC. The LP approach determine the actuator inputs producing the maximum end-effector force of an arm with any number of actuators and joints the performance of biarticularly-actuated robot arms. Xu et al. [19], presented a novel implementation of an integral sliding-mode controller (ISMC) on a two-wheeled mobile Robot (2 WMR). The 2 WMR consists of two wheels in parallel and an inverse pendulum, which is inherently unstable. ISMC has an extra degree of freedom in control when sliding mode is achieved. The author has utilized this extra degree of freedom to implement a linear nominal controller.

Lu et al. [20], illustrated the ability of the exoskeleton to enable the leg shank to track single and multiple period trajectories with different periods and ranges of motion. Lower limb exoskeleton has been developed, and a human like learning controller for neuromotor training of gait and rehabilitation of patients with walking disabilities has been presented. Adaptive learning control by incorporating the learning control approach into the exoskeleton system has been developed to help the leg to move on a desired periodic trajectory and handle periodic uncertainties with known periods. The experiments illustrate the ability of the exoskeleton to enable the leg shank to track single and multiple period trajectories with different periods and ranges of motion. Suzumura et al. [21], designed wheel-legged mobile robot (WLMR) which has both leg and wheel structures. WLMRs have adaptability advantages because they can change locomotion methods depending on the terrain. The effectiveness of the whole body motion pattern generated by the proposed methods is validated by simulations and experiments. In this paper, the author proposed a whole body motion generation and control system to produce high mobility for a 3-D WLMR. Fukushima et al. [22], proposed a method of transformation from a four-wheeled mode for high-speed mobility to an inverted pendulum mode target equilibrium point of the wheeled inverted pendulum system. The author used a nonlinear controller based on sliding-mode control. The proposed method can take into account the robot velocity from the beginning of the transformation, which enables us to complete the transformation in a smaller space. Sehoon et al. [23], proposed a coordinate system that simplifies the kinematics of a two link robotic manipulator with the biarticular actuation coordination. The dynamics of the two-link manipulator was analyzed, and a disturbance observer (DOB) was designed based on the derived dynamics to nominalize the actual dynamics and to reject undesired disturbances. The proposed DOB-based control algorithm can achieve better control performance in the rotating coordinate system, and comparative experiments verify the effectiveness of the proposed coordinate system and control methods. Design and Development of an Intelligent Robotic Arm Page 15. Feng et al. [24], presented the modelling and implementation of a two-wheel self-balancing robot which was built as a test platform. In this design, three feedback sensors, an accelerometer to measure the tilt angle of the robot with respect to gravity, a gyroscope to measure the angular rate and two shaft encoders to measure the position and velocity of the base of the robot. The system used Kalman filter for the fusion of sensor data and linear state space controller for self-balancing. It can move back and forth, turn left and right under the control of the operator from distance through a set of the remote control module. In addition, the robot features two supporting arms equipped with it, and can rest itself on them for power-saving during the break of exhibition, or be supported by them when impacted by an irresistible force from external and unable to stay upright anymore, It can switch between self-balancing and resting status swiftly and stably on its own or under the control of the operator. Sulabh et al. [25], have designed low cost 6-DOF robotic arm controlled by man machine interface. Articulation of robotic arm was achieved about six single-axis revolute joints. Man Machine interface was used to operate robotic arm in real time. Two Atmel mega 2560 Microcontroller Units interfaced through XBee Pro units. The man machine interface consists of an exoskeleton graphical user interface and a mode selection switch which enables the teleoperator to select one of the three modes of operation. Georgitzikis et al. [26], developed a system that controls physical objects via the internet using the Arduino platform over 802.15.4 networks. The author also showed how to use it in order to build a platform-agnostic heterogeneous wireless sensor network.

Zhang et al. [27], proposed a real-time multiple human perception with color-depth cameras on a mobile robot. The system was able to create an accurate system for real-time 3-D perception of humans by a mobile robot. The author also discussed the task of human detection and tracking in complex, dynamic, indoor environments and in realistic and diverse settings, using a color-depth camera on a mobile robot. Kale et al. [28], presented a mechatronics color sorting system with the application of image processing using Arduino. Image processing procedure senses the objects in an image captured in real-time by a webcam and then identifies color and information out of it. This information was processed by image processing for pick-and-place mechanism. The project involves sensors that senses the object’s color, size and sends the signal to the Arduino. The Arduino sends signal to circuit which drives the various motors of the robotic arm to grip the object and place it in the specified location. Tomas et al. [29], designed a fuzzy control system for robotic arm and its implementation to PLC. Fuzzy logic is used to calculate the proper speed of robot tool center point depending on the tilt of the joystick handle in manual operating mode. Fuzzy system was designed in the Siemes Fuzzy Control and was implemented to Simatic S7-300 PLC. Anthropomorphic geometry was realized by three revolute joints. Joints were actuated by electric motors with 9V DC supply voltage and with 250 mA current consumption. Sairam et al. [30], designed a robot which was programmed to bend the sheet metal part, using teach pendant technology. The sheet metal fabrication applies CNC equipment such as a CNC press brake. Due to the new programs which have been done to handle the articles which were done manually before has enhanced the line capacity, throughput rate and also the productivity can be increased. Another advantage was that the number of man power can also be reduced, which there by minimized labor cost and at the same time increasing the throughput rate. Ge et al. [31], designed an automatic assembly system with dual arm robot and smart cameras. Small part assembly is a very complex process and demands very high precision. The system includes dual arm robot, smart cameras, PLC, 3D printer. The author discussed quick prototyping of mechanical parts, cell calibration and vision problems in detail. Project error of camera was analyzed and corrected. Experiment results demonstrated great advantage of dual arm robot in small part assembly area. Xie et al. [32], presented an accelerometer-based smart ring and a similarity matching-based extensible hand gesture recognition algorithm. A library of eight basic gestures and 12 complex gestures is created, and the users can easily define and add their own gestures without pretraining. It achieves a basic gesture recognition rate of 98.9% and a complex gesture recognition rate of 97.2%. Compared with complete matching, the proposed algorithm based on similarity matching improves the complex gesture recognition rate ~12%. Experimental results have successfully validated the feasibility and effectiveness of the gesture decomposition and similarity matching-based gesture recognition algorithm. Xu et al. [33] have presented three different gesture recognition models which are capable of recognizing seven hand gestures, i.e., up, down, left, right, tick, circle, and cross, based on the input signals from MEMS 3-axes accelerometers. To compress data and to minimize the influence of variations resulted from gestures made by different users, a basic feature based on sign sequence of gesture acceleration is extracted. This method reduces hundreds of data values of a single gesture to a gesture code of 8 numbers. Results based on 72 experiments, each containing a sequence of hand gestures (totaling 628 gestures), show that the best of the three models discussed in this paper achieves an overall recognition accuracy of 95.6%, with the correct recognition accuracy of each gesture ranging from 91% to 100%. Xie et al. [34], presented an accelerometer-based pen-type sensing device and a user-independent hand gesture recognition algorithm. The proposed recognition algorithm achieves almost perfect user-dependent and user-independent recognition accuracies for both basic and complex gestures. Experimental results based on 5 subjects, totaling 1600 trajectories, have successfully validated the effectiveness of the feedforward neural network and similarity matching-based gesture recognition algorithm. Wang et al. [35] have presented a fiber Bragg grating (FBG) accelerometer based on a push-pull elastic cylinder structure is demonstrated. Results indicate that the transverse-induced FBG deformation is very big so that a strict transverse constrain is needed. The formula of the strain magnification is derived and the design rules of the strain magnification are given. After structure optimization according to the rules, the FBG strain increases to 1.5 times, the sensitivity increases to 1.82 times, whereas the resonant frequency reduces to 0.9 times compared with the parameters of accelerometer based on uniform cylinder structure. Finally, the accelerometer size reduces to $\Phi 20$ mm × 34 mm, the sensitivity increases to 623 pm/g, and the resonant frequency reduces to 449 Hz. Mori et al. [36] have proposed an automatic construction algorithm for gesture network by logical DP matching. The experiment was conducted for evaluating the performance of the gesture network constructed automatically. The experimental result indicated that the proposed automatic construction algorithm for gesture network can be alternative of manual construction. Iqbal et al. [37] have designed a robotic arm with 2-DOF and analyzed its workspace. The proposed model makes it possible to control the manipulator to achieve any reachable position and orientation. The forward kinematic model is based on Denavit-Hertenberg method. Results demonstrate that end effecter of the arm can point to the desired coordinates with precision of +/- 0.5cm. Parasuraman et al. [38] have developed a robot which assists people with upper limb disability using robot assisted stroke rehabilitation system. Grecu et al. [39] have carried out the analysis of human arm joints and the study is extended to the robot manipulator. This study is the first focus on the kinematics of human upper arm which include the movement of each joint in shoulder, wrist, elbow and fingers.

Those analyses are then extended to the design of a human robot manipulator. This paper presents the mechanical analysis of human upper arm joints (shoulder, elbow, wrist and fingers). The research is then extended to the study of human manipulator. Jeong et al. [40] have designed a wearable robot that a human operator wears on his arm for the purpose of human-robot interaction. The author designed robowear with suitable devices to be worn by human operator which can move around freely because this robot is designed to have base supported at the shoulder part of the operator.

Its weight is 4 kg. Zhang et al. [41] have discussed the shoulder, elbow and wrist stiffness in passive movement and their independent control in voluntary movement post stroke. The study uses a new whole arm intelligent rehabilitation robot capable of controlling shoulder, elbow and wrist individually and simultaneously. Thakur et al. [42] have suggested an integrated system to facilitate elderly and disabled people with an easy-to-use home automation system that can be fully operated based on speech commands. Lim et al. [43] have designed a new Human Robot Interface (HRI) for the spinal cord injured person and a control scheme of the robot manipulator for the developed interface. The system is mainly aimed at people with C3 and C4 injuries, who cannot move below the shoulder. Yamanobe et al. [44] have designed a training system to familiarize persons who have severe upper limb disabilities with robotic arm operation is described. The system combines a robotic arm simulator with various control interfaces and provides training tasks to learn how to operate robotic arms.

4. CONCLUSION

The reviewed of many papers that conclude, the gesture recognition based robotic arm using flex sensors for disabled persons is an accurate system and tracker. A flex sensor is better at tracking rapid movements, while a vision sensor is more stable and accurate for tracking slow movements, a novel adaptive algorithm provides accurate measurement of the robotic arm which is helpful depending on human requirements. The method is capable of reducing the velocity error and position of the robotic arm without any drift using flex sensors because of the high level of sensitivity.

Further research, the hybrid technique can be used for tracking and movements of robotic applications based on human needs and efficient works.

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