FABRICATION OF VOICE OPERATED MOTORISED EXO SKELETON ARM

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ABSTRACT

The designing of fully functioning MOTORISED prosthetic arm with coordinating speed of response and strength is the aim of upper extremity prosthetics research. Unfortunately, current prosthetic arms and collaborating techniques are still a long way from this aim. The current state-of-the-art prosthesis can be considered to be a tool rather than an upper limb replacement. The pneumatic prosthesis as a tool makes no pretense of replacing the lost arm but tries to replace some functions that were lost. The prosthesis is the device which can be worn as per will and can be removed when not wanted. Many efforts in this field are taken to make pneumatic prosthetic as an ideal upper limb replacement, however, current prosthetic arms are limited to be used as tools. The major factors limiting pneumatic prosthesis to tools are practical ones due to the heavy weight, less power, and size of the component as well as the difficulty in finding appropriate control sources to control the number of degrees of freedom. Of these the important drawback is the latter one. As a result, upper- limb prosthetics research is dominated by considerations of appropriate controls for controlling the degrees of freedom. Still, the importance of better pneumatic actuators and better multifunctional mechanisms cannot be ignored. Current motorized prosthetic arm are of single degree of freedom. Generally, vision is the primary source of feedback for the device, the number of functions that are controlled in parallel at one time is two. Otherwise, the mental loading becomes excessive and impossible. Switch, pneumatic actuators, control valves are the primary modes of control for today's upper-limb prosthetic arms. The upper limb prosthetic arms are developed according the tasks they need to perform or according to type of person whom it is wore by. The pneumatic prosthetic exoskeleton[1] used for giving additional strength to normal people in order to make them do extreme work. Therefore pneumatic prosthetic arm has found its applications in military personnel and heavy industry personnel. The exoskeleton also finds its application in physically weak people to regain their power they lost after stroke. Generally speaking, the shortcomings of the arm prostheses that are now clinically available are the following: The pneumatic prosthetic arm has far fewer degrees of freedom than the normal arm for which they are intended to act as substitute. Thus they perform certain tasks in difficult manner and in some cases only with great difficulty for the amputee. The controls for a given motion are not related to the actions of a normal person which cause the corresponding motion of a normal arm. For example, flexion of the "elbow" of the pneumatic prosthetic arm may result only from movement of the shoulder of the amputee whereas in a normal person elbow and shoulder motions are independent. The result of this is that the amputee must learn an entirely new pattern of activity in order to make the pneumatic prosthetic arm useful to him, and his ultimate performance is often limited because the degree of freedom which is required are few, and the constraints of the control system are so many. This project reviews the upper extremity exoskeleton with different functions, actuators and degree of freedom (DOF). Among the functions, power-assist[2] and rehabilitation[3] have been highlighted In addition; the structure of exoskeleton is separated by its DOF in terms of Upper extremity[4].

Keyword: - *Exo-skeleton[1], Power-assist[2], Rehabilitation[3] and Upper extremity[4].*

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1. LITERATURE SURVEY

1.1 HISTORY

The first exoskeleton structure to assist walking, jumping and running were invented by Nicholas Yang in 1890. It contained compressed gas bags to power it. The first totally functional and powerful exo-suit was developed by General Electric in association with United States Military in 1960s which lifted 110kg with effort reduction by the factor of 10. However, in the 1950s for use of artificial muscle and then commercialized by Bridgestone Rubber (Japan) in 1980s. It was then when PAMs were used in an exo-arm.

1.2 COMPARISION WITH EXISTING TECHNOLOGY

The main distinction between the design described in this paper and the existing ones is that a power assist type exoskeleton has been selected rather than a more expensive power amplification device. The cost required to design and manufacture such a device was reduced. But the main difference is apparent through the selection and control of McKibben air muscles as the main power actuator. Some implementations, which use hydraulic actuators, need internal combustion engines to compress the non-compliant fluid. This implementation uses a limited supply of pressurized, compliant gas, which reduces the power consumption by a considerable amount. Another major difference is the use of McKibben air muscles provides with a higher power-to-weight ratio than an exoskeleton using DC motors. Finally, the implementation of a combination of flex and EMG sensors, allows monitoring of the signals sent to the muscles, and potentially reduces the effort required to activate the sensors.

1.3 Upper Limb Rehabilitation Robots

Early research on rehabilitation robots for the human upper limb was based on end-effector robots. End-effector rehabilitation robots hold the patient’s hand or forearm at one point and generate interaction forces at this sole interface. The kinematic structure of these end-effector robots are based on industrial robots and the kinematics of the human limb are not considered in their design. This type of robot is simpler, easier to fabricate and can be used for patients with different arm lengths. However, determining the posture of the upper limb can be difficult with only one interface, especially if the interface is at the patient’s hand. This is because the upper arm and forearm are unconstrained and are free to move about the pivots at the shoulder and hand. Controlling the torque at specific upper limb joints is also not possible, resulting in uncontrolled load transfer between upper limb joints. As a consequence, generating isolated movement at a single upper limb joint is difficult since movement of the end effector can cause a combination of movements at the wrist, elbow and shoulder joints. In addition, the range of motion that end-effector robots can generate for the upper limb tends to be limited therefore only a limited set of rehabilitation movements can be produced by these robots.

2. OBJECTIVES

The exoskeleton is getting important to humans in many aspects such as power assist, muscle training, pneumatic functioning and rehabilitation. The research and development towards these functions are expected to be combined and integrated with the human intelligent and machine power, eventually becoming another generation of robot which will enhance the machine intelligence and human power. This paper reviews the upper extremity exoskeleton with different functions, actuators and degree of freedom (DOF). Among the functions, rehabilitation and power assist have been highlighted in addition the structure of exoskeleton is separated by its DOF in terms of shoulder, elbow, wrist and hand.

3. OPERATIONAL DEFINITION

The exoskeleton arm is found to be useful in diverse situations as mentioned below: -

Disabled people can regain the use of their limbs using the exoskeleton. The exoskeleton can be used as a means of rehabilitation. Industrial workers, dock workers and loaders who are engaged in jobs which entail lifting of heavy loads on a daily basis are empowered by the exoskeleton. Nurses who have to carry heavy patients can effectively do so with the exoskeleton. Exoskeletons have become widely popular in the military field as well, helping soldiers to carry armaments over challenging terrain.

4. OPERATIONAL FUNCTIONS

Voice actuation is one of the artificial intelligence techniques used in the robotics. In robotics speech recognition is the transformation of the voice signals in to the text commands. The process by which the machine identifies the words is speech recognition. Speech recognition is the method by which a device or controller (or any type of arrangement) identifies the verbal words. It simply means ordering to device and it exactly recognizes the voice instruction given. Speech Recognition is an ability of computer software program or hardware mechanism to decode the human command into digitized speech that can be interpreted by the computer or hardware device. Voice recognition is commonly used to operate a device, perform commands, or to command robot to pick items or to do a certain work. There are 2 important steps in speech recognition. 1) Recognize the sound excluding the noise and 2) Identifying the words from that sound. The speech recognition technique also depends on the parameters like the speaking mode, language and the style of speaking. In this proposed project a speech recognition hardware module will be installed to accomplish the task. The main objective of speech recognition technique is to interpret a phrase or words by using the microphone and transform it in to the text commands. The robotic arm is a prototype, similar to the human arm. A robotic arm consists of links and joints which are controlled by the actuators like motors and gears. The arm may be the sum total of the mechanism or may be a part of a more complex robot. 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. The terminal of the kinematic chain of the manipulator is called the end effector and it is analogous to the human hand and they perform certain task according to the situations. The common task of the robotic end effector includes grasping, welding, detecting etc.

5. METHODOLOGY

This project presents the working of a robotic arm using voice control. The main aim of this project is that it can be very useful for paralyzed people or people with motor impairments. The appropriate words to be recognized are first trained by the user using the speech recognition module. The words are stored in numbers ranging from 1 to 9 which is displayed on the 7-segment display. During working, when the user says a particular trained word into the microphone of the speech recognition module, the words are recognized by it and the corresponding BCD of the number in which the word is stored is taken out as the output. The output of the speech recognition kit is sent to the Arduino microcontroller. According to the inputs received by the Arduino, appropriate signals are now sent to the motor driver to rotate the required motor in the specific direction. Pulse width modulation is used to set the required speed with which the motor has to rotate. Thus, each part of the robotic arm can be controlled by controlling the direction of that particular motor. The motor continues to rotate until the user says a second command or a stop command. When the stop command is said all the motors remain ideal. The solar panel is placed then energy is stored in the battery.

6. 2-D DIAGRAM

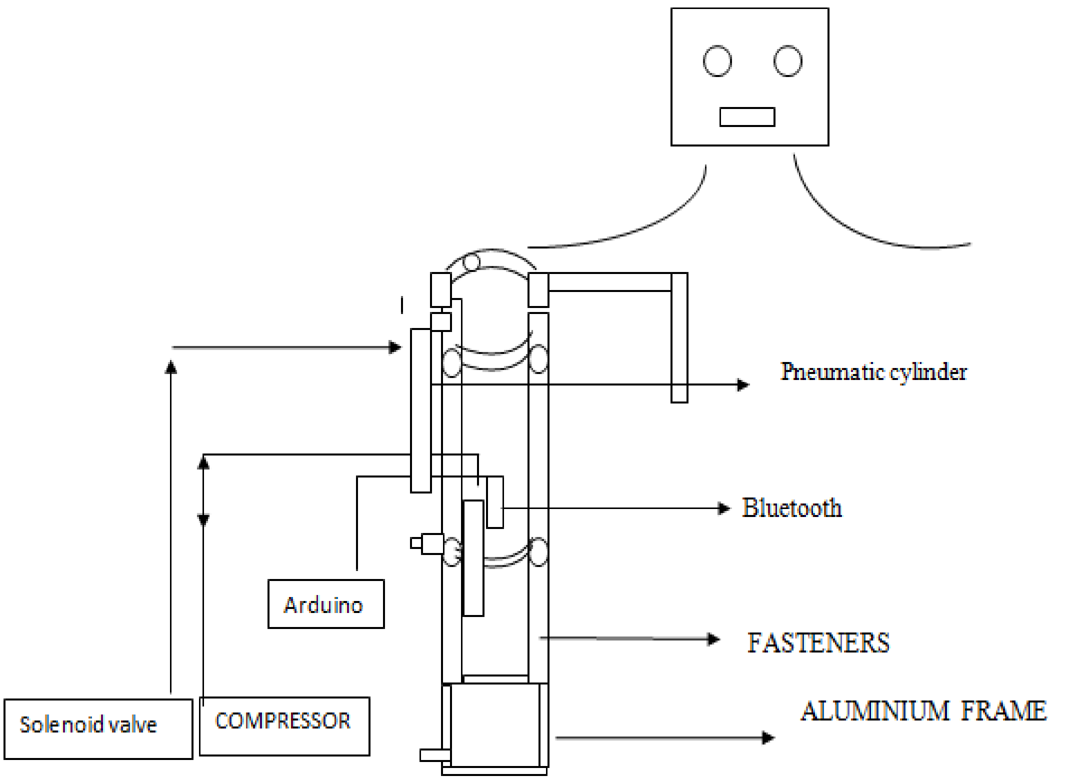

FIG-1: 2-D MODEL OF EXO-SKELETON ARM

7. BLOCK DIAGRAM

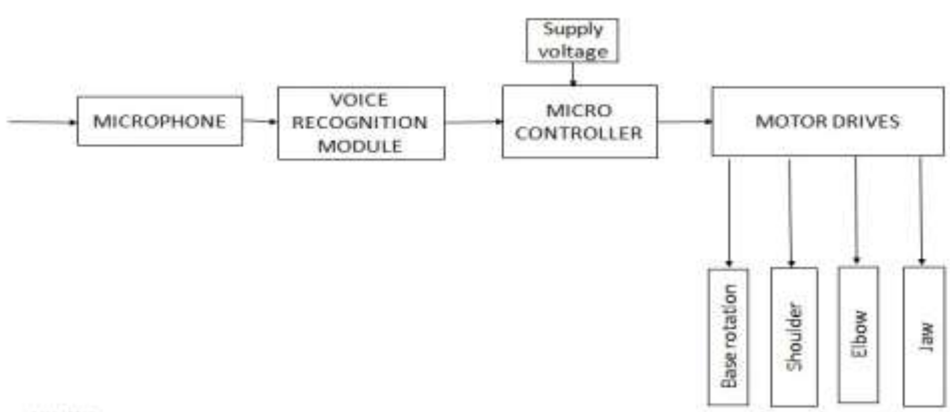

FIG-2: BLOCK DIAGRAM

The block diagram in figure 2 shows all the major components that is required for a voice controlled robotic arm using a microcontroller. The voice inputs are given through a microphone to the voice recognition module. The digital output corresponding to the voice command is provided to the microcontroller (it requires an external power supply of 6V). Microcontroller will generate the control signals to operate the four motors of the robotic arm. These signals are given to the motor drivers (to meet the additional power requirements of the motors). Motor drivers control the direction of rotation of the four motors.

8. COMPONENTS USED

- ALUMINIUM FLATS
- DC GEARED MOTOR
- 3 .BLUETOOTH MODULE
- AURDINO
- FASTENERS
- BATTERY
- SOLAR PANEL

9. TECHNICAL SPECIFICATIONS

- Microcontroller: ATmega328P
- Operating Voltage: 6v
- Input Voltage: 6-20v
- Digital I/O Pins: 14 (of which 6 provide PWM output)
- Analog Input Pins: 6
- DC Current per I/O Pin: 20 mA
- DC Current for 3.3V Pin: 50 mA
- Flash Memory: 32 KB of which 0.5 KB used by boot loader
- SRAM: 2 KB
- EEPROM: 1 KB
- Solar panel

10. DATA COLLECTING PRODUCER

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11. COMPONENTS

11.1. The DC Motor

The DC Motor or Direct Current Motor to give it its full title, is the most commonly used actuator for producing continuous movement and whose speed of rotation can easily be controlled, making them ideal for use in applications were speed control, servo type control, and/or positioning is required. A DC motor consists of two parts, a "Stator" which is the stationary part and a "Rotor" which is the rotating part. The result is that there are basically three types of DC Motor available.

FIG-3: DC MOTOR

11.2. ALUMINIUM

Aluminum or aluminum is a chemical element with symbol Al and atomic number 13. It is a silvery-white, soft, nonmagnetic, ductile metal in the boron group. By mass, aluminum makes up about 8% of the Earth's crust; it is the third most abundant element after oxygen and silicon and the most abundant metal in the crust, though it is less common in the mantle below. The chief ore of aluminum is bauxite. Aluminum metal is so chemically reactive that native specimens are rare and limited to extreme reducing environments. Instead, it is found combined in over 270 different minerals. Aluminum is remarkable for its low density and its ability to resist corrosion through the phenomenon of passivation. Aluminum and its alloys are vital to the aerospace industry and important in transportation and building industries, such as building facades and window frames. The oxides and sulfates are the most useful compounds of aluminum. Despite its prevalence in the environment, no known form of life uses aluminum salts metabolically, but aluminum is well tolerated by plants and animals. Because of these salts' abundance, the potential for a biological role for them is of continuing interest, and studies continue.

11.3. ARDUINO MICROCONTROLLER

The Arduino UNO is a widely used open-source microcontroller board based on the ATmega328P microcontroller and developed by Arduino.cc. The board is equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards (shields) and other circuits. The board features 14 Digital pins and 6 Analog pins. It is programmable with the Arduino IDE (Integrated Development Environment) via a type B USB cable. It can be powered by a USB cable or by an external 9 volt battery, though it accepts voltages between 7 and 20 volts. It is also similar to the Arduino Nano and Leonardo. The hardware reference design is distributed under a Creative Commons Attribution Share-Alike 2.5 license and is available on the Arduino website. Layout and production files for some versions of the hardware are also available. "Uno" means one in Italian and was chosen to mark the release of Arduino Software (IDE) 1.0. The Uno board and version 1.0 of Arduino Software (IDE) were the reference versions of Arduino, now evolved to newer releases. The Uno board is the first in a series of USB Arduino boards, and the reference model for the Arduino platform. The ATmega328 on the Arduino Uno comes preprogrammed with a boot loader that allows uploading new code to it without the use of an external hardware programmer. It communicates using the original STK500 protocol. The Uno also differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atmega16U2 (Atmega8U2 up to version R2) programmed as a USB-to-serial converter. The Arduino UNO is generally considered the most user-friendly and popular board, with boards being sold worldwide for less than 500 Rupees.

Fig-4: Arduino-Uno microcontroller

11.3.1. Special Pin Functions

Each of the 14 digital pins and 6 Analog pins on the Uno can be used as an input or output, using pin Mode(), digital Write(), and digital Read() functions. They operate at 5 volts. Each pin can provide or receive 20 mA as recommended operating condition and has an internal pull-up resistor (disconnected by default) of 20-50k ohm. A maximum of 40mA is the value that must not be exceeded on any I/O pin to avoid permanent damage to the microcontroller. The Uno has 6 analog inputs, labeled A0 through A5, each of which provide 10 bits of resolution (i.e. 1024 different values). By default they measure from ground to 5 volts, though is it possible to change the upper end of their range using the AREF pin and the analog Reference() function. In addition, some pins have specialized functions.

11.4. BATTERY

A rechargeable battery, storage battery, secondary cell, or accumulator is a type of electrical battery which can be charged, discharged into a load, and recharged many times, as opposed to a disposable or primary battery, which is supplied fully charged and discarded after use. It is composed of one or more electrochemical cells. The term "accumulator" is used as it accumulates and stores energy through a reversible electrochemical reaction. Rechargeable batteries are produced in many different shapes and sizes, ranging from button cells to megawatt systems connected to stabilize an electrical distribution network. Several different combinations of electrode materials and electrolytes are used, including lead–acid, nickel–cadmium (NiCd), nickel–metal hydride (NiMH), lithium-ion (Li-ion), and lithium-ion polymer(Li-ion polymer). Rechargeable batteries typically initially cost more than disposable batteries, but have a much lower total cost of ownership and environmental impact, as they can be recharged inexpensively many times before they need replacing. Some rechargeable battery types are available in the same sizes and voltages as disposable types, and can be used interchangeably with them.

FIG-5: BATTERY

11.4.1. APPLICATIONS

Devices which use rechargeable batteries include automobile starters, portable consumer devices, light vehicles (such as motorized wheelchairs, golf carts, electric bicycles, and electric forklifts), tools, uninterruptible power supplies, and battery storage power stations. Emerging applications in hybrid internal combustion-battery and electric vehicles drive the technology to reduce cost, weight, and size, and increase lifetime. Older rechargeable batteries self-discharge relatively rapidly, and require charging before first use; some newer low self-discharge NiMH batteries hold their charge for many months, and are typically sold factory-charged to about 70% of their rated capacity. Battery storage power stations use rechargeable batteries for load-leveling (storing electric energy at times of low demand for use during peak periods) and for renewable energy uses (such as storing power generated from photovoltaic arrays during the day to be used at night). Load-leveling reduces the maximum power which a plant must be able to generate, reducing capital cost and the need for peaking power plants. The US National Electrical Manufacturers Association estimated in 2006 that US demand for rechargeable batteries was growing twice as fast as demand for disposables. Small rechargeable batteries can power portable electronic devices, power tools, appliances, and so on. Heavy-duty batteries power electric vehicles, ranging from scooters to locomotives and ships. They are used in distributed electricity generation and in stand-alone power systems.

11.4.2. CHARGING AND DISCHARGING

During charging, the positive active material is oxidized, producing electrons, and the negative material is reduced, consuming electrons. These electrons constitute the current flow in the external circuit. The electrolyte may serve as a simple buffer for internal ion flow between the electrodes, as in lithium-ion and nickel-cadmium cells, or it may be an active participant in the electrochemical reaction, as in lead–acid cells. The energy used to charge rechargeable batteries usually comes from a battery charger using AC mains electricity, although some are equipped to use a vehicle's 12-volt DC power outlet. The voltage of the source must be higher than that of the battery to force current to flow into it, but not too much higher or the battery may be damaged. Chargers take from a few minutes to several hours to charge a battery. Slow "dumb" chargers without voltage or temperature-sensing capabilities will charge at a low rate, typically taking 14 hours or more to reach a full charge.

11.5. Solar panel

FIG-6: SOLAR PANNEL

Solar energy recovery has begun to take its place all over the world on the energy market due to the pureness of its electricity production. Commercial use of solar energy is unfortunately still rather small, mostly due to high prices and low efficiency compared to other sources. This report presents a literary review of the developing process of solar panels. A key part in any products prosperity lies in the product development process, the way from a products idea to final product. In the making of solar panels knowledge in areas of engineering, materials, structures, design, electronics, economy, marketing and much more are needed; making the process expensive. A lot of research is put on the solar cells material to try to increase their efficiency but very little effort is put down to the product development process of the panels and improvement of these processes. Information to this report was gathered in published books as well as on Internet webpages, governmental as well as homepages of manufacturers. A survey was made to gather information directly from producers in an attempt to increase the information input and accuracy. One company answered these questions and the result of the survey therefore concluded in a case-study in their company alone.

12. DETAILED ASSEMBLY AND MANUFACTURING

The concept of DFM (Design for Manufacture) is not new, it dates back as early as 1788 when LeBlanc, a Frenchman, devised the concept of inter-changeable parts in the manufacture of muskets which previously were individually handmade. DFM is the practice of designing products keeping manufacturing in mind. "Design for manufacture" means the design for ease of manufacture for the collection of parts that will form the product after assembly. Similarly DFA is called Design for Assembly. DFA is the practice of designing product with assembly in mind. "Design for assembly" means the design of the product for ease of assembly

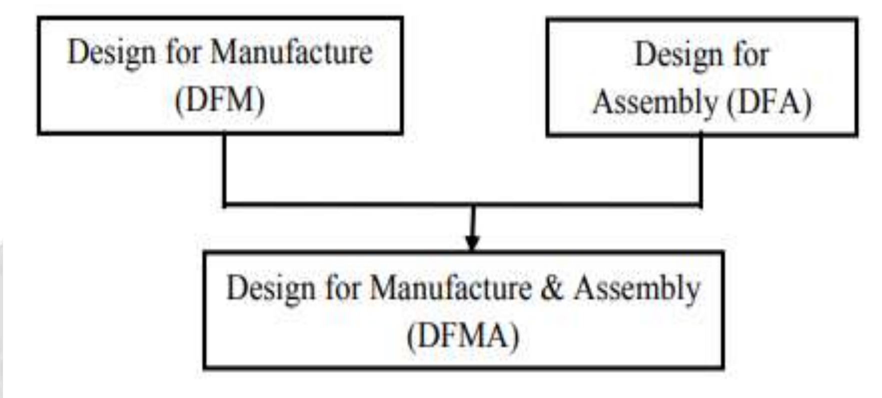

FIG-7: BLOCK DIAGRAM FORMASSEMBLY

History of DFMA 1.Eli Whitney is an inventor from America used some DFM techniques in earlier times before the term DFM came in to existence. Whitney incorporated the concept of interchangeable parts for manufacturing musket for U.S. government. Prior to this innovation, each craftsman was responsible to manufacture the complete product by using saw and files to shape each part and fit them together. 2. Henry Ford an American industrialist was renowned for his advanced and extensive use of assembly lines. The manual assembly operation was broken down into small chunks of repetitive work that could be carried out at high efficiency. Ford in his book "My Life and Work" described about the successful model T car that includes simplicity in operation, absolute reliability and high quality in materials that used in that model. The concept used at that time by Ford is now referred as DFM. 3. General Electric used value analysis techniques in the late 1940s. With the help of value analysis techniques, it is possible to find the cost of a product and obtaining the design alternatives for the product at the lowest cost. The philosophical approach of value analysis is through questioning and comparing the value and cost of each features and each element of a product design 4. The book "Metal Engineering Processes" edited by Roger W. Boltz is one of the books from a series of handbook published by ASME in 1941. This book provides a series of guidelines to designer in enhancing the manufacturability of metal components made with a number of manufacturing processes such as casting, forging, extrusion, machining, joining, finishing etc. Though Boltz used the word DFM, he is the first person arrange and plan DFM methodology. 5. In the year 1960, people started to use the terms product ability and manufacturability and about 1985, design for manufacturability and its short form DFM were widely used. 6. Geoffrey Boothroyd and A.H. Redford studied automatic assembly and provided various design guidelines to make the assembly process easier. 7. In the recent years various trade association and vendors of parts are issuing booklets to the product designers providing a series of guidelines and tolerance and materials recommendations for parts. These kinds of publications have provided valuable and authorities assistance to product designers.

Steps for applying DFMA during product the design following steps are followed when DFMA used in the design process. DFA analysis lading to simplification of the product structure early cost estimation of parts for both original design and modified design Selecting best material and process to be used.

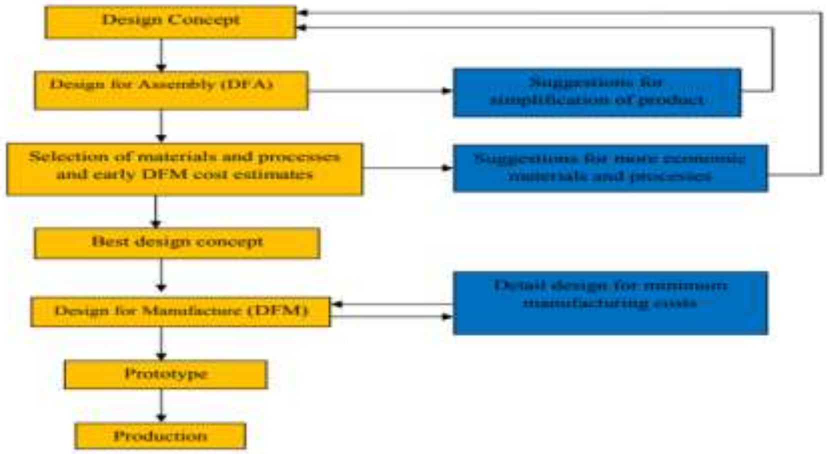

FIG-7: STEPS FOR APPLYING DMFA

13. RESULTS

The main distinction between the design described in this paper and the existing ones is that a power assist type exoskeleton has been selected rather than a more expensive power amplification device. The cost required to design and manufacture such a device was reduced. But the main difference is apparent through the selection and control of McKibben air muscles as the main power actuator. Some implementations, which use hydraulic actuators, need internal combustion engines to compress the non-compliant fluid. This implementation uses a limited supply of pressurized, compliant gas, which reduces the power consumption by a considerable amount. Another major difference is the use of McKibben air muscles provides with a higher power-to-weight ratio than an exoskeleton using DC motors. Finally, the implementation of a combination of flex and EMG sensors, allows monitoring of the signals sent to the muscles, and potentially reduces the effort required to activate the sensors. Carrying heavy objects with robotic limb is already being used in Asia, Europe and North America. Heavy companies and factories in the world already use robotic limb carrying heavy objects with many major cities in the United States like Washington D.C., Chicago, Boston and San Francisco also implementing or planning to implement this technique. Industrial injury or physical disability due to sickness is very common now days. Physical treatment or taking any form of medicines cannot guarantee fully recovery. Robotic exoskeletons can provide them a certain strength which will help them to lead a normal life.

14. CONCLUSION

In this project, a systematic approach to design and implement Voice Activated Robotic Arm is described. The 2 DOF robot arm is fabricated using the above mentioned components and the design is done on the computer software CATIA. The system was trained for 5 voice commands (Pick, Place, Rotate, Up, Down). According to these voice commands the movement of arm takes place. The commands were differentiable so that any kind of overlapping between the commands would not create the confusion to microcontroller, and finally the robotic arm should be capable for performing the commands as per the voice.

15. SCOPE FOR THE FUTURE WORK

It can be seen from the survey that most of the advanced work in this field has been done in recent decades and many of the outcomes have been demonstrated in wired environments. Because not all of the technical components are well developed enough or packaged for use in daily life and in outdoors applications, a combined amount of cooperative work and use of resources from medical technology, biomechanics, engineering, and product development are required. Power source technologies and reliable wireless technologies so that it is comfortable for outdoor chores must be resolved. Ensuring the portability of the pneumatic hand exoskeleton system is possibly the most challenging part of the development. In the review, it is found that the focus is on a single DOF at a single joint while a look at the system design of whole upper extremity and even carry out a whole body suit exoskeleton is needed. No matter how many DOFs are included in the exoskeleton, the exoskeleton is benefiting the human. Further review is needed on exoskeleton control system so that it might help to understand more about the exoskeleton.

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