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Conceptual Design of EMG Based Upper Limb Power Assist Rehabilitation Device

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ABSTRACT

Recently, power assist devices have been designed and developed to assist self-rehabilitation and daily life motions of physically weak persons. Several kinds of control methods have been proposed to control the power-assist robots according to user's motion intention. In this article, a conceptual design of electromyogram (EMG) based upper limb power assist device is proposed for elbow movements of patients who have difficulty moving their arm, but their muscle signals are still functioning. The proposed device is simple, humanlike, and adaptable to any user. The topic was academically reviewed to consider the similar devices and develop a new design. Following the conceptual design scheme, the specification and requirement list of the device was prepared. According to these specification, few possible design solutions were considered and evaluated to choose the best one. The chosen design was detailly developed and design using a CAD model. The device is designed as 1 degree of freedom (DOF) with two basic dimensions: flexion and extension.

Keywords: conceptual, design, rehabilitation, upper limb, EMG.

1 Introduction

In many countries, the increase in the aged population and the decrease in the working proportion are serious problems. To assist self-rehabilitation and daily life motions of physically weak persons such as elderly, disabled, or injured persons, many kinds of power-assist devices have been developed [1]. Since the last decade though, the assist robots are getting closer to humans, and this issue introduced thus the need for such devices which aim to help the humanity.

Recently, many researches in the field of rehabilitation robot has been demonstrated. The aim of these researches is to find the best and appropriate design that help the human to perform their desired motions. Rehabilitation of upper and lower limb technologies grows quickly due to the increase of the aged population. In upper limb rehabilitation system, robot-assisted training seems to improve arm function for daily life activities. these activities are the upper and lower limbs motion which each human demand on them. The types of medical devices can be classified based on their characteristic in some groups,

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active or passive, end effector or exoskeleton [2-7]. Upper limb rehabilitation devices perform the specified motion to the human upper limbs which include shoulder, elbow, arm, and hand.

This article proposes a conceptional design for a human upper limb rehabilitation for elbow movements of patients who have difficulty moving their arm, but their muscle signals are still functioning. The research has been done based on academic and patent research related to the topic. The proposed device is simple, easy to design, humanlike, and adaptable to be used in a home or rehabilitation centers. The proposed device is 1 DOF (2 dimension) and its control based on gathered electromyogram (EMG) signal collected from the human muscles. The proposed method is applicable to be used in any place with assist of one person. The following part of the article demonstrate academic research and then the conceptional design of the upper limb rehabilitation device is presented.

Existing works

S. H. Lee, G. Park, D. Y. Cho, H. Y. Kim, J. Y. Lee, S. Kim, & J. H. Shin [8] proposed an end effector Upper Limb Rehabilitation Robot for Hemiplegic Patients with Line and Circle Tracking Training. The work investigated the kinematics and dynamics of the robot system, the control system, and the realization of different rehabilitation therapies. They explored the influence of constraint in rehabilitation therapies on interaction force and muscle activation.

L. Zhang, S. Guo, & Q. Sun [9] Developed Assist-As-Needed Control of an End-Effector Upper Limb Rehabilitation Robot. Their controller Assists as Needed (AAN controller) is a strategy that helps the patient’s arm to stay close to the given trajectory while allowing for spatial freedom. This controller enables the patient’s arm to have spatial freedom by constructing a virtual channel around the predetermined training trajectory. Patients could move their arm freely in the allowed virtual channel during rehabilitation training while the robot aids when deviating from the virtual channel.

Y. Liu, C. Li, L. Ji, S. Bi, X. Zhang, J. Huo, & R. [10] proposed an anthropomorphic rehabilitation robot based on the basic movement patterns of the upper limb, point-to-point reaching and circle drawing movement. Their research analyses patients’ movement characteristics in aspects of movement range, movement accuracy, and movement smoothness and the output force characteristics by involving 8 patients.

M. Eslami, A. Mokhtarian, M. Pirmoradian, A. Seifzadeh, & M. Rafiaei [11] designed and fabricated a balanced passive robotic arm with the capability of applying variable mass to the end-effector in order to upper limb rehabilitation. To achieve this purpose, the first step is associated with establishing a robot structural design in the CAD environment. The next step is focused on developing the kinematic model based on the degrees of freedom and joint range of motion of the lower legs. This situation provides an equivalent force equal to the weight of selected mass from the end-effector to the user’s hand.

F. Scotto di Luzio, D. Simonetti, F. Cordella, S. Miccinilli, S. Sterzi, F. Draicchio, L. Zollo [12] proposed a novel 3D bio-cooperative robotic platform is developed. A new arm-weight support system is included into an operational robotic platform for 3D upper limb robot-aided rehabilitation. The level of arm-weight support and the level of the assistance provided by the end-effector robot are varied on the basis of muscular fatigue and biomechanical indicators.

J. C. Fraile, J. Perez-Turiel, E. Baeyens, P. Vinas, R. Alonso, A. Cuadrado & F. Nieto [13] Presents end-effector rehabilitation robot, a 2-degree-of-freedom planar robotic platform for upper limb rehabilitation in patients with neuromotor disability after a stroke. They describe the ergonomic mechanical design, the system control architecture, and the rehabilitation therapies that can be performed. The impedance-based haptic controller implemented in end-effector rehabilitation robot uses the information provided by a JR3 force sensor to achieve an efficient and friendly patient–robot interaction.

S. H. Chen, W. M. Lien, W.W. Wang, G. D. Lee, L. C. Hsu, K. W. Lee, & J. J. Luh [14] presented an assistive control system with a special kinematic structure of an upper limb rehabilitation robot embedded with force/torque sensors. A dynamic human model integrated with sensing torque was used to simulate human interaction under three rehabilitation modes: active mode, assistive mode, and passive mode. The hereby proposed rehabilitation robot, called NTUH-ARM, provides 7 degree-of- freedom (DOF) motion and runs subject to an inherent mapping between the 7 DOFs of the robot arm and the 4 DOFs of the human arm.

X. Liu, G. Zuo, J. Zhang & J. Wang [15] proposed a sensor less force estimation of end-effect upper limb rehabilitation robot system with friction compensation. This study estimated the interactive forces that indirectly detect the human motion intent. To detect the human–robot interaction force, they subtract the friction force from disturbance observer estimation result. Several experiments were performed to test the performances of the proposed methods. Those methods were applied in an end-effect upper limb rehabilitation robot system. The results show that the precision of the estimated sensor force can increase 5% than the force sensor.

S. Cai, W. Wu, & L. Xie [16] proposed a Dual-Arm Rehabilitation Robo, it was an end-effector system with collaborative manipulators assisting the upper and lower arms of a stroke patient respectively. Each manipulator of the DARR, with three active degrees of freedom (DOF) for positioning and three passive DOF for orientation, can provide rehabilitation training to the affected arm in a three-dimensional workspace and permit stroke patients to freely orient their hand as needed to grasp an object. The DARR prototype was built and conducted experiments to validate its feasibility and effectiveness, including mechanical structure and control system.

H. Guang, L. Ji, Y. Shi, & B. J. Misgeld [17] proposed a Parallel Upper-Limb Rehabilitation Robot Using Impedance Control for Patients after Stroke. To achieve the assist-as-needed impedance control for arbitrary trajectories, the strategy based on orthogonal deviations was proposed. Simulations and experiments were performed to validate the dynamic modelling and impedance control. The results showed that the impedance and resistance affected both mean absolute error and standard deviation of movements and also demonstrated the significant differences between movements with/without impedance and resistance.

Y. Huang, Y. Chen, J. Niu & R. Song [18] proposed EMG-Based Control for Three-Dimensional Upper Limb Movement Assistance Using a Cable-Based Upper Limb Rehabilitation Robot. A natural integration between human and machine is proposed by using the surface electromyography (EMG) signals from six muscles which mainly contribute to the upper limb movement. Results show that the forces from the model were real-time continuously estimated and accurate. Results showed that the robot using the state space model could provide physiologically appreciate assistance to the subject, and the robot could conduct the rehabilitation training combined with the voluntary residual motor efforts.

X. F. Zhang, X. Li, J. T. Dai, G. X. Pan, N. Zhang, H. Q. Fu, & Y. Inoue [19] designed a hemiplegic upper limb rehabilitation training system, which allowed both single degree of freedom and composite degrees of freedom for the training of shoulder and elbow. The system contained an upper limb rehabilitation robot, a pattern recognition system and a motion control system. The experiments showed that the convergence speed of the network and the recognition rate of the target action were effectively improved, which demonstrated the effectiveness of the training system.

R. Ramon & O. Bai [20] developed a methodology to be used to correlate joint angles with EMG signals for a planar model used in a developing neurological rehabilitation robot based on a Denso HS-4555 Selective Compliance Articulated Robot Arm (SCARA).

J. A. Díez, J. M.Catalán, L. D. Lledo, F. J. Badesa, & N. Garcia-Aracil [21] investigated the use of a multimodal robotic system for upper-limb neurorehabilitation therapies in physical environments, interacting with real objects. This system consists of an end-effector upper-limb rehabilitation robot, a hand exoskeleton, a gaze tracking system, an object tracking system, and electromyographic measuring units. For this purpose, the system architecture is stated, explaining the detailed functions of each subsystem as well as the interaction among them.

C. Wang, L. Peng, Z. G. Hou, L. Luo, S. Chen, & W. Wang [22] introduced a novel upper-limb rehabilitation robot and proposes a EMG-driven torque estimation model based on artificial neural networks (ANN). The robot has three DOFs, of which the first two DOFs adopt a planar parallel structure, and the wrist module has an exoskeleton form.

A. Thacham Poyil, V. Steuber & F. Amirabdollahian [23] proposed Adaptive robot mediated upper limb training using electromyogram-based muscle fatigue indicators. The electromyogram data was collected from three gross-muscles of the upper limb in 30 healthy participants. The experiment followed a protocol for increasing the muscle strength by progressive strength training, that was an implementation of a known method in sports science for muscle training, in a new domain of robotic adaptation in muscle training.

M. Mashayekhi, & M. M. Moghaddam [24] proposed a EMG- blased Fatigue Adaptation in Admittance Control of Hand Rehabilitation. Using electromyography (EMG) signals to make better communication with rehabilitation robots has been long established. A modifying controller, according to these signals ensures a proper and safe exercise for the operator. An admittance controller with an adapting strategy utilizing a machine learning algorithm on a 2 DOF robot was presented.

J. Guo, S. Yu, Y. Li, T. H. Huang, J. Wang, B. Lynn & H. Su [25] investigated a soft robotic exo-sheath using fabric EMG sensing for hand rehabilitation and assistance. They presented the design and evaluation of a soft hand exo-sheath integrated with a soft fabric electromyography (EMG) sensor for rehabilitation and activities of daily living (ADL) assistance of stroke and spinal cord injury (SCI) patients. This wearable robot addresses the limitations of the soft robot gloves with design considerations in terms of ergonomics and clinical practice.

2 Research Methodology

This research has been demonstrated based on the conceptual design scheme. The conceptual design offers useful tools in the product development process [26]. These parts are the definition of the design and the aim. Then the requirement list was given, and it is followed by the function structure. Few possible designs were suggested and one of them were detailly developed.

2.1 Conceptual design of EMG based upper Limb 2D power assist rehabilitation device

The conceptual design aims to identify the design solution that satisfies the necessary functions in a deep manner [27]. Conceptual design is an early phase of the design process, in which the broad outlines of function and form of something are articulated. It includes the design of interactions, experiences, processes, and strategies. The conceptual design has few parts, and it begins with the design specification, and the features that the device should found. These specifications are listed in Table 1.

The aim of the device is to make rehabilitation for the human elbow's parts with easy usage in home and rehabilitation centres. The device is supposed to be suitable for different people's dimensions. It is 1 DOF, two dimension and it can be used in home with confident and low cost.

2.1.1 Function structure

In the design process, the concept of function can be defined as the relationship between the inputs and outputs of the system to be designed [27]. The overall function of a system can be defined by reducing the specification requirements to general statements. In a sizable or complex design problem, the division of the overall function into subfunctions makes the solution-seeking process more straightforward [26].

This device has two main inputs; electromyography (EMG) signals and electricity and one main output; movement of robot arm by the meaning of actuators motion. The general functions between the inputs and outputs are processed in the controller unit. Electric power (E) is converted into mechanical energy (E') by means of the actuators. The material input (M) is the patient, and the material output (M') is the rehabilitated person arm. The signal input (S) represents the operation of the system by means of the control unit, and signal output (S') represents the movement of the actuators. Figure 1 illustrates the function structure. Here, the axis lines represent the boundaries of the system with all inputs and outputs.

Table 1: *Requirement list where D stands for Demands and W for Wishes*

Design Specifications	D/W
1. Geometry	
Appropriate dimensions for home. Appropriate structure for easy design. Easy mechanism for all users.	D W D
2. Kinematics and forces	
The robot is 1 DOF. 2 dimensions motion. Perform flexion and extension movements for the human's elbow.	D D D
3. Energy	
Electricity input. Home electricity source.	D
4. Materials	
Ordinary materials used for medical devices Operating at room temperature Durability and recycling	D D W
5. Safety	
The device must be safe and suitable.	D
6. Control and operations	
Easy touch screen control panel. Easy programming language. Upper limb motion control.	D W D

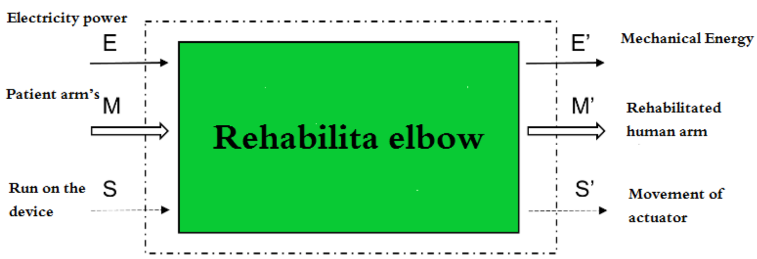

Figure 1: Overall function of the device

The details of the system design can be represented by the subfunctions. This is shown in figure 2.

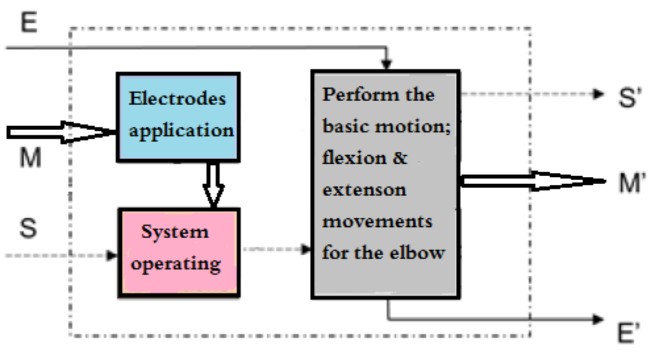

Figure 2: Subfunction of the device

The main subfunction of the device are electrodes application over the muscle, operating and processing inputs and output by controller, preforming flexion, and extension motion for the arm by the robot arm. The electrodes collect the muscle signals and send it to EMG sensor, then the controller process these signals and decide the direction of motor motion. As a result, the robot arm movements direction is specified and applied, and the rehabilitation process is satisfied on the patients.

2.1.3 Possible solutions for functions

If we consider the main requirement of design again, we notice that the device is required to have electricity source since this is the best choice to have power comparing to other sources, hydraulic and pneumatic etc...

The possible design solutions are summarized here for this medical device. As mentioned before, the aim of this robot is to make a rehabilitation for the human upper limb. This includes the elbow with biceps and triceps. Since the muscle signals are gathered by the electrodes and processed in the EMG as main input of the system, there must be an output that process the motion of robot arm. This output is represented by the transferring of mechanical energy from the motor to the robot arm.

There are different possible design choices to transfer motion from the motor to the robot arm. These possible choices for motion transferring can be achieved using of gears, chains, or belts. This section draws the definition of these choices and the following section evaluate these choices to consider the highest evaluated one.

The first choice is to use gears. Gears are a type of circular mechanical device with teeth that mesh to transmit rotation across axes, and they are a very valuable mechanism to know about as their applications range far and wide. Gears need the shafts to be totally fixed in position, offer by far the highest torque capacity.

The second choice is to use chains. A chain drive is a mechanically operating system. Chains are run over a wheel named sprocket which has several amounts of teeth around the circumference of that to grip the chain. They most used to drive camshafts in automotive and truck applications.

The third choice is to use belt. A belt is a loop of flexible material used to link two or more rotating shafts mechanically, most often parallel. Belts may be used as a source of motion, to transmit power efficiently or to track relative movement. Belts are looped over pulleys and may have a twist between the pulleys, and the shafts need not be parallel.

The processing steps of our device is summarized in Figure 3. One should notice the main aspects (inputs and outputs) of the device. These aspects are collecting the muscle signals and the motion of robot arm.

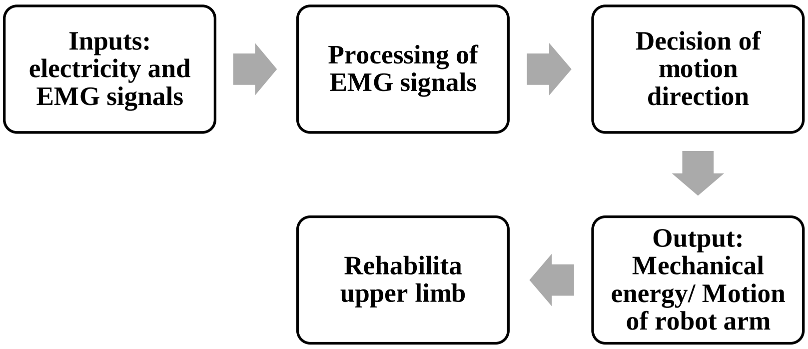

Figure 3: Main processing steps of the device

As discussed early in this section. There are three possible solution for the functioning of the system. These are using of gears, chains, or belts. The following part summarized the main aspects for using these possible different technics for motion transfer.

Design solution 1: the motion of robot arm can be achieved using of gears. This can be designed in the following scheme: the motor can be set on the highest point in the robot structure in vertical way, with two shaft one connected with motor and the first gear at its end. The second gear meshed with it in and another constant shaft can be used to hold the second gear. This gear is connected to the robot arm. By this way, the motion of motor is transferred to the robot arm. The robot arm is designed to perform two basic motions: flexion and extension movements for the human's elbow by moving up and down. DS1 is shown in Figure 4.

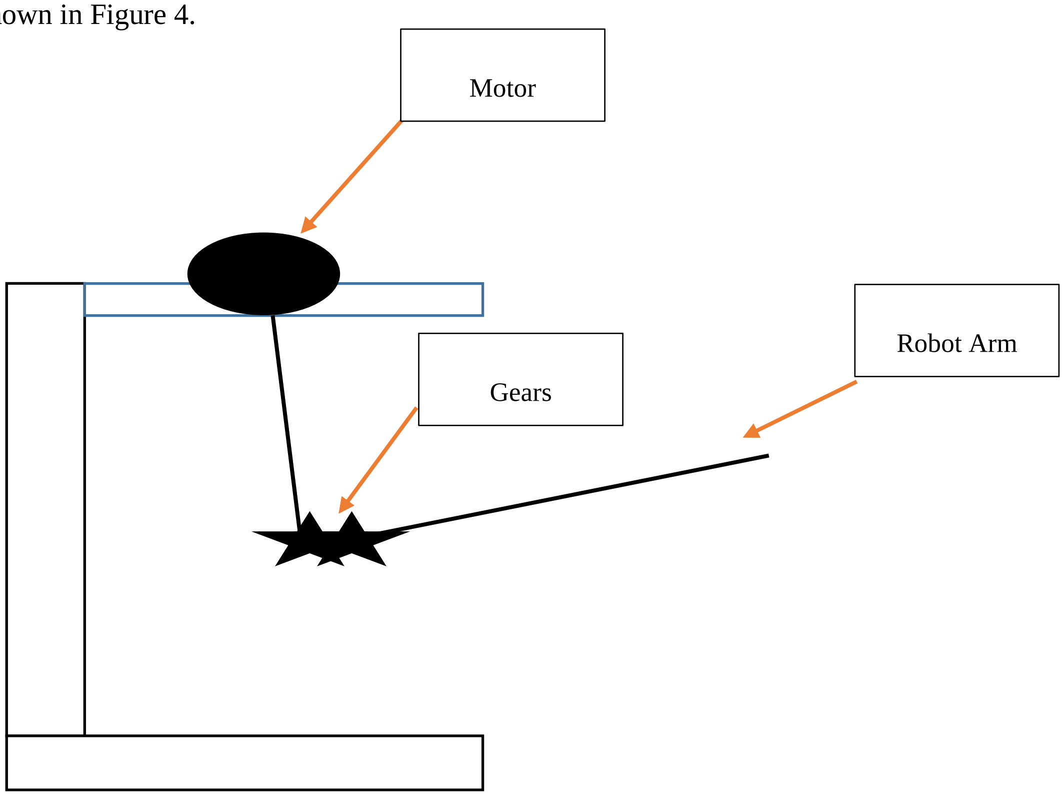

Figure 4: DS1 schematic

Design solution 2: the motion of robot arm can be achieved using of chains for transferring the motion of motor. This can be in the following scheme: the motor is again at the top of robot structure in a horizontal way. The sprocket of the first side of the chain is connected at the motor shaft. The robot arm will be connected to the second sprocket directly. The chain transfers the motion from the motor to the robot arm. By this way, the robot arm performs two basic motions flexion and extension movements for the human's elbow by moving up and down. DS2 is shown in Figure 5.

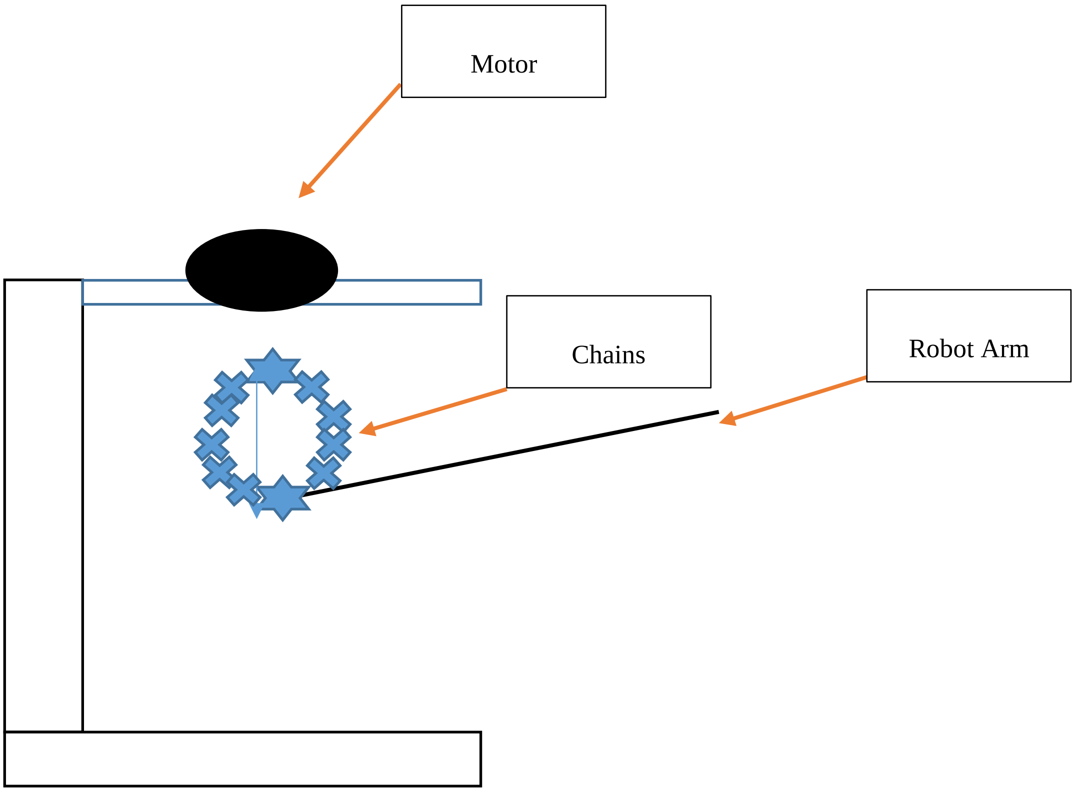

Figure 5: DS2 schematic

Design solution 3: the motion of robot arm can be achieved using of belts and pullies for transferring the motion of motor. In a two-pulley system, the belt can either drive the pulleys normally in one direction. As a source of motion, a conveyor belt is one application where the belt is adapted to carry a load continuously between two points. The first pully will be connected to the motor motion and the second pully will be connected to the robot arm. As a result of belt motion, the robot arm will transfer the load. This will satisfy the two basic direction movement for the robot arm. By this way, the robot arm performs two basic motions: flexion and extension movements for the human's elbow by moving up and down. DS3 is shown in Figure 6.

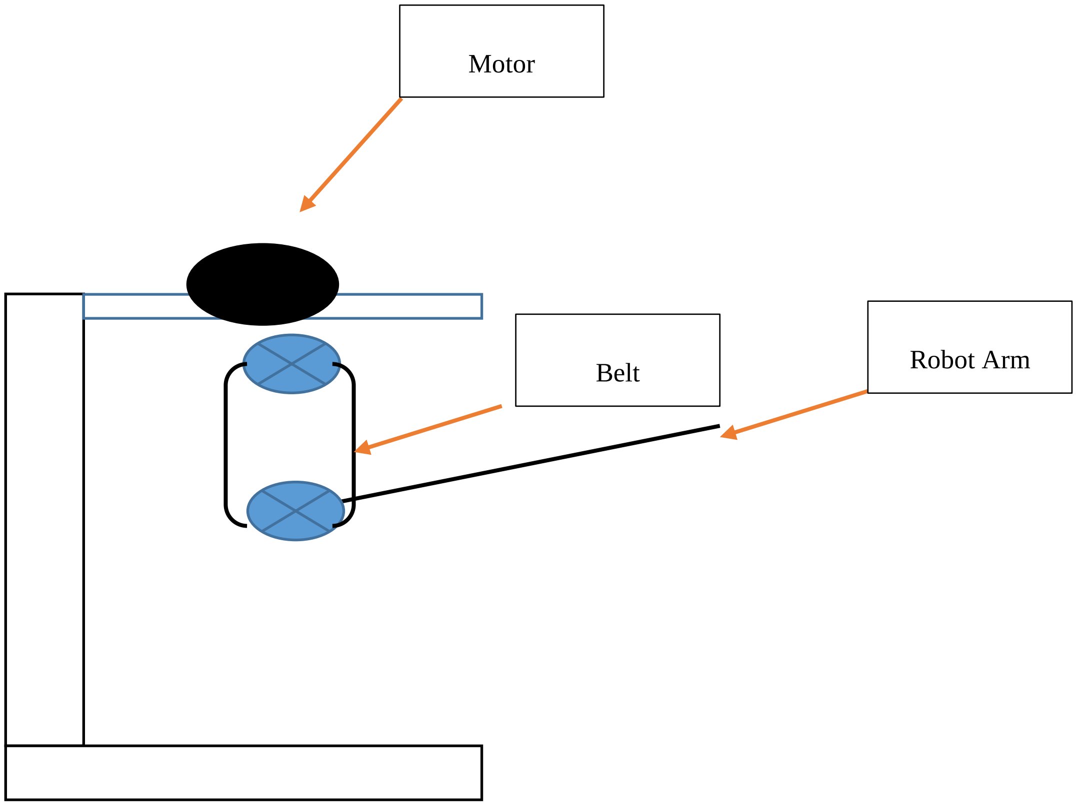

Figure 6: DS3 schematic

2.1.4 Evaluating design solutions

The different design solutions seem to be functional; however, an evaluation must be made to choose the best one between them. An evaluation criterion was established with considering the requirements given in the design specifications. This may include simplicity, reliability, and suitability. These basic criteria are explained as follow.

Simplicity: This criterion is related to the number of components of the device, the degree of freedom, the installation, and the control processes. A device with high simplicity must be composed of a limited number of parts, have a minimum degree of freedom, and require easy installation and control processes.

Reliability: This criterion is related to the safeness of the device. The device must work in high safety way. The upper limb rehabilitation robot is collecting the signals of muscle and make the desired motion using the robot arm, this indicate that the system her must perform its tasks with appropriate design and safe connection between the patient and the robot. A system with high device safety would be expected to be durable and not subject to failures.

Suitability: This criterion is related to the extent to which the device can be used with help of at most one person. This person ' s task will be for the application of electrodes on the appropriate palace on the muscles. The device then operates automatically and preform its' task.

The objective tree is shown in Figure 7.

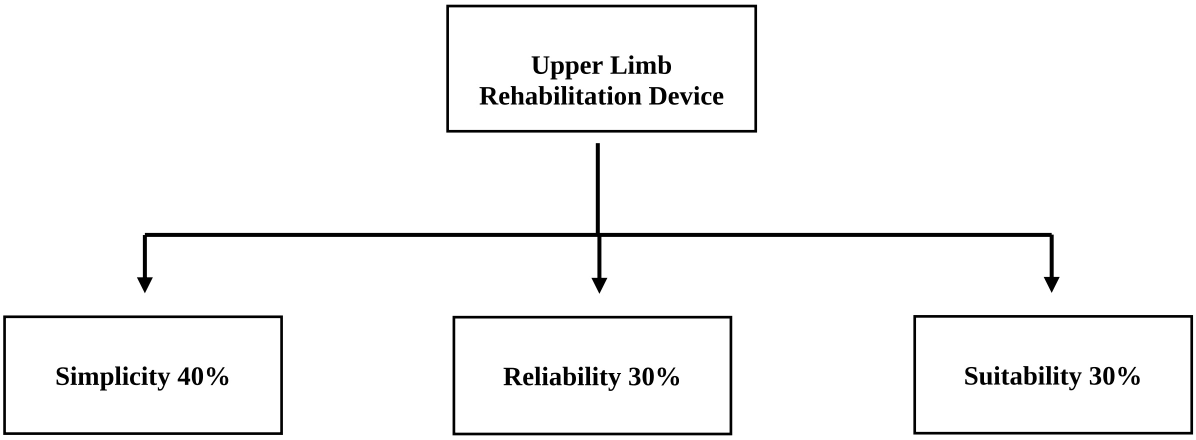

Figure 7: The objective Tree

The three previous mentioned criteria were weighted based on their importance for the development of the robot. Simplicity is the highest criteria with 40% weight. 30% weight is assigned for the each of reliability and suitability.

The evaluation of each design is made based on each of the following value ranges between [0,4].

- Unsatisfactory solution 0
- Acceptable solution 1
- Satisfactory solution 2
- Good solution 3
- Very good solution 4

Table 2 illustrates the evaluation of the three different design solutions (DSs).

Table 2: *Evaluation table.*

Criteria		**DS1**		**DS2**		**DS3**	
	Weight	**Value**	**W**	**Value**	**W**	**Value**	**W**
Simplicity	0,4	3	1,2	2	0,8	2	,8
Reliability	0,3	2	0,6	1	0,3	2	,6
Suitability	0,3	3	0,9	3	0,9	3	,9
	Σ=1		Σ=2,7		Σ=2		Σ=2,3

The last table shows the result for evaluating the desired designs. The criterion weights (w) of the designs were calculated by multiplying the percentage weight set in the tree of goals by the value analysis score. To find the total weight value for each design, the calculated weights for each criterion were added to sum up Σ for each design. It is clear from the table that the highest evaluated design is DS1. Reliability is still low for the desired designs and some careful notice should be applied during the processing time of the device.

2.2 Detailed design of DS1

This section deals with the detailed design of the end effector device. The three possible desired solutions were discussed and evaluated in the last section and the first desired design was evaluated as the highest between them. The DS1 shall be called as variant from now on. The variant design of the device demands basically on the meshed gears to transfer motion from the source to the robot arm. Using a CAD program, the DS1 was developed. The variant design is shown in Figure 8, Figure 9, Figure 10, and Figure 11 as follow.

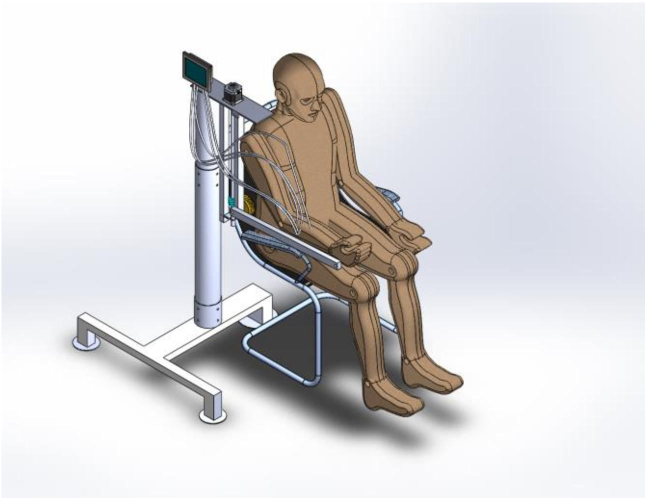

Figure 8: CAD model of DS1 (left view)

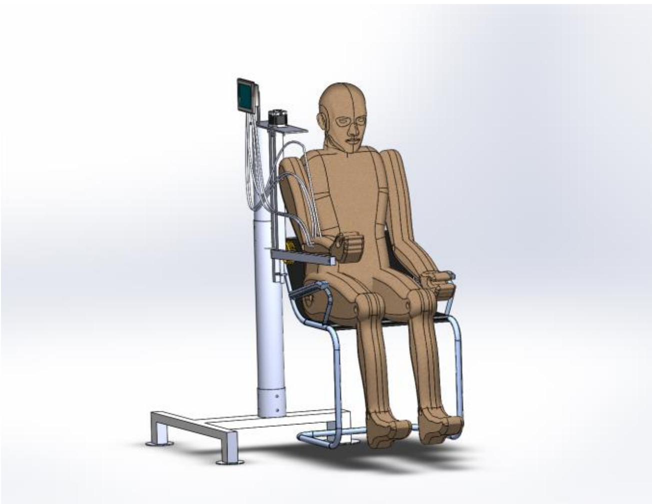

Figure 9: CAD model of DS1 (front view)

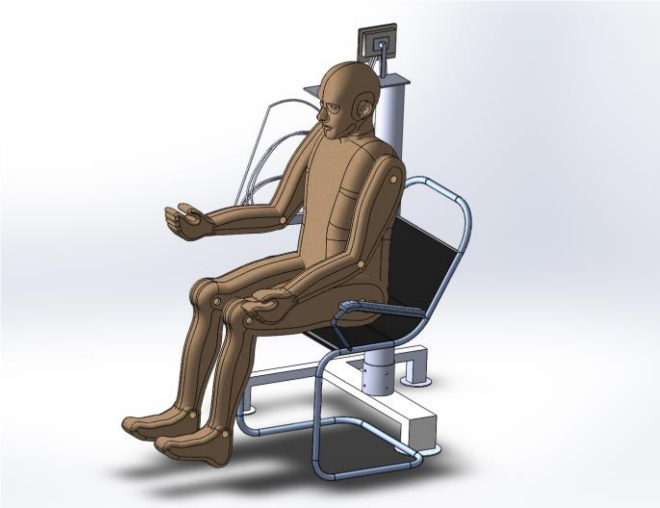

Figure 10: CAD model of DS1 (right view)

Figure 11: CAD model of DS1 (back view)

According to the previous studies, there are two options for the structure; these are stationary and portable. The upper-limb rehabilitation robot is stationary whereby the patient is sitting on a chair while being treated despite being mobile due to advice considered from the therapists, the mobile mechanism is going to push more effort on the other muscles of the shoulder and the back. The aim here is to make the rehabilitation process as comfortable as possible for the patient.

The motion transfer from the motor to the robot arm is satisfied by the meshed gears. The first shaft is desired to move with the rotation of the motor and second shaft holds and powers the second shaft which is moving up and down. This movement makes the two-basic motion from the elbow, flexion, and extension. The mechanism of the robot was designed to be adjustable with all the patients. Once the device is stepped, then it can be used for rehabilitation process.

The motor shaft will be connected a long shaft and the long shaft will be fix the robot body. The motor will give motion to long shaft and worm gear (on the long shaft) will be started rotation, along with that, helical gear will be rotated, and power transmission can be formed (90 degrees). These are the general constructor of the rehabilitation robot system.

If we touch the desired control way, a strategy based on EMG is planned for the rehabilitation robot. EMG signals record electrical activity of muscles. They measure the electric currents produced in muscles during their contraction. EMG feedback signals will provide repeated motor practice for individuals unable to perform these movements enough independently or repeatedly, which should facilitate a change in the neuro-motor system and improve strength or control. There has motion intention with estimated based on the EMG signals on real time, then robot can perform. Thus, patients who have difficulty moving the arm but neurons that signal to their muscles are still functioning will be able to get the support needed for the movement of the elbow.

Usually, the output of the system is usually defined by the input. The output is the main achievement of the system. However, the EMG signal is a raw signal and need to be processed through several plants to get the desired output. EMG is a type of the bio signals which contain allot of noise from various sources and factors. This noise might be coming from the skin, electrode location and environment in which the data is being collected, there are various types of electrodes depending on the muscle size and the purpose of use in our case we are using the EMG electrode which stands for surface electromyography.

The noise from the electrodes can be reduced by choosing gelled type electrodes by which the noise from the skin is reduced and this gel is a compound of silver-silver chloride (Ag-AgCl) as this compound is reduces the noise during the measurement [28]. However, all the noise parameters should be reduced for a better measurement such as control of environment, electrode placement and circuitry acquisition and configuration [29] [30]. For the features extraction from the EMG signal there are various ways such as frequency domain, time frequency domain and time scale domain. These types are chosen based on the purpose of analysis of the EMG signal. For the time domain, the pre-processing of EMG signals may include DC offset removing, rectification of EMG and filtering the EMG signals. For the time domain there are some features that can be applied. Some of the features that can be extracted from the time domain are Root Mean Square (RMS), Mean Absolute Value (MAV), Standard deviation (STD).

The Acquisition of the EMG signal can be handled by surface EMG. The technique that is assumed to be used in the project. It has some cone and prone, the good news for this method is that it is easy to use no discomfort for the patient like the needle EMG type and beside that it has no electrical hazards and side effects on the muscles being retained to measure, as a disadvantage the procedure is limited for muscles which are more skeletal and observable so muscles lying deep inside the tissues might cause errors for the measurement because of the distance between the electrodes placed on the surface and the deep underlying muscles as a consequence for clinical purposes the needle EMG type is used for more accurate diagnoses of various types of diseases.

So, for our case the EMG is serving our purpose to quantify and detect the muscles activity from both the (Biceps and Triceps) muscle group. Before the acquisition step of the raw data some precautions must be considered. According to Zahak Jamal et al [31] on his studies the electrode placement is an issue that need to be considered, the placement depends on the muscle being measured as for the limbs they are different for each limb, the quality of the generated EMG signal can be maximized by placing the electrodes at the belly of the muscle instead on the ends where the tendons and motor unit are.

As shown in Figure 12, the configuration is Bipolar, for this configuration type the distance between the electrodes should be 1-2 cm near to each other and the reference electrode can be connected to a bony part of the body usually the leg is a good ground reference to be connected to.

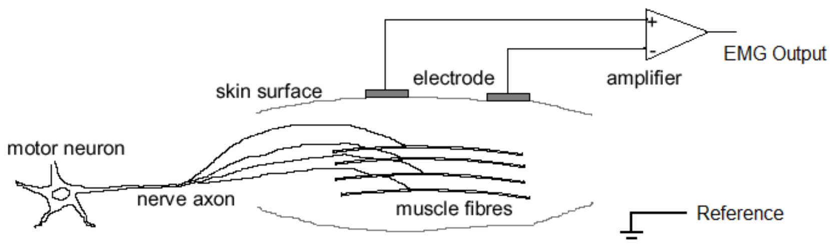

Figure 12: Acquisition of the EMG signal [31]

3 Results and Discussion

A This conceptual research project aimed to find the best design solution for upper limb rehabilitation device based on the reviews done in both literature and patents search platforms. Many close systems were investigated and reviewed related to this kind of devices and robots. By considering the conceptual design steps, requirements list was prepared and few design solutions which can satisfy these requirements were investigated. The design solutions then evaluated and the highest evaluated one were chosen for the variant design.

Using a CAD model; the variant design was modelled and reviewed until the last design perfectly satisfy the main requirements for this kind of device. Solidworks program was used for the variant design and model viewing. These all steps are the basic outline the real future design and manufacturing.

4 Conclusions

This paper investigated a conceptual design for EMG based control power assist device for the human upper limp Experimental results have shown the effectiveness of the proposed control method. This conceptual research project aimed to find the best design solution for upper limb rehabilitation device based on the reviews done in both literature and patents search platforms. Few close systems were investigated and reviewed related to the devices. The proposed device is adaptable to be used in a home or rehabilitation centres. The proposed device was 1 DOF with 2-dimension ways, and its control based on gathered EMG signal collected from the human muscles. Following the conceptual design main steps, the design specifications, requirement list were prepared. Based on these specifications, few possible design solutions were suggested and evaluated. Among the three design solutions, the highest evaluated one were chosen for the detailed design step. Using a CAD model, the highest variant design was developed and presented. Future work will focus on the development of the variant design to a real one. Other design solutions may be tested as well. Different mode of control may be applied to make the design solutions range wider.

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