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MOBILITY AID FOR PARESIS PATIENTS

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Abstract – *This Document introduces Mobility Aid for paresis patients, which is mechanical structure in the form of exoskeleton system, which has an ability to do movements same as human body mechanics with the help of various gears and fixtures powered by motors to support the paresis patients for vital movements, such as sitting. The control and processing unit of exoskeleton system is subset of Artificial intelligence that is re-enforced machine learning, Where the exoskeleton system can function independently by using pre acquired data from healthy human being, using EMG sensors. This mobility aid is designed for supporting paresis patients which is an acute condition where muscles attain plasticity and lose their strength, but Neuron System stays without defected.*

Key Words*: *Exoskeleton, mobility aid, paresis, Discrete Fourier Transform(DFT), Machine learning, Electromyography (EMG).

1. INTRODUCTION

Many researches and technology advances are been made in the field of Bio-Medical engineering and prosthetic limbs. This Documents introduce about one such technological advances in the field of bio medical engineering and mobility aid. The Exoskeleton system designed to support paresis patients are metallic structure re-enforced with carbon fiber in inner face and metallic surface in outer surface makes the system weightless and more rigid, it also has ability same as body mechanic system where it has same number of pivot point of motions, which is powered by gears and fixtures with help of motors. The Exoskeleton system is one of the break through as it has ability to function independently without any external command as it uses machine learning algorithms to function. This system is unlike prosthetic limbs which are used for amputee recipients, but this system is used for both acute paresis and temporary paralysis due to strokes, this system not only supports the patient in mobility, but also helps in healing temporary condition which needs regular movements of muscles and joints and also helps in reducing muscle plasticity in acute conditions due to prolonged inactive of muscles. The system is dependent on neuron signals obtained in neuron-muscular junctions, hence, the support of this system to patients is limited to few conditions with abnormal neural conditions.

2. PROBLEM STATEMENT

The at most challenges faced by exoskeleton in real times makes it less accepted by the individuals in need. The problems are real time issues ,which need to be sorted ,the prevailing exoskeleton lacks quick response towards the hurdles that evokes suddenly ,also the total weight of exoskeleton to be in situ ,also a challenge which can drain out maximum muscle energy by trying to maintain posture ,also quite questionable about the power limitation ,wherein the power doesn't last till end of the task or exhaust faster than expected which limits the individual from doing his chores ,lastly the cost of exoskeleton is hardship and thereby the availability lacks to the individual of various social-economic groups.

3. BIO MECHANICS

3.1 BIOMECHANICS OF LOWERLIMB AND GAIT

Bio-mechanics of lower limb and upper limb have few similarities, whereas upper limb is mostly equipped with precise activity and maximum range of motion and in case of the lower limb it is equipped for weight bearing and locomotion, maintenance of balance and posture.

As we see bio mechanics of lower limb, in context with weight bearing, locomotion, maintenance of balance and posture, lower limb always co-ordinates with spine and its segments.
Basically the lower limb is composed of three major joints, as mentioned below according to the pattern of weight transmission.

3.1.2 HIP JOINT

This coxafemoral joint is formed by the articulation of the acetabulum of pelvis and head of femur which is well secured with the ligaments.

Degree of freedom:

1) flexion :0 -120degree ,muscle involved illopsosas
2) extension :,115-0,muscle involved hamstring
3) abduction: 0-50degree,muscle involved gluteus medius, gluteus maximus
4) adduction: 0-25degree,muscles involved adductor group ,gracillus
5) internal rotation:0-30 degree,muscle involved tensor fascia latae
6) external rotation:0-50 degree, muscle involved piriformis, sartorius, as shown in fig 3.1.1

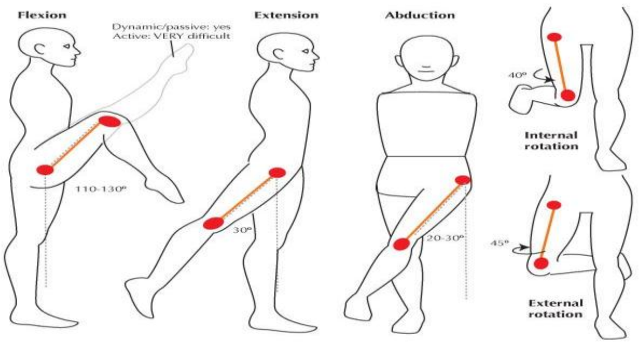


Fig 3.1.1: Hip Joint.

*note the values tend to change according to anatomical and physiological differences in the individual.

Bio-mechanical function: to support and balance the weight of head, trunk, arm, during static and dynamic movements. The load is equally being divided into both the coxafemoral joints.

3.1.2 KNEE JOINT

This joint articulates with the distal end of femur and proximal ends of tibial condyles and fibula, as movement takes place the patella which is in situ anteriorly glides over the joint.

Degree of freedom:

1) Flexion: 0 -140degree, muscle involved hamstring
2) Extension 0 degree, muscle involved quadriceps, as shown in fig 3.1.2

Bio-mechanical function: transmits the tension created by the quadricep group of muscle to the quadricep tendon, minimal rotational movement within the joint space also well secured with 4 major ligaments, whereas the tibia femoral articulation allows the transmission of body weight from femur to tibia.

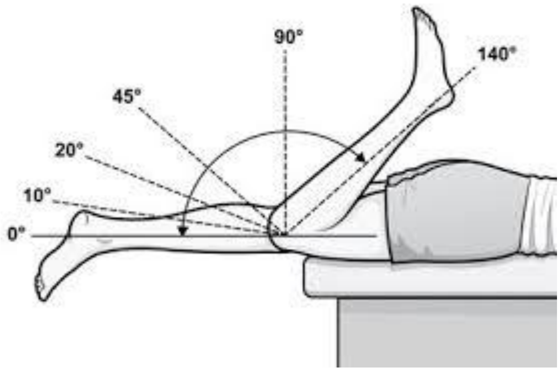


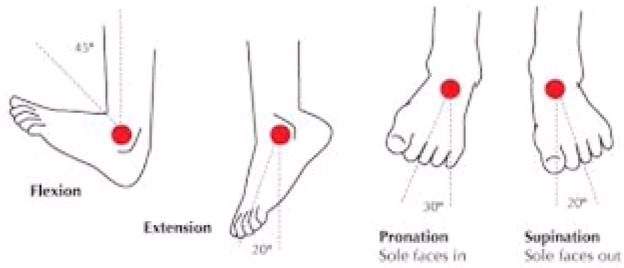
Fig 3.1.2: Knee Joint

3.1.3 ANKLE JOINT

This is the articulation between distal tibia and body of talus.

Degree of freedom:

1) Plantar flexion: 0-10 degree
2)dorsi flexion ; 0-40degree,
3)inversion
4)eversion, as shown in fig 3.1.3



bio-mechanical function ;The weight is being transmitted from the leg to the talus, then the talus distributes among the metatarsals ,toe bearing twice the weight more than the other metatarsals.

3.2 BIOMECHANICS OF SITTING TO STANDING

- Anterior pelvic tilt
- trunk extension
- hip flexion
- transition weight
- lift off
- hip extension
- trunk extension
- knee extension
- equal weight on both the limbs

Anterior pelvic tilt:

- phase 1:Flexion moment ,this moment is to intiate a moment, with the help of slight to and fro momentum, the momentum reduces slowly when there is maximum motor firing at the gluteal muscle group and the individual lifts off the chair

- phase 2:this movement starts with maximum dorsiflexion of ankle joint and hip begins to extend ,hamstring helps the body to rise
- phase 3complete extension of the hip , knee , neutral position of the ankle joint is the bio-mechanical erect posture of a standing individual , as shown in fig 3.2

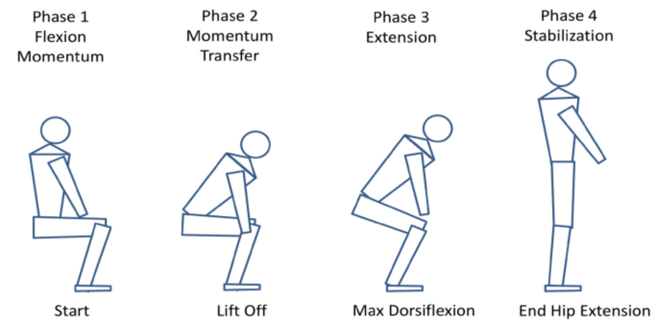


Fig 3.2

4. NEUROMUSCULAR JUNCTION

A neuromuscular junction refers to the synapse between a motor neuron and a skeletal muscle fibre, which helps in transmission of impulse from one neuron to another. The structure of neuromuscular junction can be divided into three main part : a presynaptic part[nerve terminal], the postsynaptic part[motor endplate] and an area between the nerve terminal and motor endplate [synaptic cleft]. The essential role of the neuromuscular junction is to convert a temporal sequence of action potential in motor neurons into muscle contraction. The molecular events that cause muscle contraction are triggered by increase in the intracellular calcium concentration. The axonal terminal contains a number of synaptic vesicles, these vesicles contain the neurotransmitters that are released upon receiving a nerve impulse.. As shown in figure 4.1

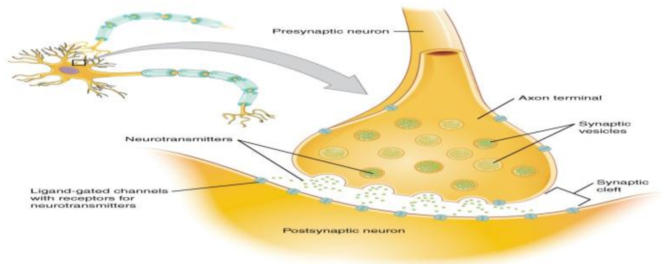
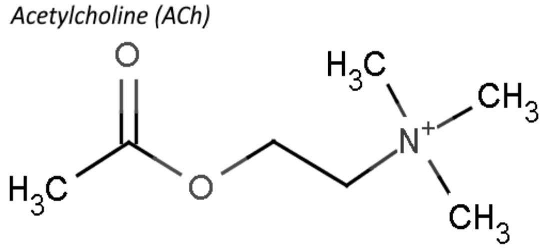


Figure: 4.1

TYPES OF NEUROTRANSMITTER

1. Amino acids : Glutamate, GABA, Glycine
2. Monoamines: Norepinephrine, Dopamine, Epinephrine
3. Acetylcholine

Acetylcholine is the most abundant neurotransmitter in human body. This neurotransmitter has an important role in muscle contraction. The acetylcholine receptors are present in postsynaptic neuron which binds to acetylcholine neurotaransmitter.



NEUROHUMORAL TRANSMISSION

Neurohumoral transmission is the communication that takes place between neurons with the help of chemical messengers.

STEPS IN NEUROHUMORAL TRANSMISSION:

1. Impulse conduction
2. Transmitter release
3. Transmitter action on post junctional membrane
4. Post junctional activity
5. Termination of transmitter action

IMPULSE CONDUCTION:

The resting transmembrane potential [70 mv negative inside] is established by high K+ premeablity of axonal membrane and high axoplasmic concentration of this ion coupled with low Na+ permeability and its active extrusion. The arrival of electrical impulse causes the sudden increase in Na+ conductance and this leads to depolarization [reverse polarization: inside becoming 20 mv positive]; K+ ions then move out in the direction of their concentration gradient and it leads to the repolarization of the membrane.

TRANSMITTER RELEASE:

The transmitter is stored in prejunctional nerve ending within synaptic vesicles. Nerve impulse promotes fusion of vesicular and axonal membrane, through Ca2+ entry which fluidizes membrane. All contents of the vesicle are released in the junctional cleft. The release process can be modulated by the transmitter itself and by other agents through activation of specific receptors located on prejunctional membrane.

TRANSMITTER ACTION ON POSTJUNCTIONAL MEMBRANE:

Excitatory postysynaptic potential increases the premeablity to all cations therefore Na+ or Ca2+ and followed by K+ efflux. Inhibitory postsynaptic potential increases the preameability to smaller ions, therefore K+ and Cl- only, so that K+ moves outside and cl- moves inside resulting in hyperpolarization.

POST JUNCTIONAL ACTIVITY:

A suprathreshold excitatory postsynaptic potential generates a propogated postjunctional action potential which causes the nerve impulse in neurons, contraction in muscle and secretion in gland. An inhibitory postsynaptic potential stabilizes the postjunctional membrane and resists depolarizing stimuli.

TERMINATION OF TRANSMITTER ACTION:

The neurotransmitter binds to its respective receptors, the transmitter is either locally degraded as acetylcholine or it is taken back into the prejunctional neuron by active uptake or diffuse away as noradrenaline and GABA. The rate of termination of transmitter action governs the rate at which response can be transmitted across a junction [1 to 1000/sec].

5. METHODOLOGY OF PROPOSED SYSTEM

The methodology of the proposed system can be divided into two division namely:

1. Mechanical design.
2. Control system design.

5.1 MECHANICAL DESIGN.

The outlined mechanical design is shown in fig 5.1.1.
The system is designed specifically such that the exoskeleton system supports the patient from hip (include medical term) to feet, keeping the prospect of supporting the patients to do most vital actions. The exoskeleton system is designed to house all the EMG sensors at major N-M junctions as referred by text 4 (Body mechanics).
The system is re-enforced with carbon fibre and aluminium to make it weight less. The carbon fibre is on inside face and aluminium in outside face of system. The gears and motors are attached to aluminium metal surface for more rigidity in system. The angle of freedom in particular gears at respective joints is as defined by body mechanics. There are 3 types of gear used in system to create extension and flexion at joints. The system is designed in modular approach with 3 pairs of major modules for limb and 1 major module to assist spine.

The modules used to assist the thigh region has a Graphene sheet rechargeable batteries sandwiched between carbon fibre and aluminium for power sources, as shown in fig 5.1.2

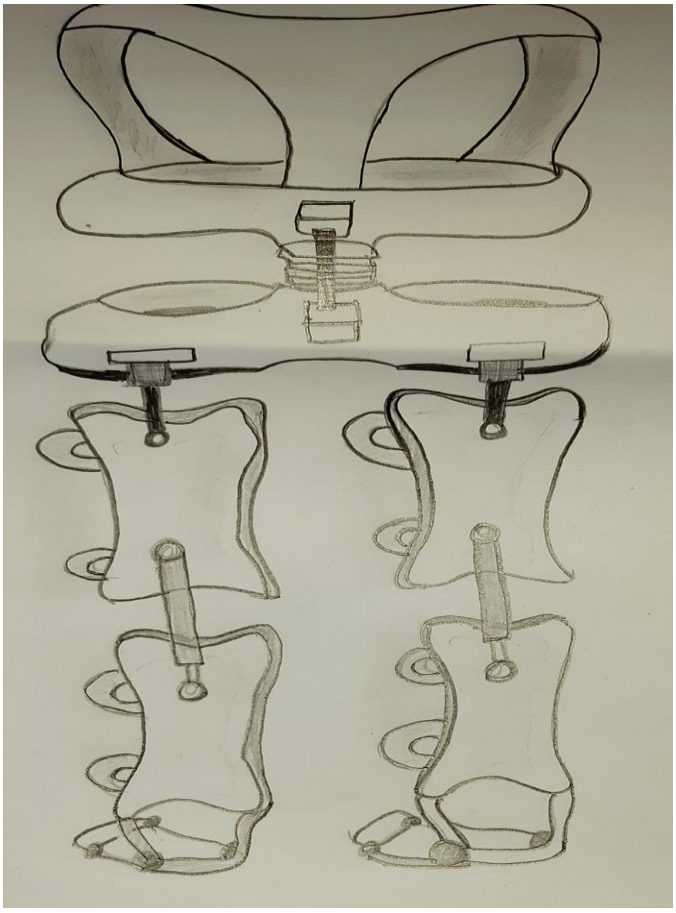


Fig 5.1.1: Exo skeleton system Design

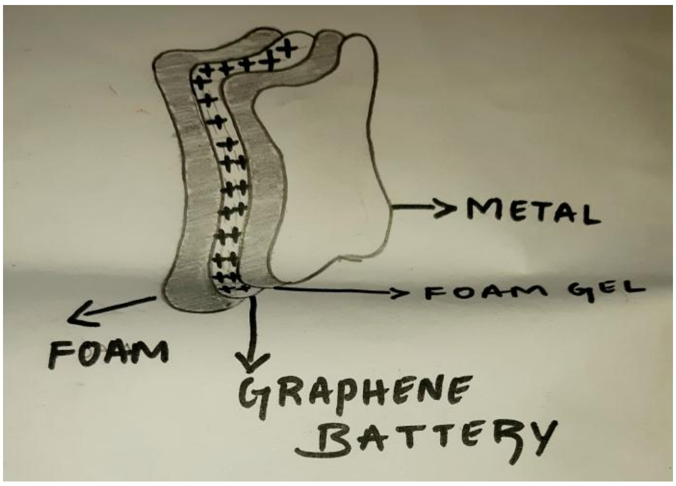


Fig 5.1.2: Layers of Modules, with Graphene batteries.

5.2 CONTROL SYSTEM DESIGN

The hardware architecture of control system of exoskeleton system is based on raspberry pi system on chip(SoC), which is capable of processing machine learning algorithms. The functions of exoskeleton system is controlled by machine learning algorithms which uses enforced data sets of EMG sensors data at specific NM junctions. The data sets are in frequency domain in nature which makes the system more responsive and creates a channel of adaptive signal processing. The data sets are acquired by using data acquisition techniques as specified in text 6 (Data Acquisition).

The data flow of the control system is given in fig 5.2.1

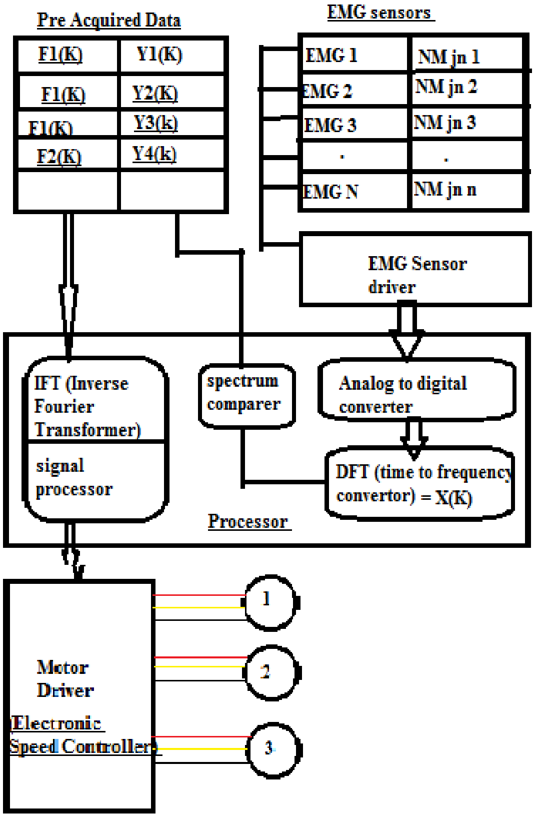


Fig 5.2.1: System flowchart.

Describing the data flow of the system, the data is collected from the EMG sensors at an interval of 10 microseconds, the data collected for 10 microseconds in time domain is then converted into frequency domain.

The frequency domain result is considered as an object let be X. Now, the processor looks into pre acquired data set to match the object X. As the object X matches with object Y in data set. The corresponding function $F_n(K)$ to that of object y in data set is executed, which in turn activates the motor and makes suitable movements in exoskeleton system.

6. DATA ACQUISITION

The data is acquired from a normal and fully functional human being. The data acquired at a time instant 't' are classified into two objects those are EMG sensor data consider to be x(t)and motion sensor data capturing motions of joints z(t), The z(t) signal is further processed to geet resulatant motor signals to function the gears and is defined as y(t).The data recorded is grouped into time period of 10 microseconds. Where the grouped object 'G' is function of x(t), y(t) and time period, defined as G(x,y,t). The grouped data is further processed to get frequency domain equivalent spectrum and saved as pre acquired data set. The data flow of Data acquisition technique is as shown in fig 6.1

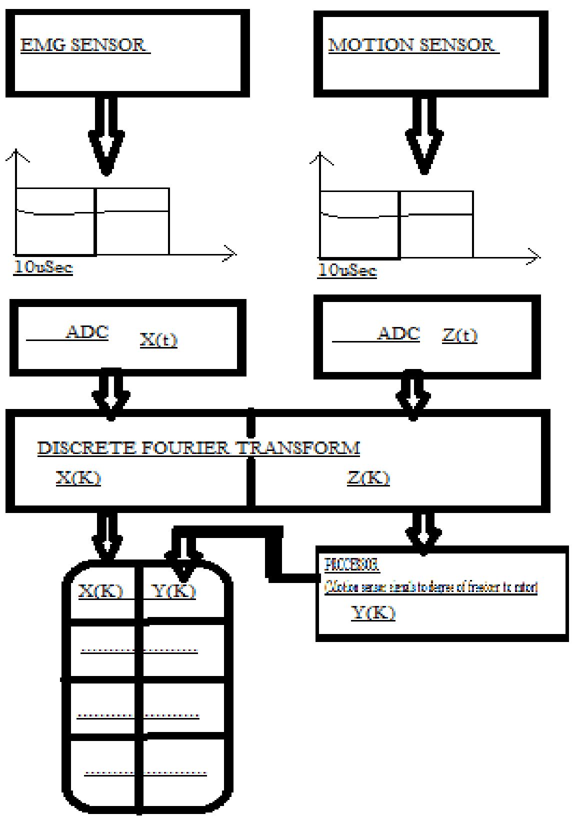


Fig 6.1: Data flow of data acquisition

7. CONCLUSION

By this technology and system design an efficient mobility aid is achieved. Which has quick response for vital actions, light in weight, easy to use, and self functioning system is produced. With total cost being almost one third to present systems in market.

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