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Weekly Report

Week-1 (22nd October 2021 to 29th October 2021)

Objectives:

- Do literature survey in sections say, on early 90's, then from 2000 to 2010 and then upto 2015 and till date and try to write a review paper in next 6 months.
- Compare the recent techniques used with the already existing techniques available in the survey. Look for its applications especially in medical and for easy walking and lifting of excess weights in ease without exceeding the fatigue limit with the help of assistive exoskeletons.
- Learning the required Software's say: the Adams, OpenSim and Solid Work software for the ongoing project and also the MATLAB software learn thoroughly.
- Simultaneously, keep focusing on the fundamental laws and its governing equations on Exoskeleton, post which simulate the model and formulate a prototype and then finally implement in real time with satisfactory performance.

Introduction to Exoskeleton:

What is an Exoskeleton?

• Exoskeleton is basically an external wearable device.

• An exoskeleton, also known as a wearable robotic, is a system that can be worn to help human beings to support and protect parts of their bodies.

• Exoskeleton is wearable mobile robot that combines various technologies to enable limb movement with greater strength and endurance.

• Exoskeleton does not work alone; it operates in parallel with the man whome it provides support to.

Used in various applications like,

• Military

• Industries

• Medicine

> The application of the exoskeleton to the human body can be divided into three locations:
>
> (1) Throughout the human body.
>
> (2) At the upper part of human body, such as the shoulders and arms, and
>
> (3) At the lower part of the human body, i.e., from the waist down.

Upper & Lower limb Exoskeleton:

• Upper & Lower limb Exoskeletons is an Electro-mechanical systems which are designed to interact with users for the purpose of,

1. Assistance: Enhancing workers when doing their job.

   • Lower limb exoskeletons are used to increase worker strength for walking on long journeys and

   • Upper limb exoskeletons help in lifting heavy items.

2. Rehabilitation:

   • In medical field, exoskeletons have been used to assist patients who have lost their ability to walk due to spinal cord injuries, stroke, and other trauma.

   > Example: Stroke is a cerebrovascular disease accompanying functional paralysis in the muscle contraction and expansion, but stroke patients can be improved by rehabilitation training.

   • Rehabilitation exoskeletons can improve the quality of exercises during rehabilitation and can accelerate recovery process.

Biomechanics of Upper & Lower human limbs:

• Hips connect the upper limbs and the lower limbs of the human body. Human hips enable their owner to perform the motions of flexion/extension, abduction/adduction, and medial/lateral rotation (three Degrees of Freedom (DoF) motions). These motions are required for a human to walk or run.

• Upper human limb have three major joints say, the shoulder, elbow and wrist and the lower human limbs have three main joints, namely the hip, knees and ankles.

- Movements of limbs :
  - **Shoulder :** Flexion/ Extension
    Abduction/ Adduction
    Medial/ Lateral
  - **Elbow** : Flexion/ Extension
  - **Wrist** : Flexion/ Extension
    Abduction/ Adduction
  - **Hip** : Flexion/ Extension
    Abduction/ Adduction
    Eversion/ Inversion
  - **Knee** : Flexion/ Extension
  - **Ankle** : Flexion/ Extension
    Abduction/ Adduction
    Eversion/ Inversion

- The main DoF involved are;
  1. **Flexion** : Positive direction movement
  2. **Extension** : Negative direction movement
  3. **Abduction :** Movement of pulling away from the center of the body
  4. **Adduction :** Movement of pushing toward the center of the body
  5. **Eversion** : Movement away from midline of the body
  6. **Inversion** : movement toward the midline of the body
  7. **Medial** : Forward shoulder movement
  8. **Lateral** : Backward shoulder movement

History of Exoskeleton:

1. MIT-MANUS:

The MIT-MANUS was developed at the Massachusetts Institute of Technology in the early 1990's with the goal of determining whether repetitive reaching exercises using a robotic device can enhance recovery of the arm function in hemi-paretic stroke survivors.

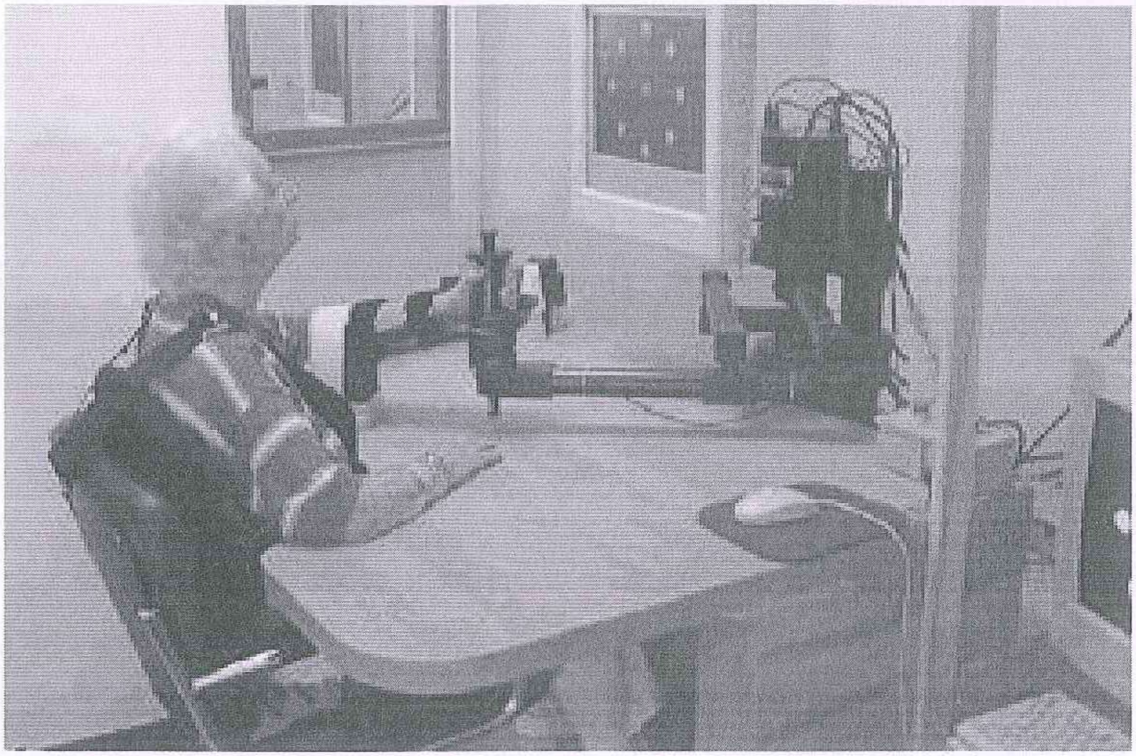

Figure. 1. MIT-MANUS (Interactive Motion Technologies, Cambridge, MA), Joseph Hidler, 2005 [2].

The MANUS, as shown in Figure 1, allows subjects to execute reaching movements in the horizontal plane.

During movements, the device can assist or resist the subject and monitor arm position and applied forces. The manner MANUS interacts with the subject is intended to be safe, stable, and compliant throughout the training paradigm. The robot-trained subjects used the MANUS to reach toward various targets across their workspace; if they were unable to complete the movement, the robot assisted them. Even in the chronic stages of their injury, subjects are able to improve shoulder and elbow function after training for 6 weeks with the robot.

Limitations: One possible limitation with the MIT-MANUS is that it emphasizes training within the horizontal plane. Subjects who trained on the MANUS did demonstrate improvements in shoulder strength and function, but some researchers have hypothesized that training in a three-dimensional workspace may enhance these functional gains.

2. MIME:

Mirror-Image Movement Enabler (MIME) is a collaborative effort between the Veteran Administration Medical Center in Palo Alto and Stanford University. PUMA 560 industrial device was modified so that it could interact with subjects in a stable and repeatable manner.

Figure. 2. Mirror-Image Movement Enabler (MIME), Joseph Hidler, 2005 [2].

The subject's impaired limb was placed in a splint, which in turn was connected to the robot through a 6-degree of freedom force-torque sensor, as shown in Figure 2.

The idea behind this protocol was to explore the effectiveness of restoring arm function in stroke subjects by having them execute movements that mirror one another in both of their upper limbs.

Limitations: Improvements in elbow and shoulder muscle activation patterns were also observed in subjects who performed reaches against gravity, but no improvements were noted during table-top movements.

Available Exoskeletons :

Sl.No	Product/ Institution Name	Purpose	Limitations
1.	**RUPERT**	**Upper limb rehabilitation:** Upper limb rehabilitation training robots.	Inappropriateness for finger training as well as bulky.
2.	Japanese Gifu University **"16 DoF Robot",** S. Ito et. Al, 2008 [1].	**Hand rehabilitation:** It can perform and train normal movements of each finger in daily life.	Too large and complicated to ware and use because actuators and sensors are needed in each joint and the length of joints is adjusted to that of human.
3.	**ARM-GUIDE** Assisted Rehabilitation and Measurement Guide	**Rehabilitation:** Allows stroke subjects to reach along a rail, which in turn can be positioned so that the subjects' reaching motion can be neutral to gravity or can work against gravity.	The type of robotic-assisted therapy used in this study is not optimal for addressing arm impairment in this patient population.

Application on Exoskeleton:

Sl. No.	Author & Year	Type	Application
1.	Yong-Kwun Lee, 2014	**Aid robots**: Aid robots Replacing physiotherapists	Used for patients to whom hand or arm rehabilitation training is Conducive for the recovery.

References:

[1] S. Ito, H. Kawasakia, Y. Ishigureb, M. Natsumec, T. Mouria, and Y. Nishimoto, "A design of fine motion assist equipment for disabled hand in robotic rehabilitation system," Journal of the Franklin Institute, 2008.

[2] Joseph Hidler, Diane Nichols, Marlena Pelliccio, and Kathy Brady, "Advances in the Understanding and Treatment of Stroke Impairment Using Robotic Devices", Top Stroke Rehabil., 2005.

Learning the required Software's:

Objective:

- How to create bodies.
- How to connect bodies with joints.
- How to create motions.
- How to measure displacement, velocity or acceleration.
- How to view results.

Adams:

- Adams is the leading multi-body dynamics simulation software.
- Adams software helps us to assess the system's performance using computer models before investing in physical prototypes.
- It is used extensively by, Engineers in product development within Automotive and other Industrial sectors worldwide.

Solid Works: Used to design a human structure.
