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46th SERIES OF STUDENT PROJECT PROGRAMME

SYNOPSIS

- **Project Reference Number**: 46S_BE_2082
- **Title of the project** : DESIGN & DEVELOPMENT OF WEARABLE DAMPER SYSTEM TO MINIMIZE HAND TREMORS CAUSED DUE TO PARKINSON'S DISORDER
- **Name of the College :** DAYANANDA SAGAR COLLEGE OF ENGINEERING
- **Department :** MECHANICAL ENGINEERING
- **Name of the students :**
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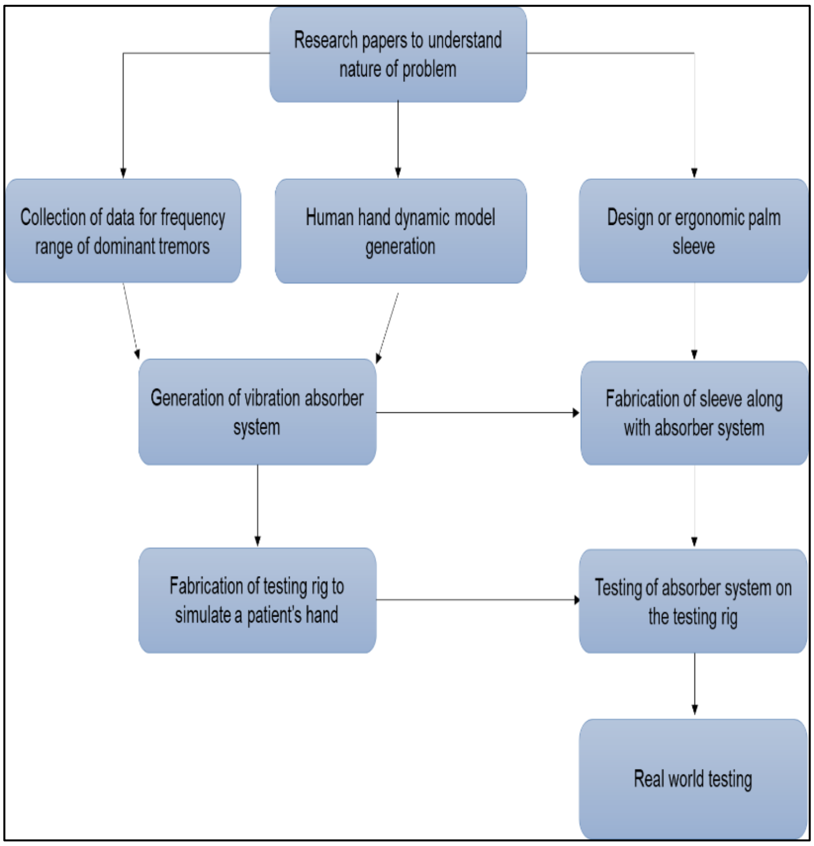
- **Name of guide:** Prof. ANAND BADIGER
- **Keywords :** Parkinson’s; wearable damper; biodynamic modelling; tremor reduction.
- **Introduction :**

Parkinson's is a neurological disorder that has no known cure. A major symptom is hand tremors that cannot be wholly eliminated through medication. There have been successful attempts at creating gyroscopic systems in order to balance out and minimize these tremors. The main disadvantage is that they are purely electrical in nature and tend to have to be replaced regularly (Batteries, circuitry, etc.) We will hence be using a damping system that is majorly mechanical in nature to dampen these tremors that are essentially vibrations. It is essentially a suspension for one's arm, smoothing out vibrations. The chief aim of the project is to create a viable solution to reduce the tremors experienced by patients suffering from Parkinson's disease. The design philosophy behind the same would be based on using a damper system to assist reduction in vibrations.

- **Objectives :**
  - i) To understand the behavior and characterization of hand tremors caused due to Parkinson's (Amplitude, frequency, etc. of vibrations in yaw axis only).
  - ii) To design & develop a wearable arm sleeve system that minimizes said tremors using a damper system attached to the arm virtually.
  - iii) Fabrication of the above-mentioned arm sleeve type design and its real-world testing and effectivity analysis

- **Methodology:**

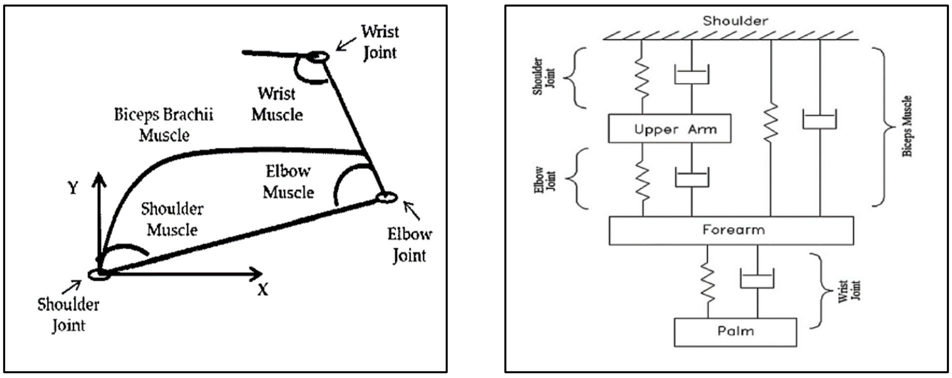


Design Methodology

Understanding the human arm

The human arm is then further converted into an effective mass spring damper system to hence create its dynamic model.

The human hand is modeled to describe the flexion motion at the shoulder, elbow, and wrist joints. The mass is concentrated at the centroid of each segment

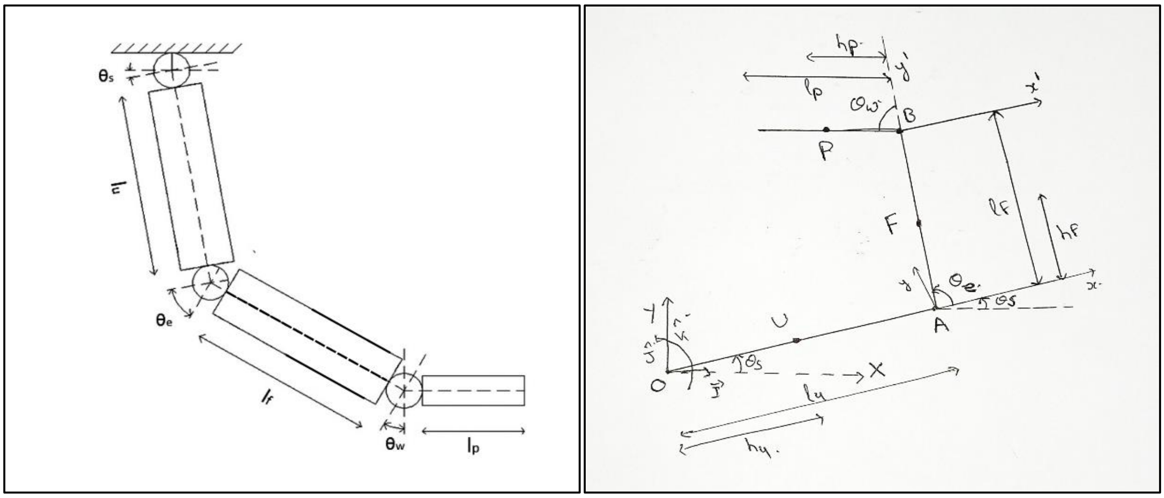


Human arm with all responsible muscles and joints and it’s representation as a spring mass system

Dynamic Model and equation of motion

The objective of biodynamic modeling and driving the equation of motion is to determine the hand's response when it is subjected to an excitation force equivalent to that of PWPD.

Data collected is used to develop a dynamic model and generate the equation of motion for a human hand. The equation of motion can be obtained using the Lagrange theorem and the velocity and acceleration of rigid links at various points of the three-dof system can be determined using the Coriolis theorem.



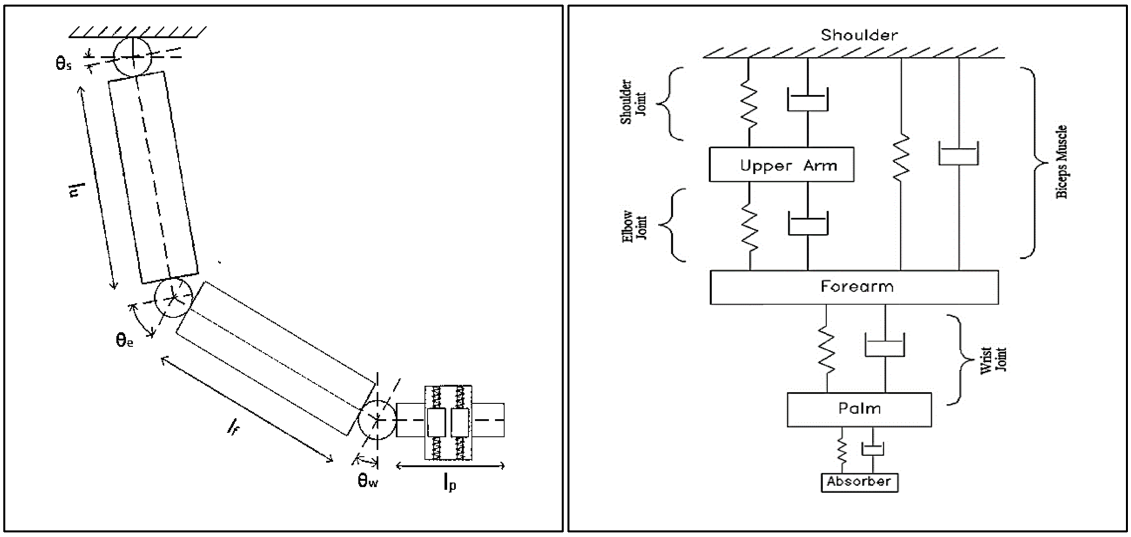
Dynamic model of the human hand

<u>**Effect of Parkinson's tremor**</u>

Parkinson's tremor were found to be in the range of 4hz to 6hz which falls in the range of the first two natural frequencies obtained by modal analysis. An external torque of unit magnitude and frequency equivalent to the natural frequency is applied at the shoulder, elbow and shoulder plus elbow to obtain 3 different resonance conditions to obtain resonance condition. ($[M]\{\Theta''\} + [C]\{\Theta'\} + [K]\{\Theta\} = \{F_i\}$)(Where Fi is the force vector).The equations are then solved using the same function-defined (beta Newmark method) to obtain amplitude (in radians) vs time(s) plot using MATLAB.

<u>**Damper system**</u>

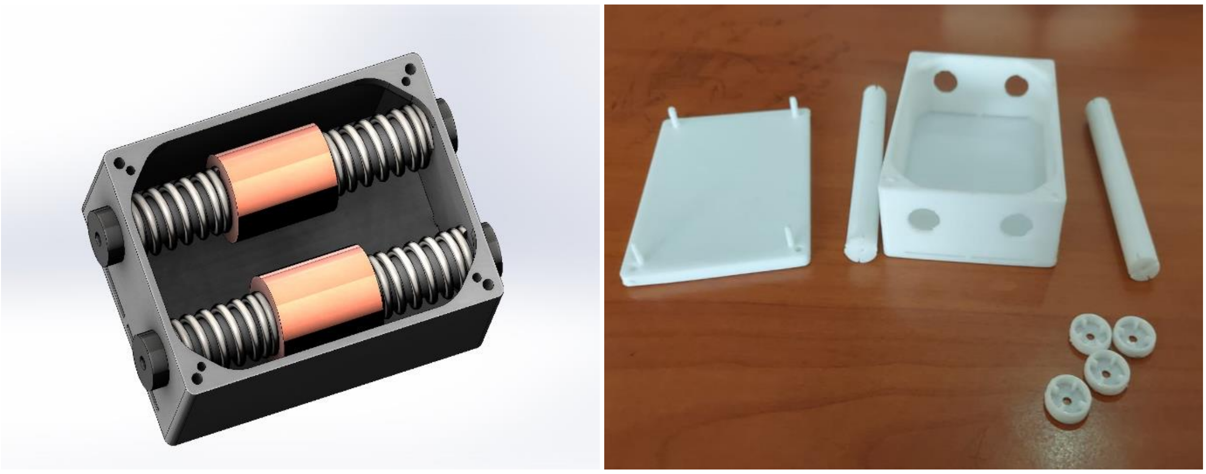
A 2 DOF-tuned mass damper is proposed as a solution to this problem. The damper will attach to an ergonomic sleeve and slide onto the patient's hand at a calculated position to maximize its damping effect. The parameters of the first absorber mass and the attached springs are adjusted to match the excitation frequency of the shoulder, while the parameters of the second absorber mass and the spring attached to it are adjusted to agree with the frequency of excitation of the elbow. The adjustment in the mass of the absorber was carried out to minimize the device weight and maximize the energy absorption capacity using optimization.



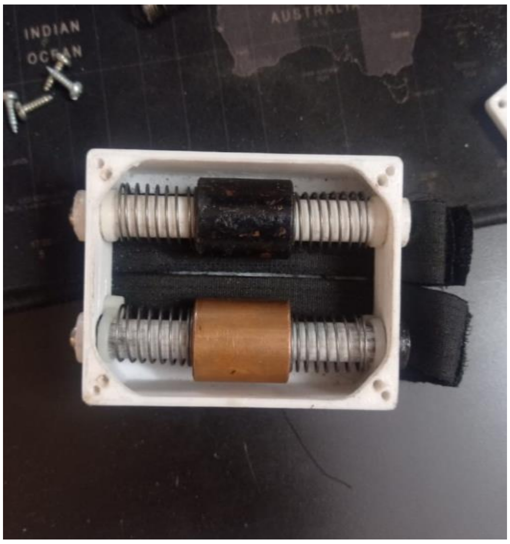
Dynamic modelling of human hand with damper and it's equivalent representation

<u>**Design and Fabrication of Damper**</u>

The assembly was designed in accordance with the anthropometric data used to develop the biodynamic model to prevent any inconsistencies during testing. The dampers themselves will be made out of copper for its high density thus making them less bulky. Casing is going to be 3d printed due to expected complex geometry and according to the space constraints the springs will are also designed.



Proposed model and 3d printed case for the damper system



Components Assembled

Assembly sitting comfortably on users' hand

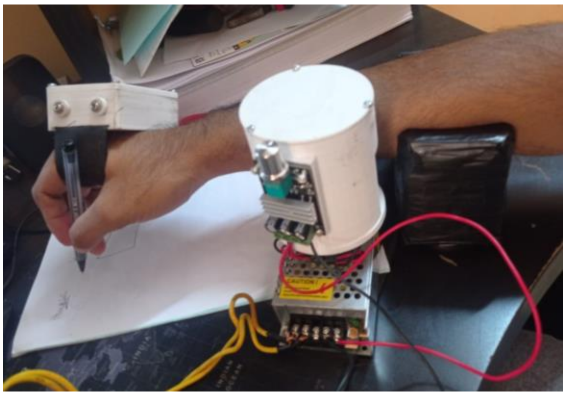
- ## Results and conclusion

Theoretical results were as follows:

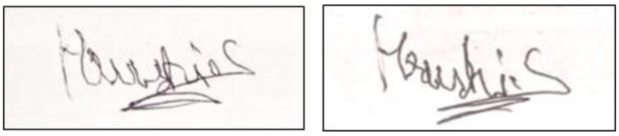
Tremor Type	Shoulder	Elbow	Shoulder + Elbow
Peak amplitude without damper(deg)	5.096	10.422	15.504
Peak amplitude with damper(deg)	2.011	6.07	8.044
Percentage reduction(%)	60.537	41.758	48.116

Comparison of without and with damper

A wearable testing rig was developed to replicate tremors and hence show effect of damper for patient

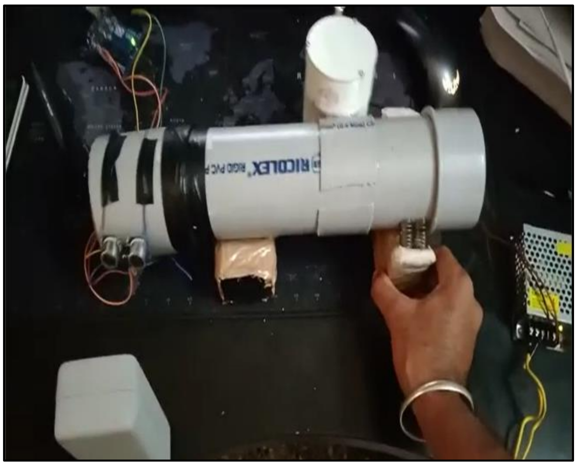


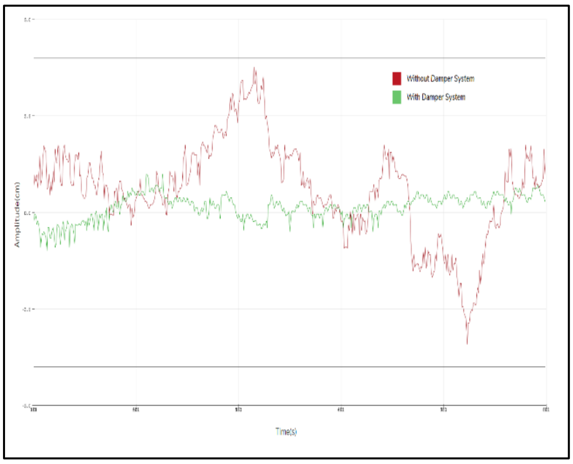
Testing Rig set-up



Signature comparison without(left) and with(right) damper

Due to ambiguous uncontrollable hand motions a new testing rig was created to collect data on tremor reduction using ultrasound sensors. The ultrasound sensor data is collected using Arduino serial plotter for with and without damper.





Final Testing rig set up and ultrasound sensor data

The ultrasound sensor data shows that there is a 50% decrease in amplitude which is in corelation theoretical results obtained.

- ## Conclusion and scope for future work

With the results obtained, it can be ascertained that the end goal of providing a feasible solution to the problem statement has been successfully achieved. The future scope of this project lies in the scalability of the product with regards to mass production and also while reducing economical expenditure.

- **Innovation**

i) A non-intrusive patient specific solution to the chronic disorder is the uniqueness of this product.

ii) The product developed covers 3 different types of Parkinson's tremor giving over 40% damping.

iii) The parameters for damper components can be instantly obtained specific to patient's anthropometric data using MATLAB code developed and casing can be modelled accordingly.