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Design of a vibration absorber system for tremor reduction in Parkinson patients using a cluster based algorithm

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Abstract: Parkinson's disease is a progressive disorder of the central nervous system that affects human movement. The treatment of Parkinson disease using passive control devices such as Dynamic Vibration Absorber has received considerable attention in recent times. In this work a new optimization algorithm termed as the Cluster Based Algorithm (CBA), developed by the authors for the design optimization of dynamical systems, is used to evaluate the absorber parameters. It is seen that the designed absorber parameters which when attached to the primary system resulted in reduction of steady state amplitude of primary system (Human Hand). Moreover, it is also seen that absorber parameter sets converge to a cluster in the parameter space. Parameter cluster gives the designer more freedom to choose a parameter set satisfying the design considerations.

Keywords: Tremor reduction, Vibration absorber, Cluster Based Algorithm

1. Introduction

Parkinson disease is a neurodegenerative disorder caused by the deficiency of dopamine in the brain and influences the brain control of muscles, leading to tremor (shaking), slow muscle movement and motion balancing problems. Passive vibration control devices such as vibration absorbers can be used to control movements, and can prove to be an effective mechanical treatments for tremor patients. Tremor suppression in Parkinson patients is generally a broadband vibration control problem with frequencies varying from 2Hz to 10Hz [1]. In this work control of tremor in hand is analysed numerically by modeling a biodynamic human hand where joints and muscle movements are satisfying physical laws of nature. Here, the mathematical model and corresponding equations are adopted from [2] and emphasis is on the estimation of feasible absorber parameters using the proposed cluster based algorithm. Human body's trunk was considered to be immovable and connections were made at shoulder and elbow joints and were idealized as hinged joints. Human hand is mathematically modeled as a two degree of freedom system and Human hand with absorber attached is modelled as a three degree of freedom system . An external harmonic torque of amplitude, is applied at the lower arm and the uncontrolled steady state amplitude of the system is evaluated by numerically solving corresponding differential equations of motion. The primary aim is to design an absorber system to be attached in the lower arm which reduces the steady amplitude of the lower arm. The absorber parameters are the position (l3) along the lower arm, distance from this position to the absorber centroid (a_3), the mass of the absorber (m_a), absorber stiffness (k_a), absorber damping (c_a). A schematic representation of the human hand with absorber attached (as an equivalent pendulum model) in the lower arm is shown in Fig. (1).

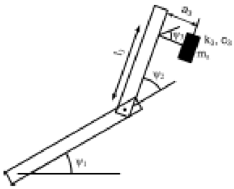

Figure 1. Mathematical model of Human hand with attached absorber system

2. Results and Discussion

CBA as discussed in [3] is implemented in the design of absorber system and parameter cluster is obtained as shown in Fig (2).

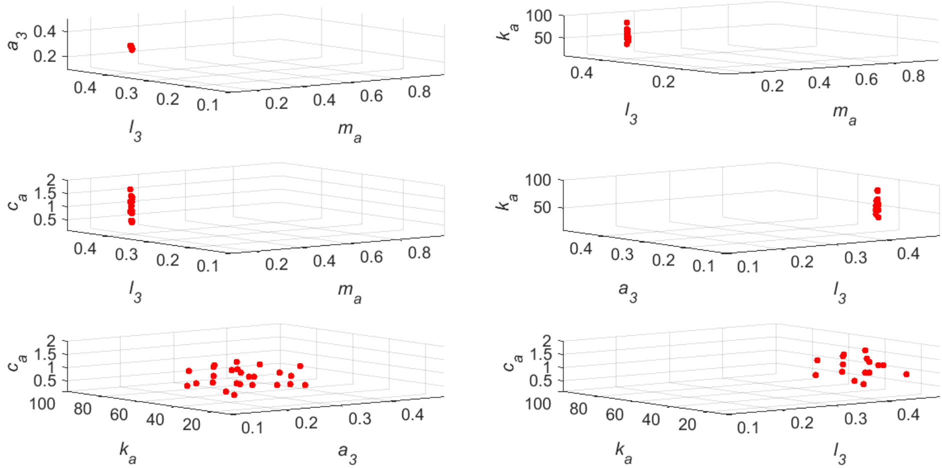

Figure 2. Parameter cluster for absorber design parameters

3. Concluding Remarks

CBA is implemented in the design of absorber for tremor suppression in a bio-dynamic hand model for Parkinson patients. Position of absorber, mass, damping coefficient, etc. were evaluated which reduced the amplitude of motion of the forehand model. Parameter sets satisfying design consideration converged to a cluster giving the designer more freedom to choose a parameter set satisfying the design considerations.

References

[1] S M Hashemi, M F Golnaraghi, and A E Patla. Tuned vibration absorber for suppression of rest tremor in parkinson's disease. *Medical and Biological Engineering and Computing*, 42(1):61–70, 2004.

[2] Mostafa Rahnavard, Mojtaba Hashemi, Farzam Farahmand, and Ahmad F Dizaji. Designing a hand rest tremor dynamic vibration absorber using h 2 optimization method. *Journal of Mechanical Science and Technology*, 28(5):1609– 1614, 2014.

[3] Premchand V. P. , M. D. Narayanan, Sajith A.S. A New Cluster-Based Harmonic Balance Aided Optimization Procedure With Application to Nonlinear Vibration Absorbers". *ASME Journal of Computational and Nonlinear Dynamics,* 14(7), 2019.