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”PACO#5 - A passive nonlinear absorber for controlling pathological tremors of human arm”

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Mechanical vibration absorbers are applied in different domains to protect structures and machines from undesired vibrations. One of the precise applications of such control systems is reducing tremors of the human arm caused by some neurological disorders such as essential tremors. In recent studies, active and linear passive controllers are designed, in the form of a wearable bracelets, to reduce the shaking in the upper limbs of patients. Active controllers require a power source to operate, and their components are a matter of concern regarding safety. Passive linear absorbers need accurate calibration of their operating frequency to be efficient and require the usage of multi-absorbers to solve this problem. Passive nonlinear absorbers are proposed to overcome the shortcomings of linear absorbers because they can be designed to have a broadened frequency bandwidth. In the current work, the arms of the upper limbs are modeled as links connected by joints, and the passive tissues of the muscles as springs and dampers. A voluntary moment is considered to represent the torque exerted by the human to place his arms at a desired position. The involuntary moment is used to excite the system and to reflect the activity of the muscles generating the tremor. Tremor signals at the upper limbs, of a patient with essential tremor, are measured to obtain the translational and angular responses. These measurements are used to calibrate the modeled dynamical system of the upper limbs and to deliver a reliable numerical response very close to the measured one. The system is coupled to a passive nonlinear absorber and the multiscale method is used to study the behavior of the system at the fast and slow timescales. It allows us to obtain the invariant manifold of the system and to detect the equilibrium and singular points needed for the design of a nonlinear energy sink (NES). A non-smooth, piece-wise linear NES is used for its design. The response of the system obtained analytically is validated by those obtained from numerical simulations. The designed NES is fabricated and the preliminary prototype is obtained.

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