UNIVERSITÉ PARIS-EST

ÉCOLE DOCTORALE UNIVERSITÉ PARIS-EST
Sciences, Ingénierie et Environnement

# Manufacturing of a Mechanical Vibration Absorber to Reduce the Tremor at the Hand of a Parkinson's Patient

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## Objective & Principle

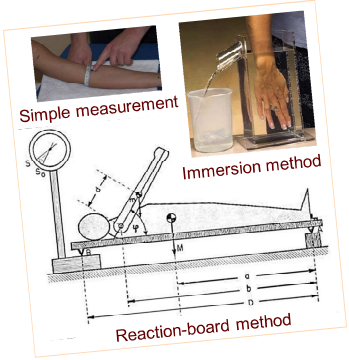
### Objective

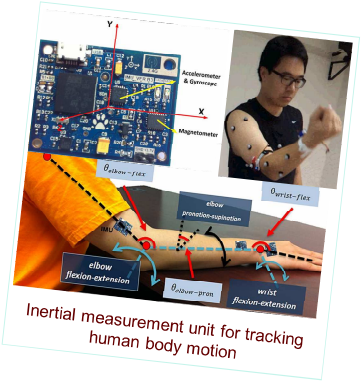
The project objective is to help the neurodegenerative disorder Parkinson's patient suffering from the involuntary tremor in their upper limbs. Mechanical devices actuated electrically gained recently the research interest as an alternative treatment that can control human's unintentional tremor instead of using medical and surgical treatments which puts their life under danger. A vibration controller is tuned to counteract against the instantaneous tremor's characteristics, i.e. the tremor's real-time frequency and moment magnitude. The device can designed by the transformation of the mechanical to electrical analogous system, so that a mass can be added without loading the system. The device is manufactured and tested when attached to the forearm of the hand to adjust the palm's motion without influencing the voluntary movement. Controller's consumed power during its activation is desired to be generated within the system without any external source. Comparison is done between the experimental and numerical results to validate the modeled system.

### Principle

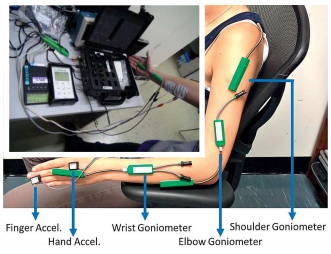
Tuning of the absorber yields to design its parameters such that it produces a force (or moment) has the same magnitude of opposite sense with same frequency as the undesired vibration. Tuning a tremor suppression device required good knowledge of the biomechanical behavior of human hand at the musculoskeletal level. Consequently, hand parameters are needed to be determined experimentally in order to model an equivalent hand model to be used for the numerical investigations before intending to manufacture the suitable real device. The hand parameters to be determined are like: the upper arm, forearm and palm segments mass, centers of mass and mass moments of inertia, the muscles stiffness and damping coefficients, hand's natural frequency and tremor's driving frequency range and angular behavior. The absorber's mass and stiffness coefficients with some level of damping are designed based on the modeled hand system. The closed loop feedback system in real-time. Then, their equivalent resistance, capacitance and filers electrical parameters can be found to used reduces flexible modes without mass-loading the structure. Passive and intelligent controllers can be manufactured and compared in terms of their performance, power requirements, operational bandwidth and cost.

## Hand properties :

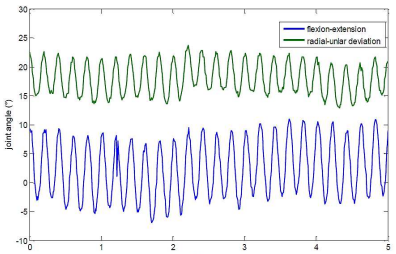



Inertial measurement unit for tracking human body motion

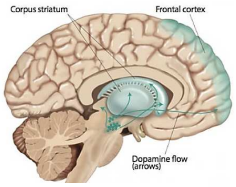


Placement of biometric motion sensors along the arm

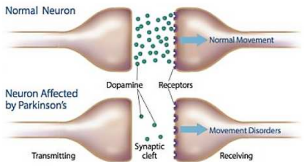


Wrist joint angle measured by goniometer under functional electrical stimulation

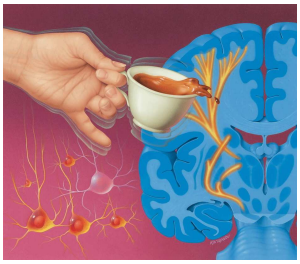
## Parkinsonism and control :



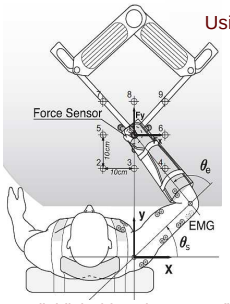
Dopamine location



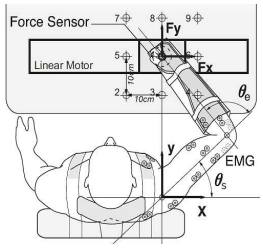
Main cause of Parkinson


Parkinson's symptom

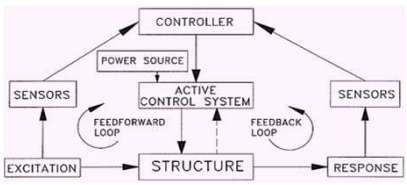
Using electromyogram (EMG)



Parallel link drive air-magnet floating manipulandum for measuring muscular stiffness in the relaxed state



Linear motor system for estimating the muscular stiffness in the co-contraction state



Closed loop feedback system


Active tremor suppression device

## Applications and benefits

Parkinson's disease tremor is due to an abnormality in the central oscillator which causes the reduced community ambulation and raises the danger of slips, falls and faults. Tremor makes them suffer while performing their daily tasks and they can feel embarrassed to face other people. Each type of medication, surgery and pharmacological treatments, used for reducing the symptoms of neurodegenerative disorders, has its weakness and may have high risks involving brain operation which points to the need for an alternative approach to reduce the vibration. Mechanically, this problem is solved to suppress the tremor of Parkinson's patient leaving no sever risks on patient's life quality. In order to move hand smoothly without affecting patient's voluntary tremor, actuators are used to convert the passive controller into an intelligent device which can modify the real time behavior of the system. The project also shows the procedure of determining the mechanical and geometrical hand parameters. Based on these parameters, a reliable 3D hand modeling able to reflect its biomechanical behavior is designed and validated experimentally. Vibration absorbers can be also used to suppress the undesired vibration many practical implementation like machines and buildings. They can control the vibration level of: a building against earthquake, a bridge against high speed or turbulence wind and airplanes wing flutter. The behavior of different types of controllers: passive, active, semi-active and piezoelectric shunt controllers may be done to compare their ability in reducing the involuntary tremor, required input power intensity, cost and design complexity.