Northern Illinois University

Electromechanical Systems to Control Essential Tremor

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Basic Idea

- Tremor makes life difficult
- Reduced tremor – improved quality of life
- Medical methods available
- Mechanics may help
- Active systems
  - Being investigated
  - Show some potential

Essential Tremor

"involuntary tremulous motion, with lessened voluntary muscular power, in parts, not in action" J. Parkison 1817

- Caused by contraction of antagonistic muscles
- Considered involuntary
  - Rhythmic
  - Roughly Sinusoidal

Essential Tremor Effects

- Not life threatening
- Daily tasks difficult
- 10 Million people affected
- About 5% of people above age 65

Drug Therapy Solutions

- Propranolol drug of choice
- Some limitations
  - Heart conditions
  - Asthma
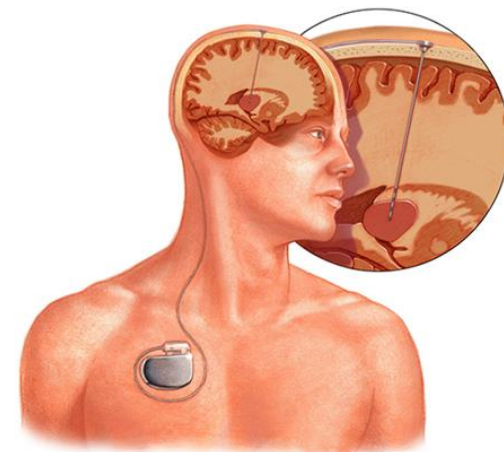- Long list of side effects
  - Fatigue
  - Lightheadedness

Source: http://www.mayoclinic.org/diseases-conditions/essential-tremor

Surgical Solutions

- Deep brain stimulation
  - When drugs don't work
  - Some side effects
  - Surgical risks
- Spinal cord stimulation
  - Still experimental

Sources:
http://www.mayoclinic.org/diseases-conditions/essential-tremor
http://www.sciencedirect.com/science/article/pii/S0896627314008964

Mechanical Engineering Approach

- Look at using mechanical systems
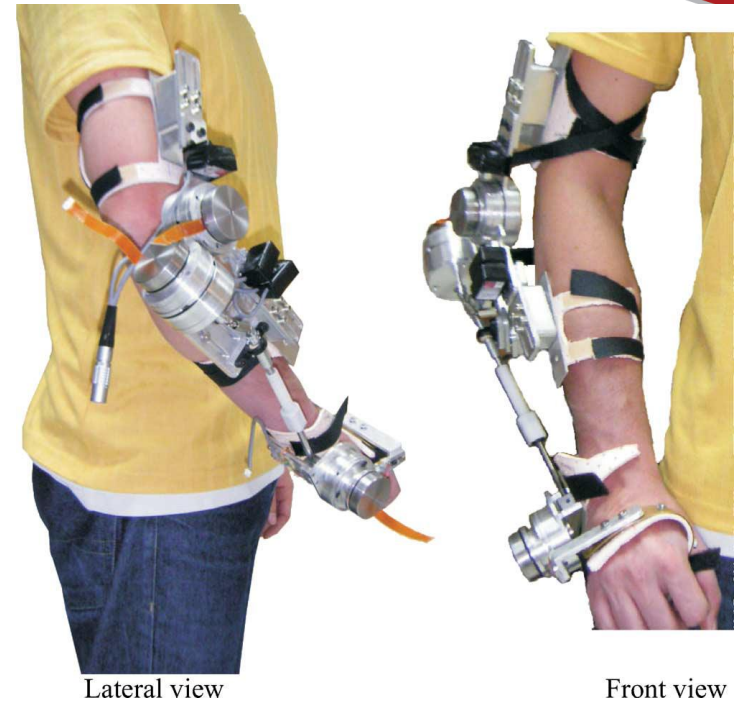
- Use systems to help dampen tremor
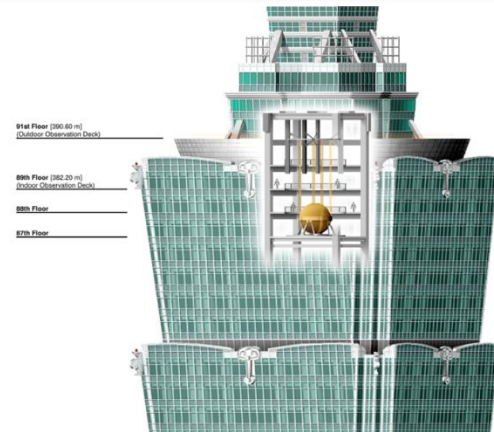
- Example exoskeleton

Lateral view   Front view

Fig ROCON *et al.*: DESIGN AND VALIDATION OF A REHABILITATION ROBOTIC EXOSKELETON, IEEE TRANSACTIONS ON NEURAL SYSTEMS AND REHABILITATION ENGINEERING, VOL. 15, NO. 3, SEPTEMBER 2007
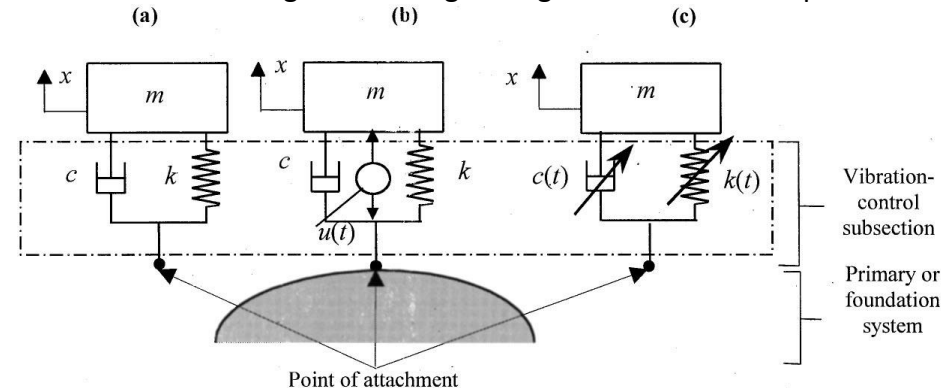
Counteracting Forces Examples

- Taipei 101
  - Passive system to counter earthquakes
- Active and passive combined
  - Could lead to better solution

From: http://gizmodo.com/5019046/how-a-730-ton-ball-kept-the-second-tallest-building-from-falling-during-the-chinese-earthquake

From: N. Jalil, A Comparative Study and Analysis of Semi-Active Vibration-Control Systems, Transactions of the ASME, Vl 124 Oct 2002

NIUs Initial Mechanical System

- Used motor connected to brace
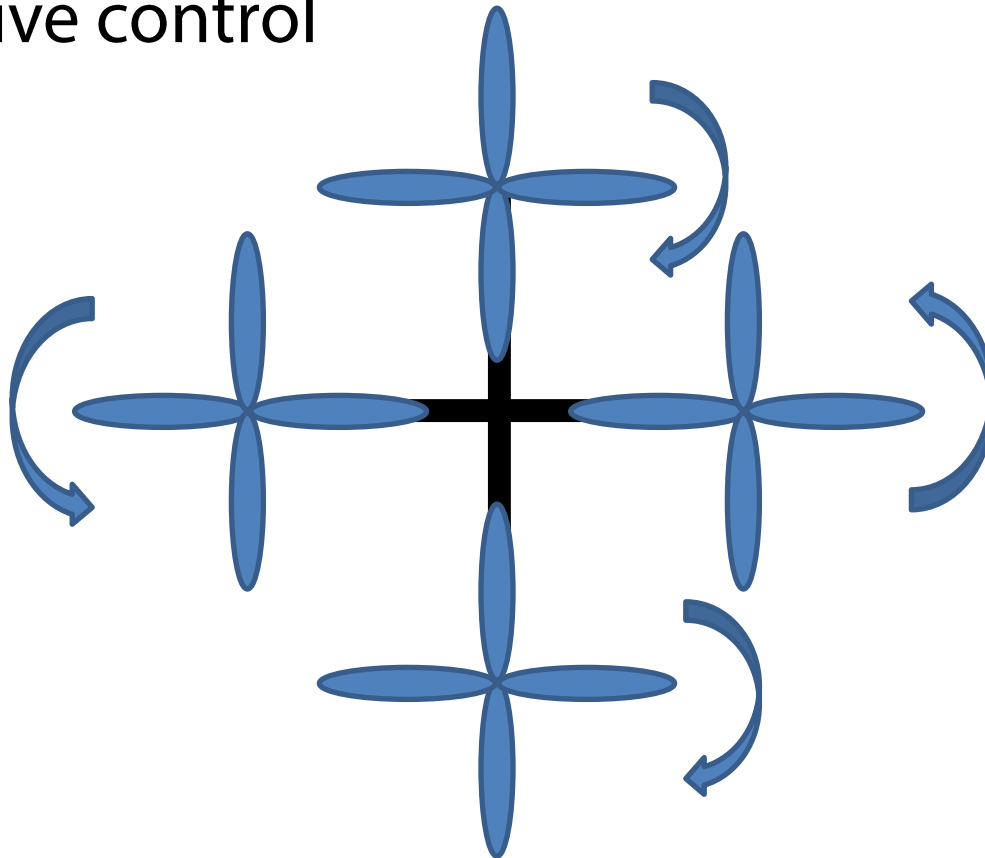- Some success in reducing vibration

Manikya Sandeep Ganti, SUPPRESSION OF ESSENTIAL TREMOR,
NIU Thesis – Director Abhijit Gupta

Counteracting Torque Concept

- Create a torque to counteract unwanted force
- Use active control

Tremor Signals

- Roughly sinusoidal
- Tremor frequencies
  - Resting 3-7 Hz
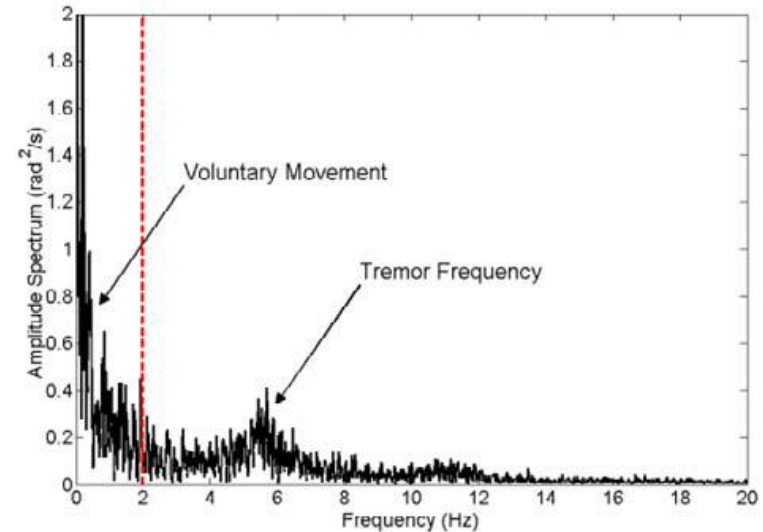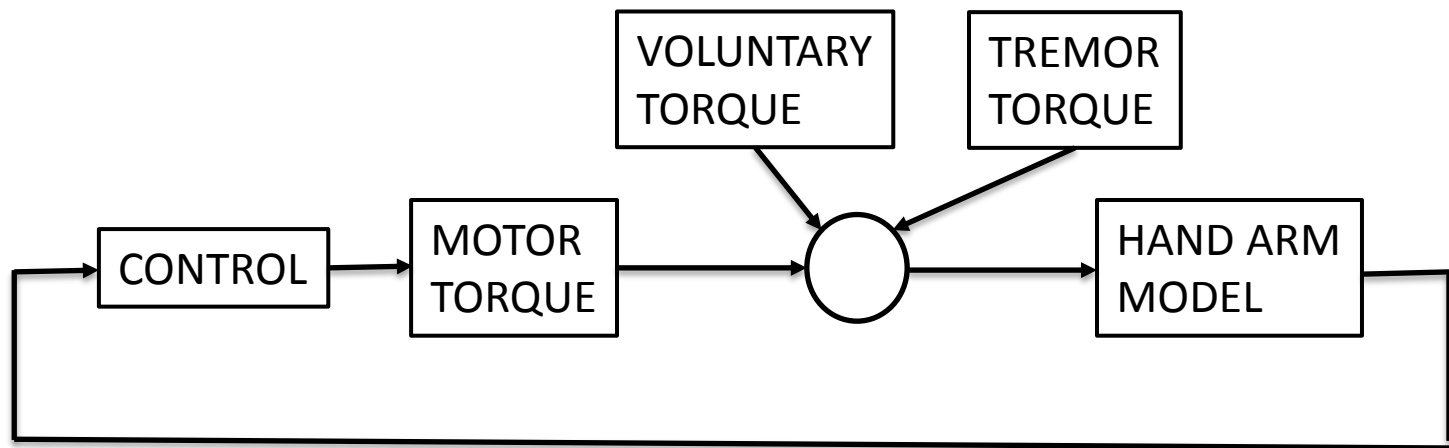 - Postural 5-12 Hz
- Voluntary motion lower frequency

Fig from J. A. Gallego et al., "On the use of inertial measurement units for real-time quantification of pathological tremor amplitude and frequency" Proceedings of the Eurosensors XXIII conference, 2009
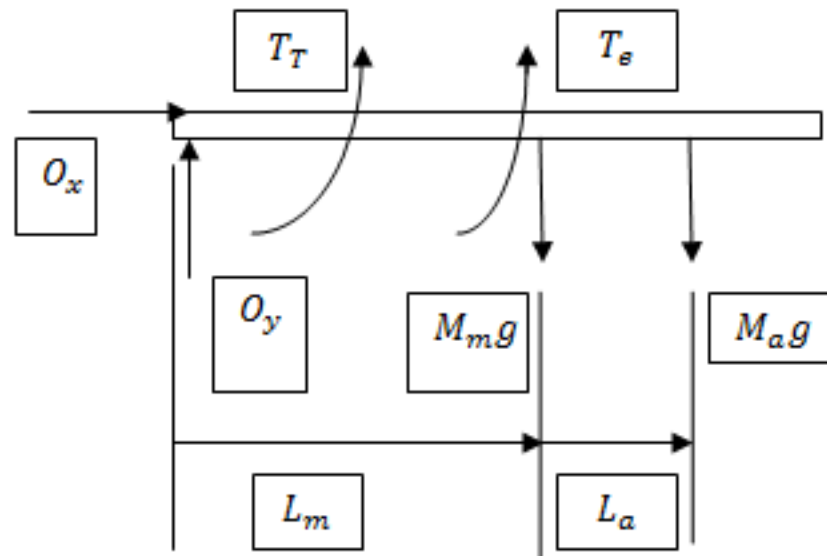
Separating Signal from Noise

- Advanced techniques could be used
- Started simple – PID feedback

Initial Simulation Model

- Used a simple cantilever model
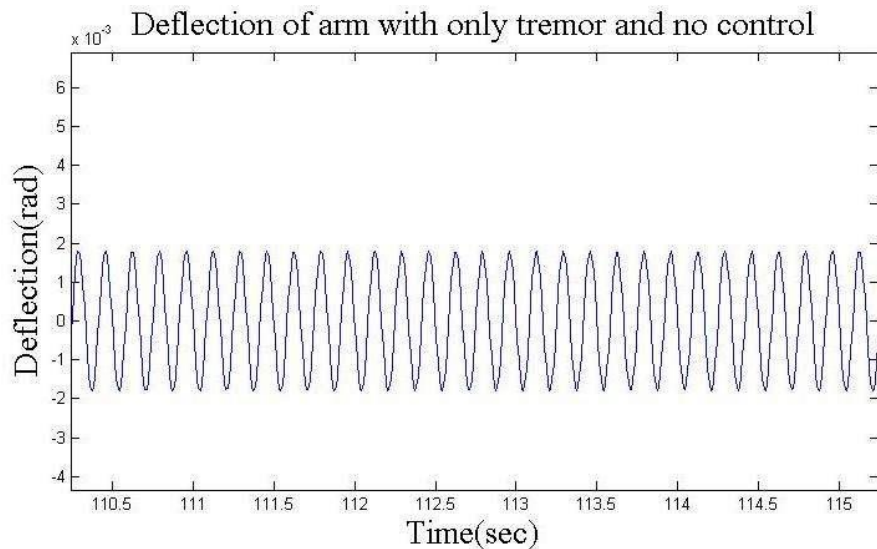- Tremor modeled around elbow

From: R. Velusa, SIMULINK IMPLEMENTATION OF ACTIVE CONTROL OF HUMAN HAND TREMOR OF PARKINSON'S DISEASE. NIU Masters Thesis
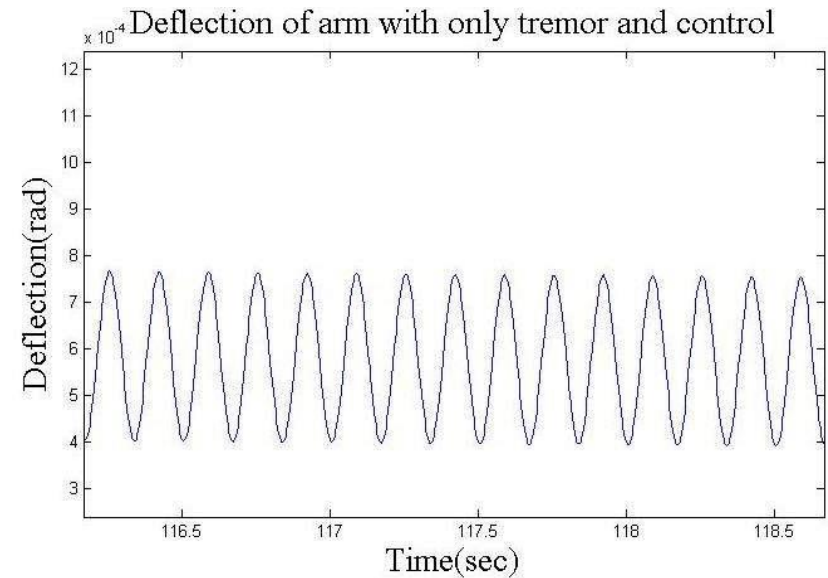
Simulated Tremor

- Tremor significantly reduced

Deflection of arm with only tremor and no control

Vert. Scale 10^{-3}

Deflection of arm with only tremor and control
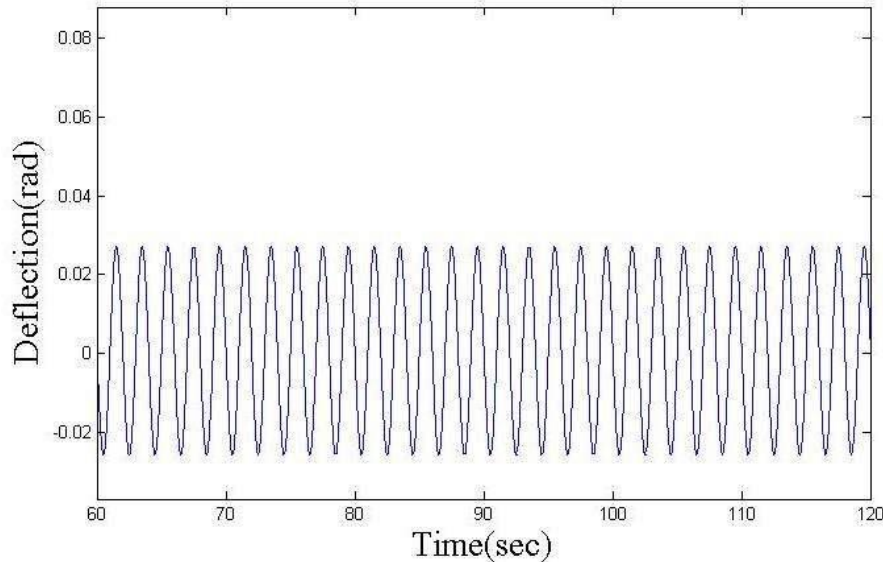
Vert. Scale 10^{-4}

From: R. Velusa, SIMULINK IMPLEMENTATION OF ACTIVE CONTROL OF HUMAN HAND TREMOR OF PARKINSON'S DISEASE. NIU Masters Thesis
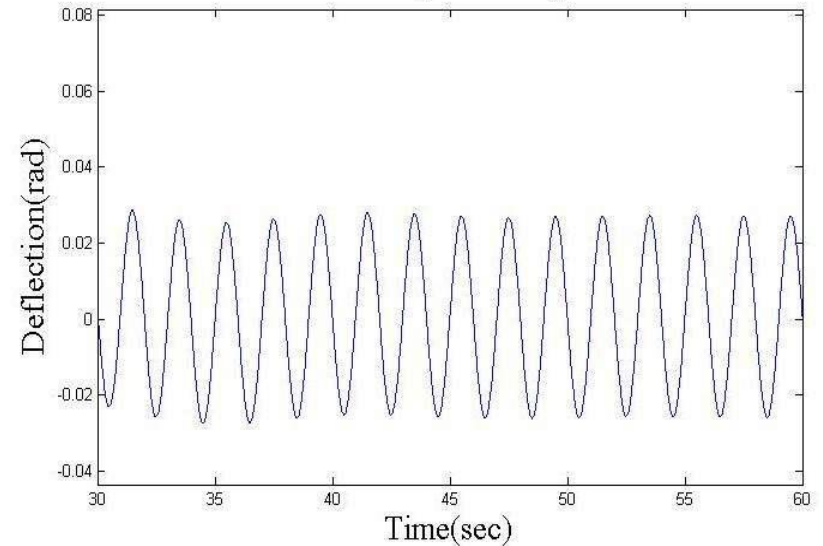
Simulated Voluntary Control

- Voluntary motion relatively unchanged

Deflection of arm with only voluntary motion and no control

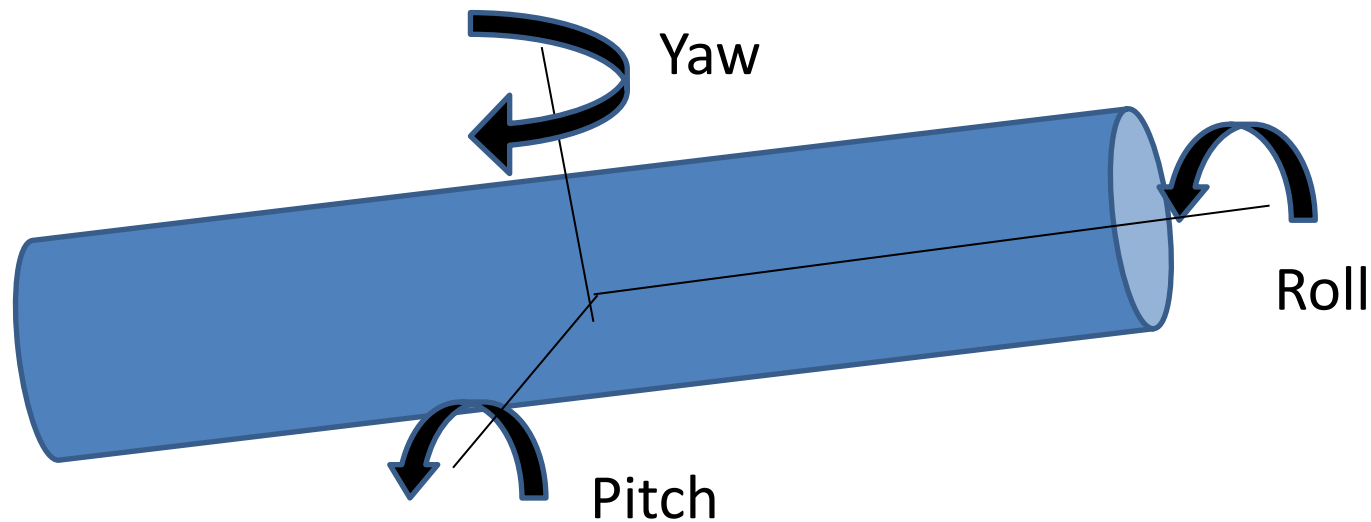Deflection of arm with only voluntary motion and control

From: R. Velusa, SIMULINK IMPLEMENTATION OF ACTIVE CONTROL OF HUMAN HAND TREMOR OF PARKINSON'S DISEASE. NIU Masters Thesis

More Complicated Motion

- Tremor motion multidimensional
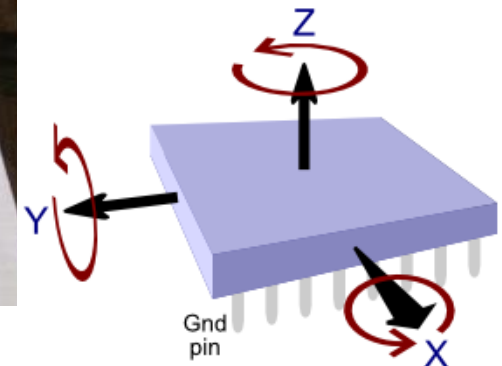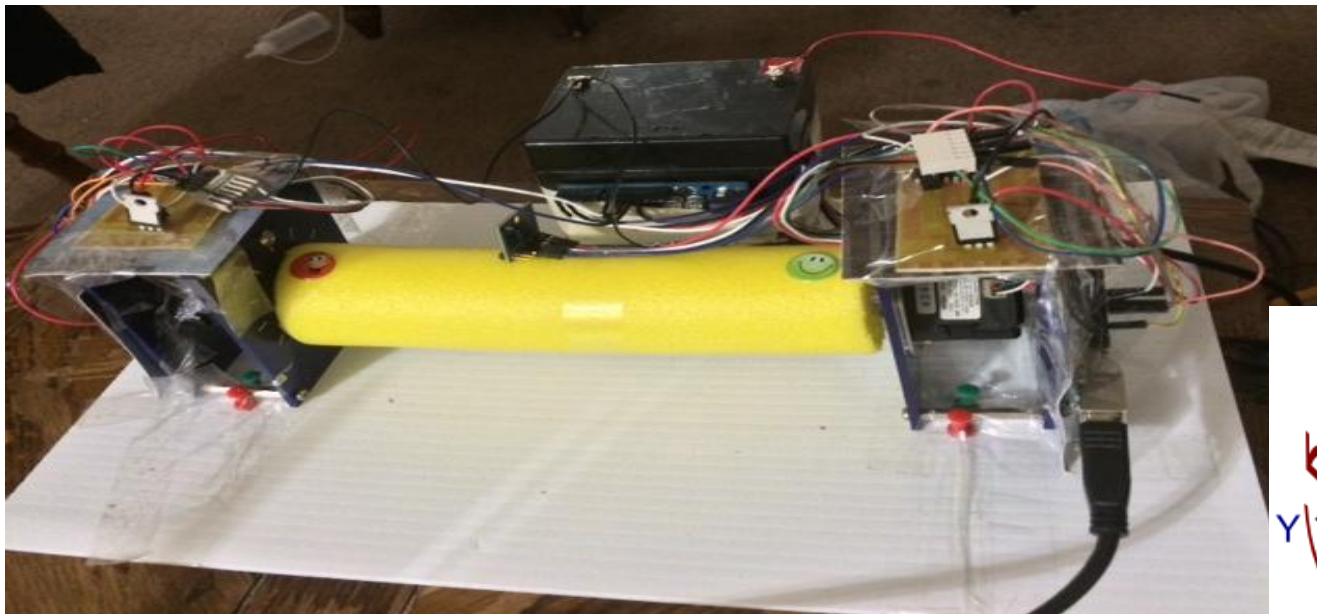- Important to measure in multiple dimensions

Sensing Tremor Vibrations
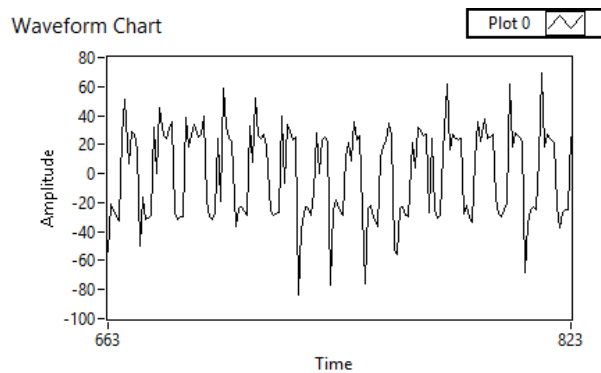
- System to measure three dimensions

From: D. Uppuluru, SENSING AND ANALYSIS OF VIBRATIONS OF TREMOR. NIU Masters Thesis
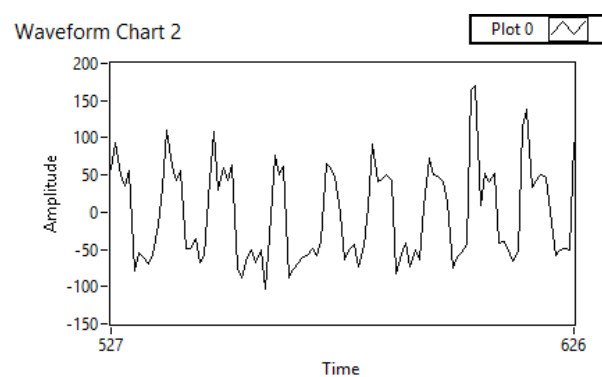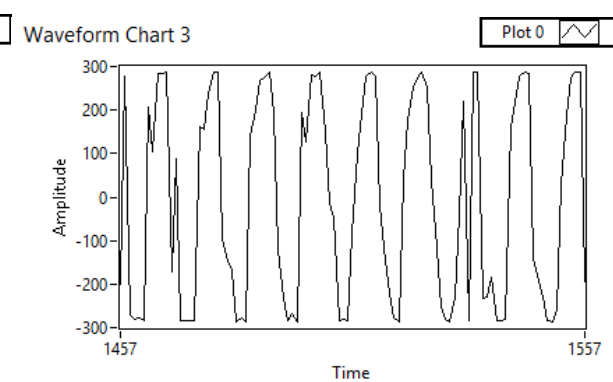
Sensor Results

- Measured values in three dimensions
- Consistent with tremor input
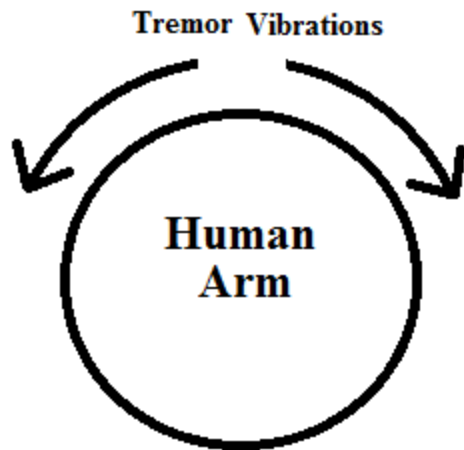

X   Y   Z

From: D. Uppuluru, SENSING AND ANALYSIS OF VIBRATIONS OF TREMOR. NIU Masters Thesis

Developing a Counteracting Torque

- Looked at rolling motion

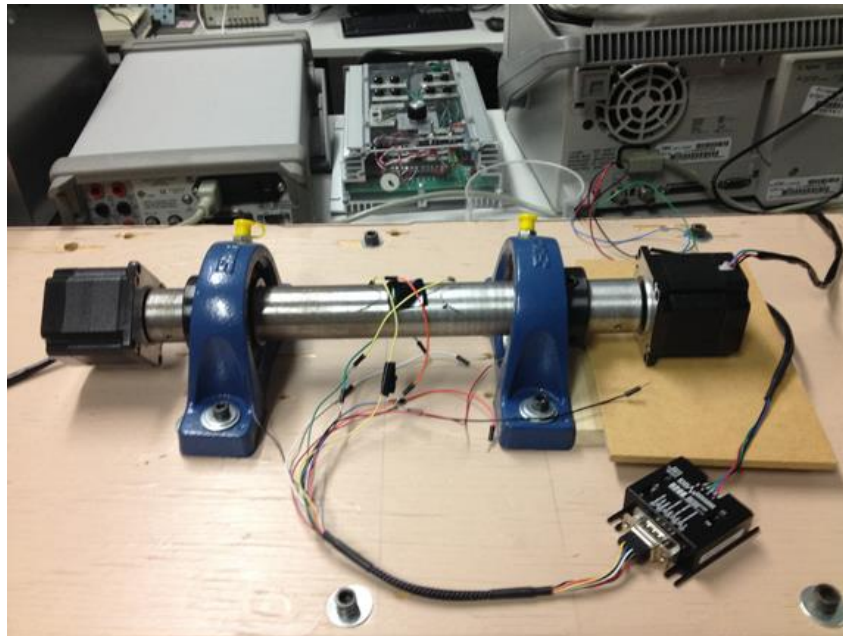- Freestanding motor used to counter torque

From: S Bahnoori, TREMORControl. NIU Masters Thesis
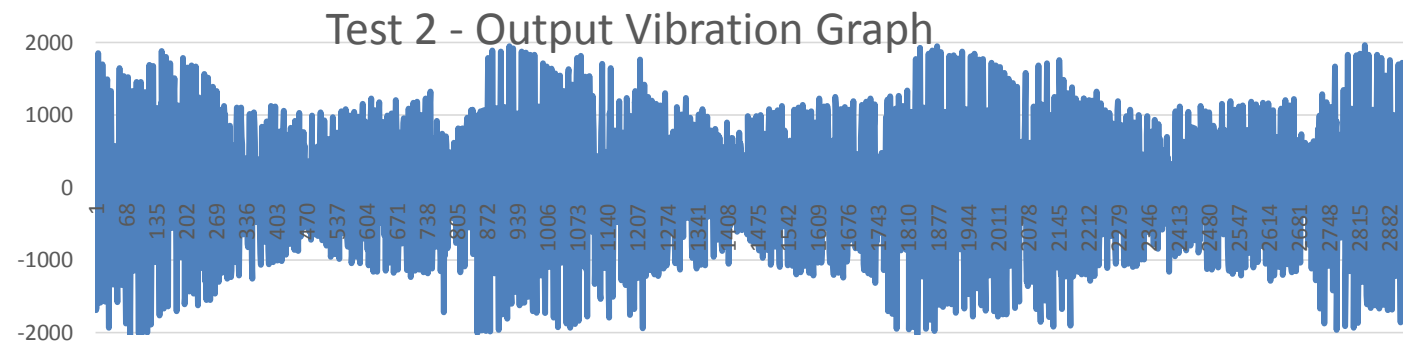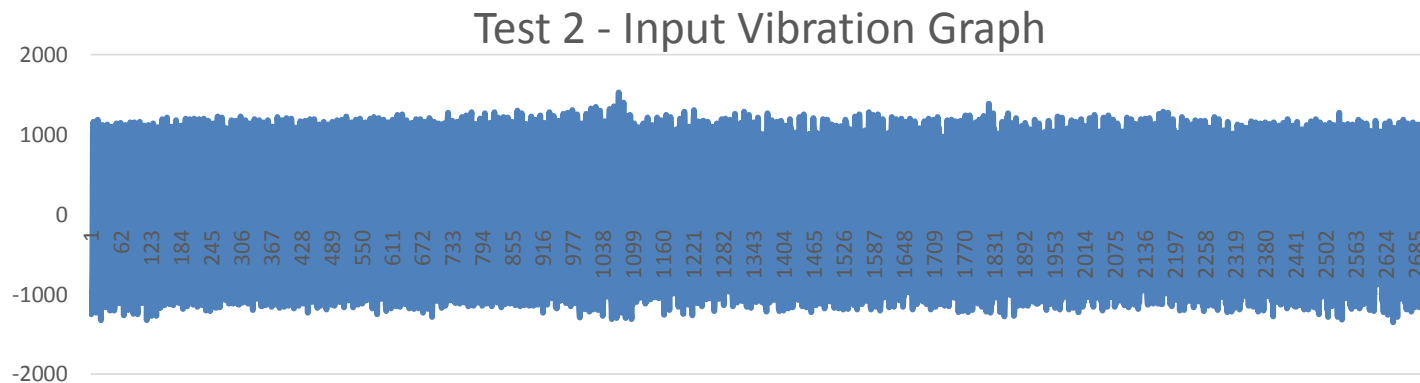
System Used

- Fixed motor to create vibration

- Free motor to counter the torque

Basic Results

- Not closed loop
- Beat frequency seen
- Indicates potential for reduction

Test 2 - Input Vibration Graph

Test 2 - Output Vibration Graph

From: S Bahnoori, TREMORControl. NIU Masters Thesis

More Work Needed

- Implies reduced oscillations possible

- Need to close the loop

- Free motor needs torque control

- More degrees of freedom

Concluding Remarks

- Reducing tremor desirable goal

- Solutions are being explored

- Electromechanical system may have a role

- Much work needs to be done