Northern Illinois University

Electromechanical Systems to Control Essential Tremor

IEEE RRVS Computer and Controls Meeting

Donald S. Zinger
Jan. 28, 2016
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
“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
Mechanical Engineering Approach

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

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

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
• 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

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

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