Wearable Essential
Tremor Solution

University of Florida
Biomedical Engineering

Jason Winters, Philip Barish, Nikita Agarwal,
Jennifer Jackson, Ethan Sherman, Tang Te
What is Essential Tremor?

- Common neurological disorder
- Shaking of hands and head
- Occurs during intentional movements
- Can affect almost any part of the body
  - Head, neck, torso, legs, tongue, voice
- Affects 10 million Americans (mostly over 60 years old)
- Not linked to other diseases
Essential Tremor Patient

Patient’s drawings show improvement with medication

(click picture to watch video)
Effects

- Not debilitating, but is distressing
- Social embarrassment
- Can lead to depression
- Everyday tasks and those requiring fine motor skills are difficult
  - Decrease in quality of life
Current Solutions

- Deep Brain Stimulation (Thalamus)
- Medication
- Mechanical Restraints
- Moderate alcohol consumption

Neater Eater
Bledsoe Arm Brace
Project Goal

Design a wearable device to mechanically or electrically alter or minimize tremor.
Solutions Considered

- Gyroscopes
- Resistance bands
- Workstation with fixed objects
- Active servo control
- Muscle stimulation
- Mechanical Damping
Initial Design – Servo Assisted Movement

- Computer-controlled feedback system
- Resists high frequency tremor motion
- Allows motion only under persistent force (low frequency)
- Measures current needed to maintain position
Materials

- Hobby servo (Futaba S3003)
- Servo control board (NetMedia’s SRV8-T)
- Power source
- Visual Basic program
- Graphical display
System Components

- Computer running visual basic control software
- Futaba S3003 servo
- 6V battery
- RS-232 link
- Servo control circuit
Theory of Operation

- Intended motion
- Tremor
- Time (sec)
- Approximation of Torque
- Torque trigger threshold
- Reset condition
- Intended motion timer triggered
- Actual motion of servo & couple joint
Drawbacks with Design

- Relies on software to decide patients intended movements
- Complicated
- Requires power source
- Not waterproof
- Delicate mechanism
Final Design – Viscous Damper Device

- Single DOF mechanism allowing flexion/extension motion of wrist
- Suppresses high frequency tremor but permits slower movements using viscous damping
- Attaches to forearm and hand

(click picture to watch video)
System Components

- finger loop
- linkage
- dashpots
- frame
- finger loop rail
- hinge joint
- elastic bandage
- adjustable valve
Construction

- Frame made of 6061 aluminum alloy
  - Elastic bandage attached to frame using 2-part epoxy
- Dashpots adapted from 10ml plastic syringes
  - Dashpot carriage held together with 2-part epoxy
  - Water used as viscous fluid (dye added for visibility)
Viscous Dampening

- Dissipates energy by restricting viscous fluid flow through a small orifice.
- Damping force is proportional to the velocity of the vibrating body.

\[ F = cv \]

- \( F \) is the damping force.
- \( c \) is the dampening coefficient.
- \( v \) is the velocity of the piston.

(Piston in cylinder dashpot arrangement)
Double dashpot design

- Opposing dashpots attached to one carriage
- Dashpots function as reservoirs as well
- Overcomes “suction cavitation” problem of single dashpot design
- Convenient place for flow restriction valve

(click picture to watch video)
Essential Tremor Simulations

Simple mass-spring-damper simulation shows influence of mechanical dampening on tremor

\[ m \ddot{x} + c \dot{x} + kx = F(t) \]
Normal Movement Simulation

Data Set: run1
Y: 0
t: 0

M

B
K

(click picture to watch video)
Movement with Essential Tremor

Data Set: run2

Y: 0

M

D

K

Y: 0

+Y

+1

(click picture to watch video)
Essential Tremor Patient with Damping

Slower movements but motion from tremor is suppressed.

(click picture to watch video)
Attachment to Body

- Elastic bandage with Velcro® provides adjustable yet secure attachment to forearm.
- Finger loop holds rail tight to back of hand but allows translation along length
  - Needed since wrist joint and device hinge joint aren’t coincident
Minimum torque required to overcome mechanical friction = 0.37 Nm

- Equivalent to flexion of wrist while gripping 1 pound weight

Total range of motion = 100°

- Flexion: 60°
- Extension: 40°

Device weight = 10 oz
Validation

<table>
<thead>
<tr>
<th>Test</th>
<th>Trial 1 (Hz)</th>
<th>Trial 2 (Hz)</th>
<th>Trial 3 (Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test 1</td>
<td>2.35</td>
<td>2.45</td>
<td>2.3</td>
</tr>
<tr>
<td>Test 2</td>
<td>1</td>
<td>1.3</td>
<td>1.25</td>
</tr>
<tr>
<td>Test 3</td>
<td>0.8</td>
<td>0.95</td>
<td>0.9</td>
</tr>
</tbody>
</table>

Duration = 20 sec
Test 1: no device
Test 2: device on, stopcock open full
Test 3: device on, stopcock mostly closed

Damping constant has clear effect on motion suppression.

User was asked to cycle device as many times as possible in given time.
Advantages

- Damping force adapts to tremor vibration
- Easily adjustable damping constant
- Requires no power source
- Simple
- Inexpensive
- Robust
Design Issues

- Attachment to the body
- Slight play with the hinge
- Leaks possible under heavy loading
- Difficult to attach to body on one’s own
- Patient testing needed
Future Implementation

- Currently designed for wrist joint but can be applied to other hinge joints (i.e. elbow)
  - More joints need damping to greatly suppress tremor
- High precision machining to reduce play in linkages
- Custom molded cuffs for easier attachment to body
- More compact design