Quantitative Hand Tremor Measurement using a LeapMotion Controller

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The LeapMotion Controller

Costs $80
What does it do?

**Interaction Area**
2 feet above the controller, by 2 feet wide on each side (150° angle), by 2 feet deep on each side (120° angle)

Detects hand movements and gestures in 3D area above and around the device
How do you use it?

- USB Device
- Move one or more hands above it
- Software can detect:
  - Palms
  - Fingers & thumbs
    - Including joints
  - Position
  - Rotation in 3D
- Samples at whatever frequency you wish
- Sub-millimeter accuracy
Programming the LeapMotion

• Leap.js
  – JavaScript library of APIs
• LeapMotion controller can therefore be used to control the User Interface of a browser-based application
The idea

• Kudos to Steve Owen, VA

• Could the LeapMotion Controller be used for quantitative assessment / measurement of hand tremor?
  – Doctors attending the NHS Hackday agreed it was worth trying out
Why Hand Tremor?

• Many reasons
  – Symptom of conditions such as Parkinson’s Disease
  – Indicator/symptom of other conditions
    • Neurophysiological
    • Psychological
    • Drug-induced
    • Trauma-induced
Currently 100% Subjective

Classification of tremors

Tremors can be initially classified as rest or action tremors. Rest tremors occur when the body part is supported against gravity, e.g. hands at rest in one’s lap. Mental stress or general movement makes rest tremors worse. Action tremors are further subdivided into static, postural or kinetic tremors.

- **Static** - occurs in a relaxed limb when fully supported at rest. Causes include Parkinson’s disease, Parkinsonism, other extrapyramidal diseases and multiple sclerosis.
- **Postural** - occurs when a part of the body is held in a fixed position against gravity (it can also remain during movement). Types include physiological tremor, exaggerated physiological tremor (e.g. thyrotoxicosis), anxiety states, alcohol abuse, drugs (see below), heavy metal poisoning, neurological diseases. Wilson’s disease, neurosyphilis, peripheral neuropathies, essential (familial) tremor, and task-specific tremors such as primary writing tremor.
- **Kinetic or action tremor** - occurs during voluntary active movement of an upper body part. If action tremor worsens as goal-directed movement approaches its intended target, this is intention tremor (indicative of a cerebellar cause). Associated with brain stem or cerebellar disease, including multiple sclerosis, spinocerebellar degenerations, vascular disease and tumours.

Summary

Tremor is the most common movement disorder. [1] It is defined as an involuntary rhythmic oscillation of ≥1 body parts, mediated by alternating contractions of reciprocally acting muscles. [2] It commonly affects the upper extremities, but can also affect the head, chin, voice, or legs. Tremor, if severe, may impair activities of daily living.
The Team

- Rob Tweed: Project leader / EWD.js Developer
- Simon Tweed: JavaScript / EWD.js Developer
- Fraser Thomson: Medical Student / Clinician liaison and research
- Madeleine Neil-Smith: Fourier Analysis expert
- Charlotte Lewis: User Experience
Demo

• Using EWD.js interface to VistA
  – Record measurements of hand tremor
  – Retrieve previous measurements

• 100% JavaScript using off-the-shelf Open Source libraries
  – Securely integrated with VistA
Potential Applications

• Effect of deep brain stimulation
• Recovery from brachial plexus/spinal trauma
• Monitoring progression of Parkinsons/Huntingdons (in terms of decline or medication)
• Detecting early onset of such diseases
• Efficacy of physiotherapy
• Hyperthyroidism (and quantify advantages of Thyroidectomy vs thyroid reducing drugs)
• Monitoring narcotic withdrawal (drug, alcohol, tobacco...even coffee?)
• Detecting placebo induced tremor
• Assessing control of prosthetic hand or limb
• Assessing finger dexterity
Next Steps?

- Possible clinical trials
- Collating sample traces from patients with “classic” symptoms of a variety of conditions
  - Taxonomy of trace profiles
Parkinsons

Narcotic withdrawal
Patient Telemedicine

• Cheap enough and simple enough to have patient use the device themselves at home
• Web Application, so results can be saved against patient record at hospital
  – View / Play-back traces
• Or, using Leap.js V2 APIs:
Virtual Hand Tremor Visualisation

3-D Rigged Hand Model

- real-time remote visualisation of patient hand tremor
- Playback of recordings
LeapMotion Controller

- Potentially could have a major impact
- Huge numbers of possibilities
- Opportunity to turn what is currently an entirely subjective “science” into true quantitative science

- Not bad for a $80 device!
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