Measuring Parkinson's Tremors with Kinect v2

Sponsor: CASAS & Microsoft

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Motivation

- Parkinson's Disease:
  - Progressive nervous system disorder
  - Major symptom is 3-7Hz tremors, often in the extremities
  - Affects over 7 million people worldwide[1]
- Proper pharmaceutical treatment requires frequent tracking of tremor severity[1]
  - Currently measured via visual inspection which is subjective and often unreliable[2]
- Objective tremor measurement devices currently in-use/being developed involve wearable sensors
  - Intrusive and their weight can mask tremor symptoms.[3]

Project Goals

1) Use Microsoft Kinect v2 to measure frequency and amplitude of hand tremors

2) Provide tremor rating consistent with clinical metrics
3) Validate design/implementation through rigorous testing
4) Target clinical test and wearable sensor comparability
5) Deliver prototype to CASAS for Parkinson's research

Glossary

- **Optical Flow:** Technique for measuring pixel motion
- **EMGU CV:** .Net wrapper for OpenCV library
- **OpenCV**: Open source computer vision library
- **FFT**: Fast Fourier Transform
- **TETRAS**: The Essential Tremor Rating Assessment Scale

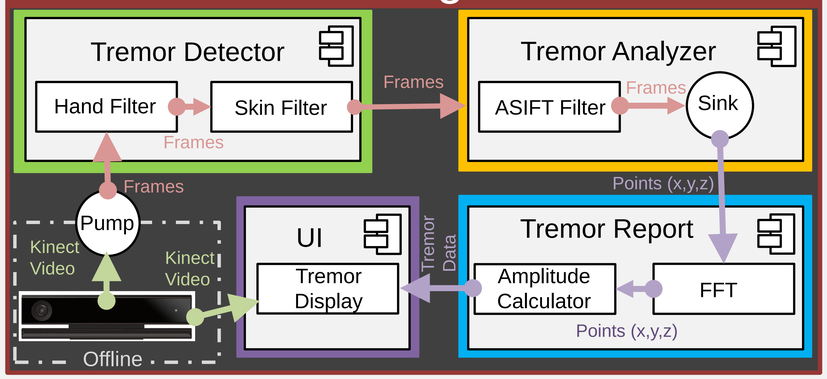
References

[1] Parkinson's Disease Foundation. www.pdf.org

[2] Bennet D et al. Metric properties of nurses' ratings of Parkinsonian signs with a modified Unified Parkinson's Disease Rating Scale. Neurology 1997; 49(6): 1580-1587

[3] Lemoyn R et al. Implementation of an iPhone for characterizing Parkinson's tremor. Conf Proc IEEE 2010

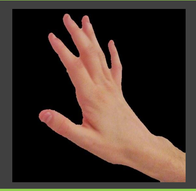
Design



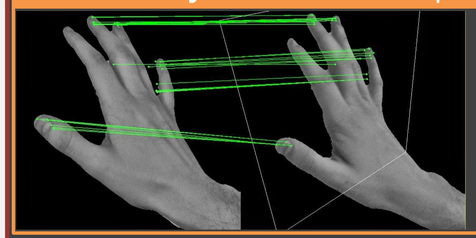
Implementation

Tremor Detector: Hand isolation and skin filter

- Use Kinect Skeletal feed to isolate area surrounding the hands
- Filter out pixels with color not falling within normal skin-tone range

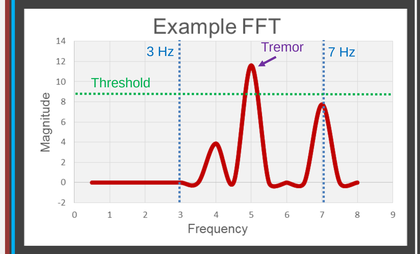


Tremor Analyzer: EMGU CV Optical Flow point matching

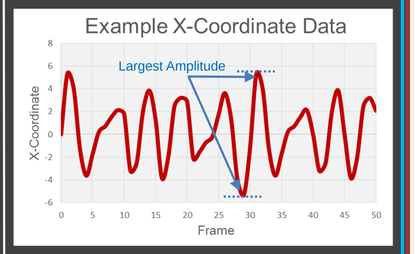


- Match points from frame to frame
- Record x,y,z coordinates of tracked points across time

Tremor Report: FFT & Amplitude Calculation



- Apply FFT to tracked data
- FFT outputs magnitude of frequency components
- Filter < 3Hz or > 7Hz
- Above threshold = tremor

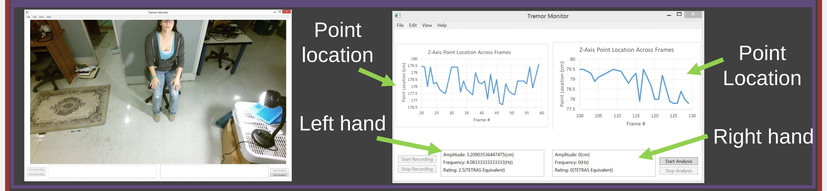


- Filter out outlying amplitudes
- Find largest amplitude (peak to peak) in cyclic tremor segments

Results

1) Software calculates tremor frequency & amplitude

User Interface: Display Tremor Data



2) Software calculates tremor rating based on TETRAS clinical tremor rating scale

Amplitude: 2.14147789929688(cm)
Frequency: 4(Hz)
Rating: 2(TETRAS Equivalent)

3) Rigorous testing of the software is underway

- Unit tests for each component integrated into automated test framework
- IRB approval obtained and test apparatus installed in Kyoto (Smart Home) for testing with target population

4) Test design mimics visual and wearable sensor testing for rest, postural, and action tremors
   - Positions product for future software testing and validation

Impact & Future Directions

Impact

- Increases Parkinson's research ability for CASAS
- Demonstrates new use for Kinect v2 hardware

Next Steps

- Improve hand filtering for better point detection
- Determine best cutoff magnitude for FFT
- Conduct in-depth research program for validation
- Compare software with wearable sensors
- Enable software integration into non-clinical settings

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Team Millennium Falcon