ParkinSense™: A Wireless Movement Disorder Quantification System

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Parkinson's Disease

1. Three major clinical features of Parkinson's disease (PD) include tremor, bradykinesia, and rigidity
2. Treatment with medication, particularly levodopa therapy, may result in dyskinesias
3. Currently, physicians assess PD severity by patient recollections and subjective scoring of a physical examination during patient visits using the Unified Parkinson's Disease Rating Scale (UPDRS)

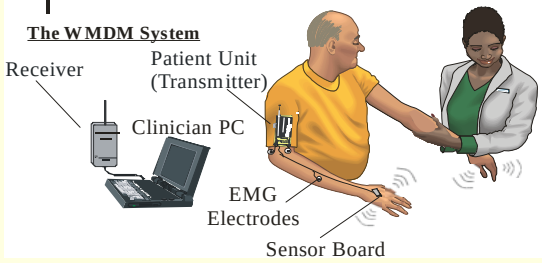
Project Objectives

1. Design, build, and clinically assess a portable, wireless device for monitoring and recording Parkinson's disease symptoms
2. Allow clinicians to more effectively modulate treatment interventions to provide subjects maximum symptom relief
3. Provide a novel research tool that combines kinetic motion and electromyography to quantify new treatment results

Figure 1: Wireless Movement Disorder Monitor

Real-time, Wireless Monitoring and Recording of Movement Disorders

Objectively quantifies Parkinson's symptoms and relates the measures to the Unified Parkinson's Disease Rating Scale.



Clinical Assessment
The current standard for evaluating Parkinson's disease is the Unified Parkinson's Disease Rating Scale, a qualitative assessment assigned a score and usually performed at a clinic

Methods

Hardware

Figure 2. Finger worn sensor board and wrist worn radio and data collection unit.

- Small, lightweight system
- Finger and wrist worn units
- 3 orthogonal accelerometers
- 3 orthogonal gyroscopes
- 2 channels of electromyography
- Bluetooth radio communication
- 12 hour rechargeable battery
- On board memory storage

Software

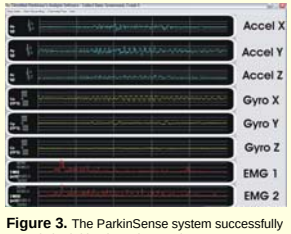


Figure 3. The ParkinSense system successfully records both kinetic and EMG data.

- Real-time data display
- Saves and recalls files
- Patient database
- Memory download and erase
- Configurable display settings
- Remote data access
- Report generation

System Overview

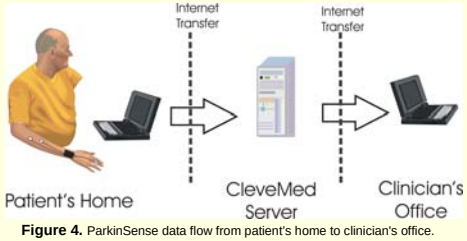


Figure 4. ParkinSense data flow from patient's home to clinician's office.

- The subject wears the ParkinSense system at home and completes UPDRS tasks as directed by the software interface
- The software automatically scores the severity of patient symptoms and generates a clinical report
- During the night, the patient PC sends the report files directly to a CleveMed server
- The clinician can connect to the server at anytime to download patient reports
- The clinician can modify the patient treatment protocol based on the report information

Clinical Trials

Figure 5. Clinical trials were completed for each subject as they wore the ParkinSense device and were evaluated by a clinician as per a subset of the UPDRS motor evaluation.

Subjects. To this point, trials have been completed with one normal and four PD subjects. Two PD patients utilized deep brain stimulation for symptom control, while the others used pharmaceutical therapy.

Evaluation. The subjects wore the ParkinSense while a clinician conducted a subset of UPDRS tests for tremor, bradykinesia, and rigidity. Each trial was videotaped so that clinician UPDRS scores could later be obtained for each trial. Two data collection periods were completed for each subject, once when Parkinson's symptoms were at maximum (an "off" period from medication or deep brain stimulation turned off) and once when the symptoms were under control from medication ("on") or deep brain stimulation. A randomized sequence of videos was then presented to clinicians for UPDRS scoring. The average clinician score was computed for each trial to minimize effects of scoring variability.

Figure 6. Subjects completed several motor tasks.

Clinical Results

- Quantitative variables were successfully processed from the kinetic sensor board data for each PD symptom
- Those variables were successfully fit to regression models that accurately output a clinician's UPDRS score for tremor and bradykinesia
- A higher UPDRS tremor score was correlated with a higher peak frequency, a higher power, a higher average excursion, and higher peak amplitude
- A higher UPDRS bradykinesia score was correlated with a lower peak frequency, a lower power, lower average amplitude, a higher slope, and a higher damping coefficient.

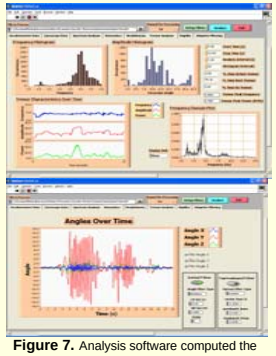


Figure 7. Analysis software computed the temporal and spectral characteristics (top) as well as other variables of interest such as hesitations (bottom).

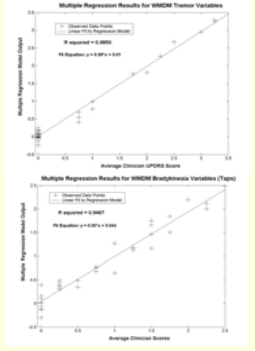


Figure 8. A multiple linear regression model was fit to clinician scores for tremor (top) and bradykinesia (bottom).

Conclusions

The ParkinSense system successfully recorded kinetic and EMG data. The kinetic data was successfully processed and fit to a model to accurately predict a clinician's UPDRS score of a particular PD symptom.

By capturing the complex fluctuation patterns of patient symptoms at home, we can develop a method of monitoring severity of PD manifestations that will provide a better way to assess responses to clinical therapeutics and improve the quality of life of PD patients.

Figure 9. The ParkinSense system could be used in any location to evaluate the severity of Parkinson's symptoms.

Acknowledgments

This work was supported by NIH Phase I SBIR Grant No. 1R43NS043816-01A1 and Phase II SBIR Grant No. 5R44NS043816-03