iTrem

Robert Delano, Brian Parise and Leanne West
Georgia Tech Research Institute, 925 Dalney St., Atlanta, Ga, U.S.A.

Keywords: iPhone, Essential tremor, Parkinson's, Mobile phone, Human-computer interaction.

Abstract: iTrem is an iPhone application that uses the phone's built-in accelerometers to collect frequency and amplitude data of hand tremor in people with Essential Tremor, Parkinson's Disease, and other neurological conditions. iTrem makes it possible to take frequent tremor data samples from a subject and communicate it in real time to a doctor or researcher independent of the subject's location. Aggregating the tremor data collected by iTrem provides a way for patients, doctors and researchers to collaborate on a grand scale, possibly shedding light on new avenues of treatment and therapy.

1 INTRODUCTION

Essential Tremor and Parkinson's disease are the most common neurological conditions defined by tremor and collectively affect 5 to 10 million people in the U.S. (Boelen, 2009). Parkinson's kills one person every 26 minutes in the U.S. alone (Xu, Kochanek, Murphy, and Tejada-Vera, 2007)! There is no definitive diagnosis for either condition; both are a clinical diagnoses based on symptoms and response to medication (Anwar and Sweeny, 2010). Very little data about tremor is available to track the effectiveness of medication and therapy over time.

Essential Tremor affects nearly 1 out of 5 people over 65 and is usually progressive (Beers and Jones, 2005). Commonly beginning in young adulthood, Essential Tremor becomes more obvious with age, usually resulting in some degree of disability.

Originally called "The Shaking Palsy", Parkinson's is a progressive disorder of the central nervous system caused by a loss of Dopamine in the brain. The patient experiences four primary symptoms: tremor, rigidity, slow movements, and loss of balance. One of the most common neurological disorders 5 to 10 percent of people with Parkinson's present will symptoms before the age of forty (Grimes, 2004).

Dopamine replacement is the "gold standard" for treating Parkinson's disease. Patients experience what doctors refer to as "on/off" times with the medication refer to. On is when there is some symptom relief and off is when the symptoms return. To sustain a therapeutic effect it is crucial to anticipate the off times and take medication in advance to reduce the occurrence of off times. Some patients take medication every two hours and others just a few times daily. Being able to track the severity of symptoms throughout the day will help patients and doctors define an optimum daily medication schedule.

Tremor is the most common movement disorder and is defined as an involuntary, rhythmic, oscillating movement of nearly constant amplitude (Anwar and Sweeny, 2010). The amplitude of a tremor determines the severity of the disability where the frequency can be characteristic of a specific disorder (see Table 1).

There are three categories of tremor, resting, postural, and kinetic or intention tremor. Resting tremor occurs when the body is at rest and supported against gravity. Postural tremor occurs when holding any intentional posture, such as the arms out stretched. Kinetic or intention tremor may appear during any voluntary movement. Many patients experience a combination of all three types of tremor. (DeMeyer, 2004).

There are three categories of tremor, resting, postural, and kinetic or intention tremor. Resting tremor occurs when the body is at rest and supported against gravity. Postural tremor occurs when holding any intentional posture, such as the arms out stretched. Kinetic or intention tremor may appear during any voluntary movement. Many patients experience a combination of all three types of tremor (DeMeyer, 2004).

Delano R., Parise B. and West L..
iTrem.
DOI: 10.5220/0003177701150118
In *Proceedings of the International Conference on Health Informatics* (HEALTHINF-2011), pages 115-118
ISBN: 978-989-8425-34-8

Table 1: Tremor Frequencies (Rohkamm, 2004).

Frequency	Disorder
2.5-5 Hz	Cerebellar tremor, Holmes tremor
3-6 Hz	Parkinsonian tremor
7-9 Hz	Essential tremor, postural tremor in parkinsonism
7-12 Hz	Physiological tremor, exaggerated physiological tremor
12-18 Hz	Orthostatic tremor

The severity of tremor is most often determined by a subjective clinical observation made by a Movement Disorder Specialist (MDS). The doctor or patient bases medication and therapy choices on an observed response to medication.

Reproducible objective tremor data, as is collected by the iTrem application, will provide doctors with more information when choosing daily medication schedules and types of therapy. With a larger quantity of reliable data, researchers will have another avenue to spot trends in therapy. Actively involving the patient may also provide some level of comfort for the patient, increased communication with the doctor, and more satisfaction with the care provided (Sheldon and Kaplan, 1985).

2 TREMOR MEASUREMENT

The cost and challenge of gathering frequent tremor data discourages the collection and aggregation of data. In many cases, therapy choices are based solely on the subjective clinical observation of a doctor. These observations could work in conjunction with objective data collection, thereby creating a multidimensional approach towards the treatment of tremor (Tarsy, Vitek and Lozano, 2003).

2.1 Clinical Rating Scales

Most tremor rating scales are based on a simplistic rating score of 0 to 4, with 0 being no detectable tremor. Although still used, many scales have not been validated or found to be reliable. The Washington Heights-Inwood Tremor Rating Scale is the only validated clinical tremor rating scale (Chen and Swope, 2010).

The Washington Heights-Inwood Tremor Rating Scale first has the patient hold his/her arms in front with wrists pronated and then in a “wing” position. The patient is also asked to pour water from one cup into another, use a spoon to drink water, perform finger to nose movements, and draw Archimedes spirals. Tremor is rated on a scale 0 to 3, with 0 being normal. Although, this technique has been validated, a scale of 0 to3 does not allow for subtle differences in frequency and amplitude. The Washington Heights-Inwood Tremor Rating Scale is also not designed for the testing of resting tremor (Tarsy, Vitek and Lozano, 2003).

2.2 Professional Measurement Systems

The expense and time required for doctors to use electronic-physiologic methods like the EEG and EMG usually discourages the use of these devices. By attaching 16-20 electrodes to a patients scalp, an Electroencephalography (EEG) can record the electrical activity along the scalp caused by the firing of neurons in the brain (Niedermeyer and da Silva, 1999).

An electromyography EMG uses a very thin needle electrode that is placed through the skin into the muscle. The electrode then picks up the electrical activity produced by the muscles. An EMG may cause mild discomfort where the electrodes are inserted and may leave the tested muscle tender afterwards.

Both EEG and EMG are expensive and time consuming. An average EMG takes around 15-20 minutes to complete and may cause discomfort. An EEG can last about 1-½ hours. EEG and EMG procedures also require the patient to be on location. iTrem is affordable, mobile and painless.

2.3 Off-the-shelf Measurement Systems

Although off-the-shelf products are available for tremor measurement, there are no devices that collect and store tremor data for review and research. They also require that the patient and doctor be in the same location.

Two examples of off-the-shelf tremor measurement devices are the Tremorometor (www.managingtremor.com) and the Stressometer (www.tnr.fr). Designed to test for tremor in an office or clinic, the Tremorometer® provides acceleration measurements by taping a sensor to the patient’s index finger for 15-second tests. The Stressometer has the ability to measure tremor caused by neurological disorders, but instead focuses on the microscopic tremors of the nervous system as they relate to stress.

Table 2: Feature comparison.

Feature	iTrem	Tremorometer	Stressometer
Measure tremor	Yes	Yes	Yes
Real-time patient doctor communication	Yes	No	No
Aggregate patient data	Yes	No	No
Expandable	Yes	No	No
Hardware Cost	>=$199	$595	~$650

3 iTrem

Both a phone and a breakthrough Internet device, the iPhone garnered over 25 percent of the mobile market by the end of 2009 (Tabini, 2010). The iPhone's sensitive accelerometers, Internet access, and popularity made it an ideal hardware choice for creating an application to track tremor and communicate that data instantaneously to doctors.

iTrem is a newly developed mobile iPhone application that provides an affordable and easy method to collect reproducible, objective tremor data (See Figure 1). Resting, postural, and intention tremors can be measured with the iTrem system. iTrem can connect the doctor, patient, and researchers in real time without requiring them to be in the same geographic location. Tremor data can be transmitted to a web repository for doctor review or aggregated for research. Through the patient's web profiles, doctors can remotely schedule tests, test reminders, and medication reminders.

To collect data with iTrem, the patient holds the iPhone and performs simple arm or hand movements to test resting, postural, and action tremors (See Figure 2) that are based on the movements that a patient would perform in the Doctor's office. To collect data with iTrem, the patient holds the iPhone and performs simple arm or hand movements to test resting, postural, and action tremors (See Figure 2) that are based on the movements that a patient would perform in the Doctor's office. The tests last 10 to 15 seconds each. Holding the iPhone during these tests, the iTrem application measures tremor data, including amplitude and frequency, using the iPhone's accelerometers.

To collect data with iTrem, the patient holds the iPhone and performs simple arm or hand movements to test resting, postural, and action tremors (See Figure 2) that are based on the movements that a patient would perform in the Doctor's office. The tests last 10 to 15 seconds each. Holding the iPhone during these tests, the iTrem application measures tremor data, including amplitude and frequency, using the iPhone's accelerometers.

Figure 1: Actual tremor index meter.

Doctors and researchers can program the phone via the web server. Test schedules and configurations are stored on the server and synchronized to the phone periodically. The iPhone will remind the patient when to take each test with an alert or reminder. The phone will then briefly instruct the patient as to what actions to perform for each test including, resting, postural, and action. The results of every test are stored in a Web Repository.

After collection, patient data is uploaded to a private profile on a secure web server. Doctors can then review the objective data to assess medication response, progression, and tremor severity. This information will also help the patient and doctor anticipate "off" times and adjust the daily medication schedule accordingly.

Figure 2: Resting, postural and action tremor tests.

Access to the data is restricted to the patient and their doctor. Researchers could have access to an anonymized version of the entire patient databases (See Figure 3). The tremor data will assist doctors in diagnosis, as well as helping patients refine their daily medication schedules to minimize "off" times.

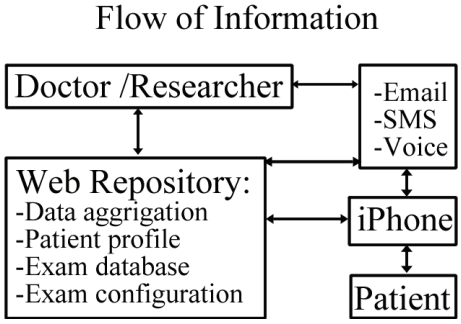

Figure 3: Flow of information.

3.1 Data Collection

Accelerometers inherently produce a small amount of noise, and the iPhone accelerometer is no different. iTrem compensates for with custom filters and data smoothing algorithms. To date, the collected data has been consistent. Validation has been performed by comparing results from iTrem with results gathered by the Mayo clinic using their measurement instrumentation. More rigorous validation will occur in the next phase of development with the use of a motion capture system. Using the high fidelity tracking capabilities of the modern IR-based motion capture systems iTrem will be able to measure in 3 dimensions hand tremor displacement and compare that with the data collected by the iTrem application.

4 FUTURE DEVELOPMENT

While continuing to develop the tremor tests the iTrem team is now collaborating with a Movement Disorder Specialist (MDS) and clinical researcher whose specialty is the study and treatment of Parkinson's disease. The MDS has agreed to determine the effectiveness of iTrem as a tool in the exam room as well as the validity of the measurements.

Simple games are also being developed to record tremor data. The game is designed so that the motion of the game play can be filtered out to reveal the tremor data. Games also offer the capability to gather baseline data from individuals without tremor who are willing to play the game and contribute their movements to the tremor database as well as allow for the collection of data from patients who are focusing on using tremor affect hands and arms to perform tasks such as keep a character in the game still.

ACKNOWLEDGEMENTS

Funding for this effort to date has been provided by of the Georgia Tech Research Institute Electro-Optical Systems Laboratory's Landmarc Research Center through Internal Research and Development funding.

REFERENCES

Ahmed, Anwar, Sweeny, Patrick Tremor. Retrieved March 2, 2010 from Cleveland Clinic: http://www.clevelandclinicmeded.com/medicalpubs/disease management/neurology/tremors/.

Beers, Mark H. and Jones, Thomas V. *The Merck Manual of Health & Aging.* Ballantine Books, New York, 2005. 357, 360.

Boelen, Miriam *Health Professionals' Guide to Physical Management of Parkinson's Disease.* Human Kinetics, Champaign, IL, 2009. 69.

Chen, Jack J. Swope, David M. Retrieved March 3, 2010 from Medscape: *Essential Tremor: Disability Associated with Essential Tremor: Clinical, Functional, and Psychosocial.* http://www.medscape.com/viewarticle/461397_9.

Greenfield, Sheldon, M. D., Kaplan, Sherrie, Ph.D., M. P. H; and Ware, John E., Jr., PhD *Expanding Patient Involvement in Care: Effects on Patient Outcomes.* Annals of Internal Medicine , April 1, 1985.

Grimes, David A. *Parkinson's: everything you need to know.* Firefly Books, Buffalo, New York, 2004.

DeMeyer, William Technique of the Neurologic Examination. McGraw-Hill Companies, Inc., 2004. 347-348.

Rohkamm, Reinhard *Color Atlas of Neurology*. Thieme, Stuttgart, Germany, 2004.

Niedermeyer, Ernst, da Silva, F. H. Lopes *Electroencephalography*, 4th Ed., Lippincott Williams & Wilkins, Philadelphia, PA 1999.

Stressometer: www.tnr.fr

Tabini, Marco comScore: *Apple gained US smartphone market share* in December. Retrieved March 4, 2010 from MacWorld: http://www.macworld.co.uk/

Tarsy, Daniel, Vitek, Jerrold Lee, and Lozano, Andres M. *Surgical treatment of Parkinson's disease and other movement disorders*. Humana Press Inc., Totowa, New Jersey, 2003.

Tremorometer: www.managingtremor.com/.

Xu, Jiaquan, M. D., Kochanek, Kenneth, M. A., Murphy, B. S. and Tejada-Vera, B. S. *National Vital Reports.* U.S. Department of Health and Human Services, Hyattsville, MD, 2007.