A Wearable System for Home-Monitoring of Parkinson’s Disease

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Parkinson’s Disease (PD)

- Affects 7-10 million people worldwide
- Symptoms
  - Tremor
  - Bradykinesia (slowness of movement)
  - Rigidity
  - Freezing of gait
  - Sleep problems
  - Mood disorders (depression and anxiety)
  - Unexplained pain
- Combined direct/indirect cost of PD: $25 billion/year
  - Treatment
  - Social security payments
  - Lost income from inability to work
  - Frequent clinic visits
Treatment Protocol

1. Patient meets with doctor every 3-6 months
2. Patient self-reports symptoms and medication response
3. Quick motor function assessment
4. Doctor adjusts medication dosage

Patient self-reports are inaccurate and motor function assessments are a single snapshot
Motor Function Assessment

- Movement Disorder Society – Unified Parkinson’s Disease Rating Scale (MDS-UPDRS)
  - Four parts
    1. Non-motor aspects of experiences of daily living (13 questions)
    2. Motor aspects of experiences of daily living (13 questions)
    3. Motor Examination (18 questions)
    4. Motor Complications (6 questions)
  - Each question is scored 0-4 (larger means more severe)
  - Severity rating is sum of scores

*UPDRS is subjective (inaccurate) and logistically difficult to administer*
Problems

• Inaccurate patient self-reports
  • Difficulties monitoring patient symptoms and medication response

• Subjective motor function measures
  • Difficulties monitoring disease progression

• Frequent clinic visits
  • Inconvenient for patient
  • Major contributor to high cost of PD treatment
Solution: Home-Monitoring

- Tremor
- Stiffness
- Medication intake
- Dyskinesia

Project funding through DHTI
AUTOMATED MOTOR SYMPTOM DETECTION THROUGH WEARABLES
Impacts

• Enable clinicians to track their patients:
  • Symptom occurrences
  • Medication response
  • Disease progression
• Facilitate a more personalized drug-therapy regimen
• Help evaluate candidates for deep brain stimulation (DBS)
• Develop a more objective severity estimate
Hardware Considerations

- Battery life
- Sensors
  - Accelerometer
  - Gyroscope
  - Magnetometer
- Cost
- Wearability
  - Size
  - Ease of use
  - Aesthetic appearance
Progress to Date

• Development of machine learning algorithms

• Tests on three data sets:
  • Synthetic data
  • Accelerometer data of human motions
  • Accelerometer data of simulated PD tremor (using healthy subjects)
Segment-based Support Vector Machines (Seg-SVMs)
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1. Model
2. Scores (likelihood of being a symptom)
Segment-based Support Vector Machines (Seg-SVMs)
Progress to Date

• Development of machine learning algorithms
• Tests on three data sets:
  • Synthetic data
  • Accelerometer data of human motions
  • Accelerometer data of simulated PD tremor (using healthy subjects)
Methods

• One healthy subject
• Single accelerometer on dominant wrist
• Simulated tremor events (10-30 seconds each)
• Training data:
  • 1 hour of normal activity
  • 10 simulated tremor events
• Testing data:
  • 2 days of normal activity (excluding sleeping)
  • 10 simulated tremor events
Training Data

![Graph showing acceleration over time with x, y, and z-axis data.](image)
Training Data

![Graph showing acceleration as a function of time with three axes (x, y, z) plotted over time. The graph displays various data points and trends.](image)
Testing Data Results

![Graph showing acceleration and score over time](image)
Testing Data Results

Score (confidence)

Time
Summary

• Problem – Current PD treatment protocols suffer from several shortcomings
  • Frequent clinic visits (inconvenient and costly)
  • Inaccurate monitoring of patients between visits
  • Subjective motor function assessment tests
• Solution – home-monitoring using the Microsoft Kinect sensor and wearable devices
• Current Progress
  • Developed machine learning algorithms
  • Tested algorithms on three datasets (synthetic, human motion, simulated tremor)
• Next Steps
  • Collect data from PD patients
  • Test algorithms
QUESTIONS?