Monitoring Human Performance with Wearable Accelerometers

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Motivation

- Parkinson’s Disease (PD): A progressive neurodegenerative movement disorder affecting 3% of the population over 65 years.
- Periodic assessment of motor impairments is very crucial; currently used human observer-based assessments are subjective and inadequate for spotting mild symptoms.
- Motion capture systems: Becoming more portable/affordable for clinical use and give very precise motion information of the whole body.

Project goal: Use motion capture data for quantitative analysis of motor symptoms in PD

Dataset

- Participants: 4 PD patients (1 male, 1 female) and 2 healthy controls. All the PD patients had Deep Brain Stimulator (DBS) implanted (age range from 51 to 67 years).
- Patients were off-drugs for 12 hours and then went through various motor tests on and off stimulator. The UPDRS motor components tested were: action tremor, tremor at rest, hand movement, leg agility, gait and postural stability.
- Used a Vicon motion capture (Mocap) system with 16 infrared cameras (sampling at 120 Hz) to capture body movements during each test. UPDRS scores (0 to 4 range) were assigned by trained professional: 0-2 → mild symptoms and 3-4 → severe symptoms.

Features

- Marker trajectories were high-pass filtered (4 Hz cut-off).
- Maximum amplitude variations after high-pass filtering (tremor effect). Ratio of the total signal energy with energy content beyond 4Hz.
- Frequency domain entropy. Compute the features on the variations of the hand-normal, knee height variations (for leg agility).
- Center of Mass (COM) variations, body angle variance (postural stability); mean speed, mean step width (gait).

Mild vs. Severe Symptom Classification

- We demonstrate the quantitative differences between mild and severe symptoms for different features across various motor tasks (below). F1 through F5 represent various features associated with high frequency energy content and peak-to-peak amplitude variations. F6 and F7 represent maximum speed deviation and body angle variance.
- We used a Support Vector Machine (SVM) for discriminating mild (score 0-2) vs. severe (score 3-4) symptoms as well as ON vs. OFF DBS states across various motor tasks.
- Each classifier went through a leave one out cross-validation test (classification results are shown here).