In-Home Video and IMU Kinematics of Self Guided Tasks Correlate with Clinical Bradykinesia Scores

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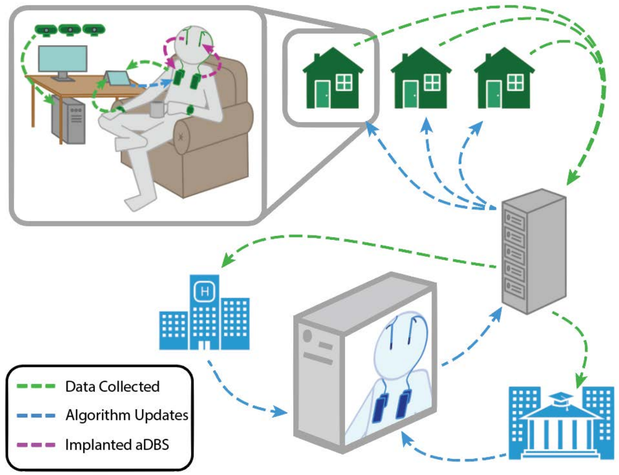
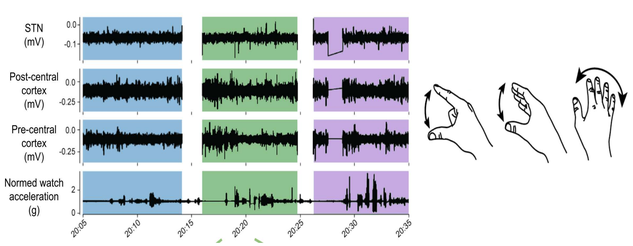
Motivation



Adaptive Deep Brain Stimulation (aDBS) uses symptom-related biomarkers to adjust therapeutic stimulation parameters in real time to treat symptoms of neurodegenerative diseases such as Parkinson's Disease (PD). To make aDBS scalable, methods for automating aDBS parameter updates must be developed. This in turn **requires methods to assess PD symptoms outside clinical observation**.

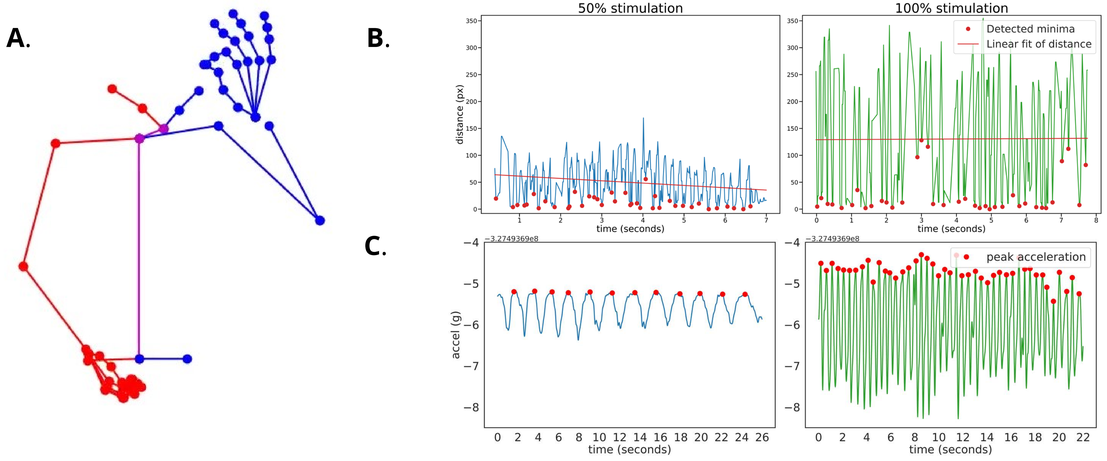
Study Setup

Patient Implantation: 1 adult male with PD had leads implanted in the subthalamic nucleus and the motor cortex.
Multi-Modal Data Collection Platform: We designed and deployed a remote data collection platform to the subject's home.
Experimental Tasks: We collected data for 1 week while the patient performed clinical tasks taken from the Unified Parkinson's Disease Rating Scale (UPDRS), including finger tapping, hand open-closing, and wrist rotations. Each task was repeated at three **different stimulation levels** to expose stimulation-dependent symptom changes.



Assessing Bradykinesia

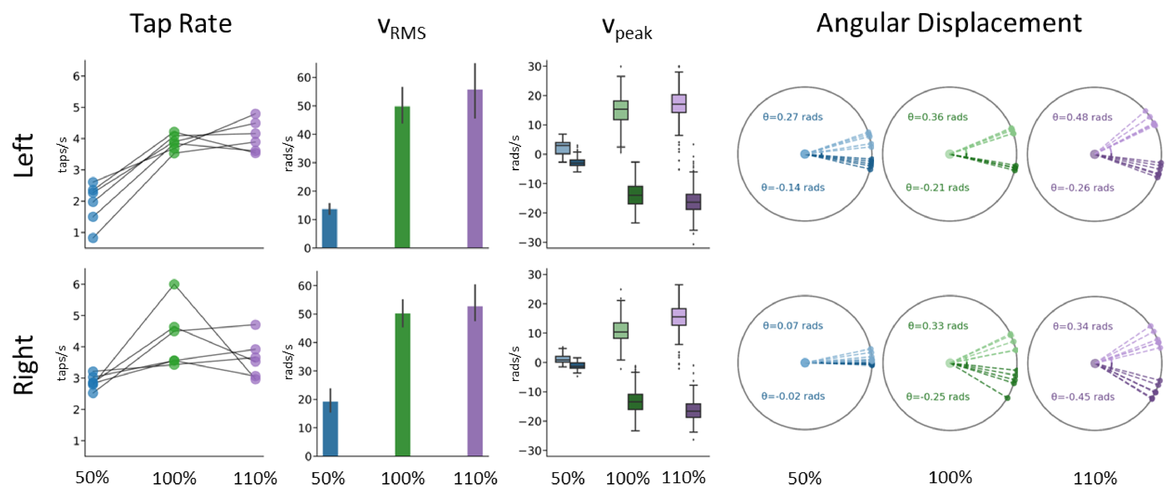
Bradykinesia is a *slowness of movement* characteristic of PD. Our pilot data showed observable differences depending on stimulation settings. Smart watches measure acceleration and angular velocity, while video-derived pose data captures isolated finger movements that are not observable from a smart watch.



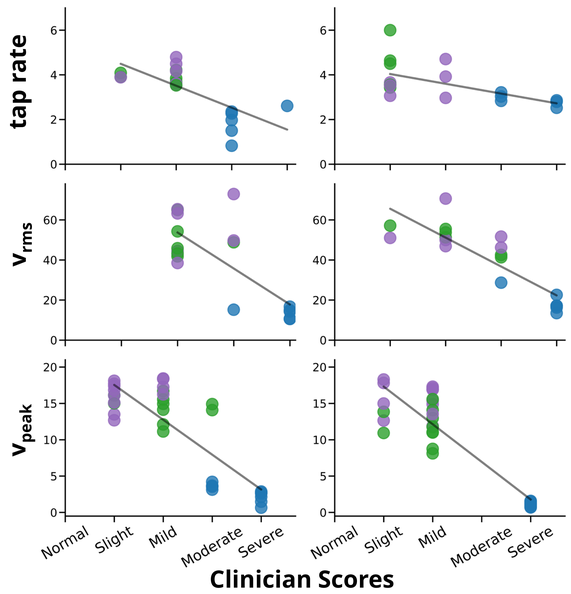
A. A single video frame of pose data during a finger tapping task. **B**. The difference in pixel space between the thumb tip and pointer tip at low stimulation and preferred stimulation during a finger tapping task. **C**. Raw acceleration from a smart watch during a wrist-rotation task.

Movement Features Discriminate Between Stimulation Settings

We calculated **tap rate** during a finger tapping task, **root mean square velocity** (v_{RMS}) during a hand open-close task, and **peak angular velocity** (v_{peak}) and **angular displacement** during a wrist rotation task.



Movement Features Correlate with Gold Standard for Symptom Scoring



Our automated movement assessments were significantly correlated with the gold standard for measuring bradykinesia.

Developing automated methods to assess PD symptoms outside clinical observation is necessary to automate aDBS programming.

Future work on bradykinesia assessments can formalize metrics to capture clinically-actionable features based on continuous movements.

REFERENCES

[1] R. Gilron et al. Nat. Biotechnol., 39, 9, Sep. 2021. **[2]** C. G. Goetz et al. Mov. Disord., 23, 15, Nov. 2008. **[3]** R. Powers et al. Sci. Transl. Med., 13, 579, Feb. 2021. **[4]** Z. Cao et al. IEEE Trans. Pattern Anal. Mach. Intell., 43, 1, Jan. 2021.

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