Towards Ambulatory Motor Monitoring: Measuring Dyskinesia During Activities of Daily Living

Webinar Will Begin at 12:00 PM EDT

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Outline

- Motor Fluctuations and Levodopa-induced Dyskinesia
- Challenges with Clinical Dyskinesia Assessment
- Intelligent Algorithms for Continuous Monitoring of Dyskinesia

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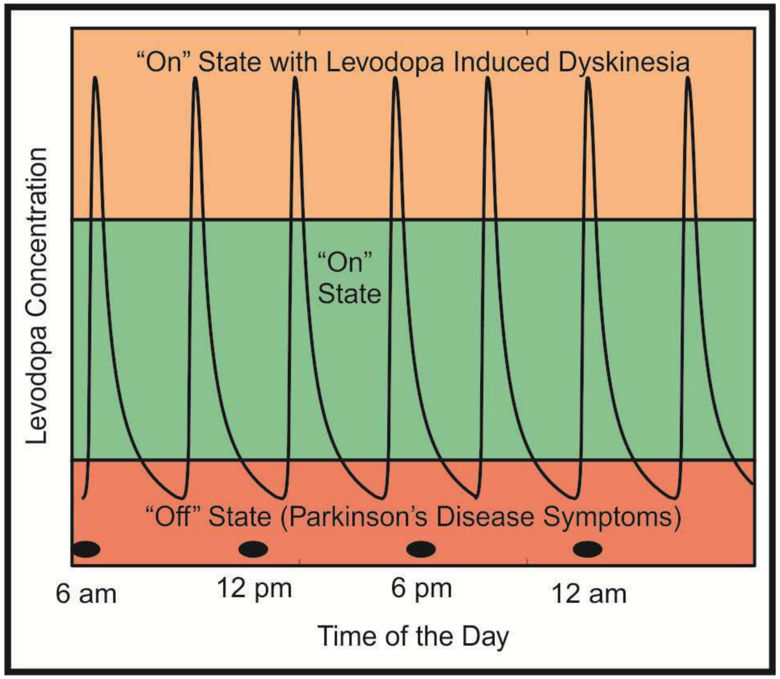
Fluctuations and Dyskinesia

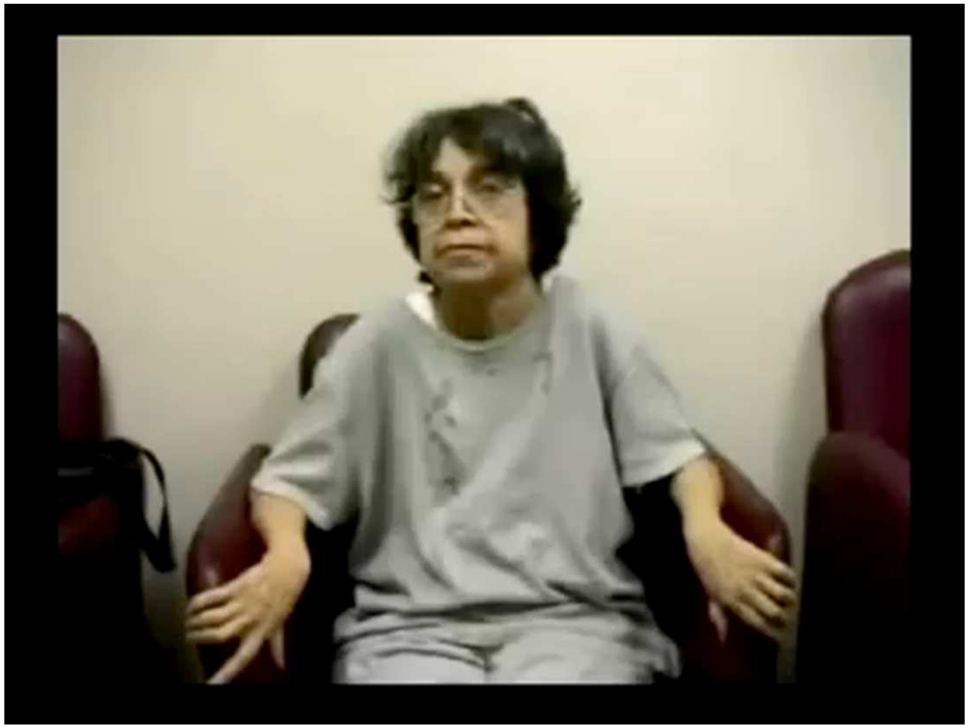
- Motor Fluctuations
  - Alternate between “OFF” and “ON” states over dose cycle
- Levodopa-induced Dyskinesia
  - Involuntary, episodic, and irregular movements
  - Most commonly occur at peak dose

Chronic Stages of Levodopa Therapy



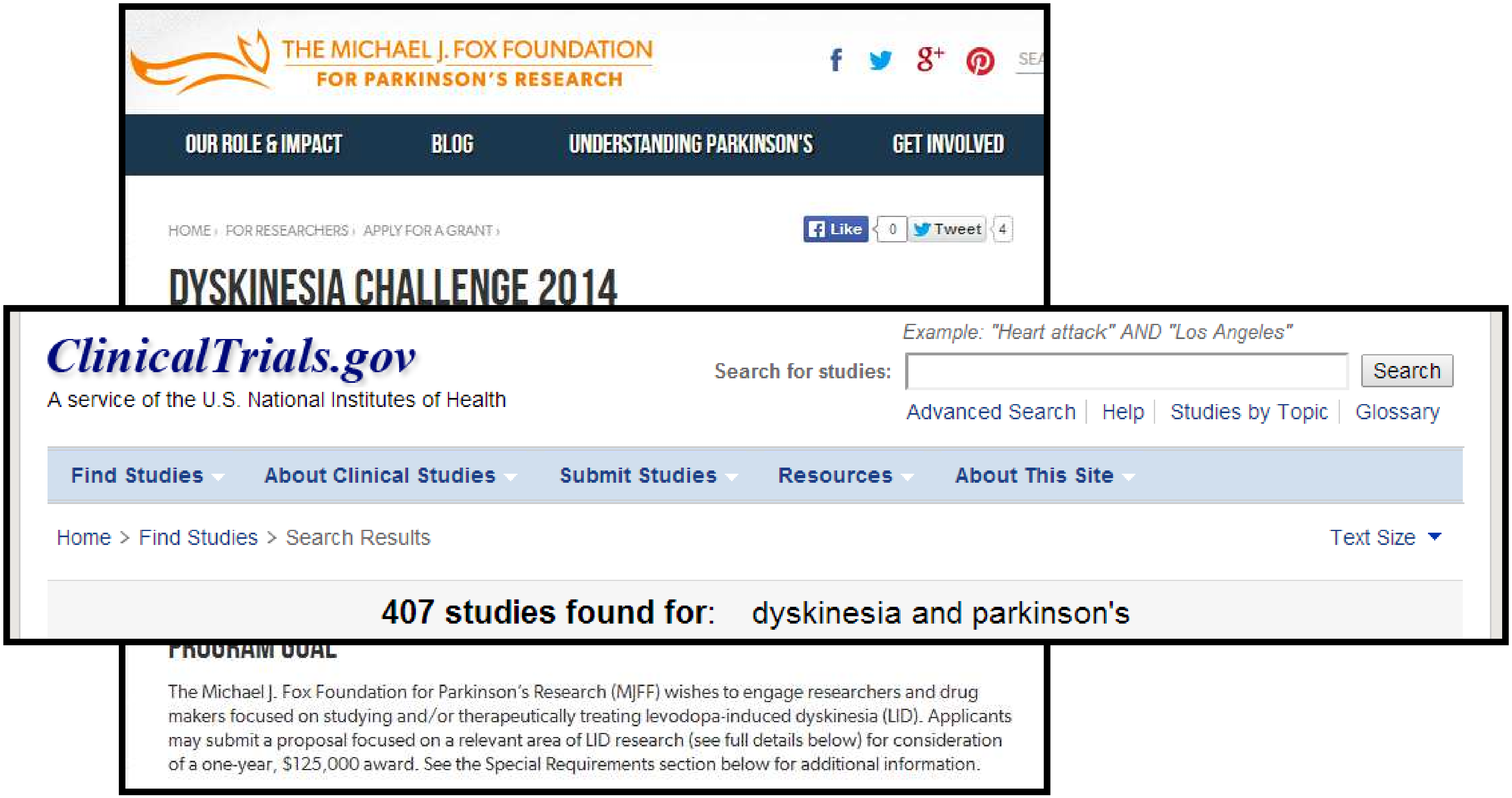
Keijsers et al., Movement Disorders 18(1), 2003

Patient Impact

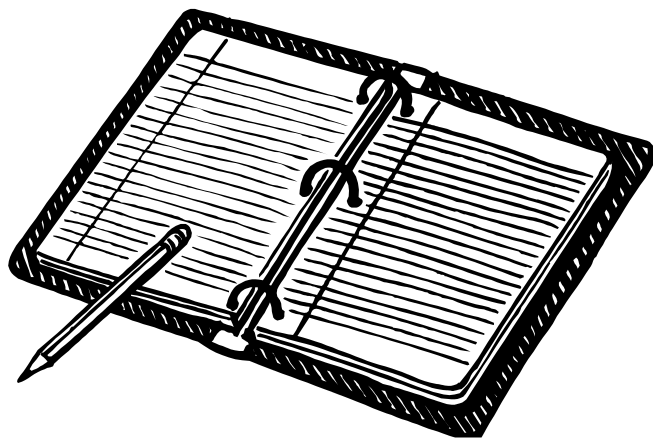


https://www.youtube.com/watch?v=CaJymwziF-M

New Therapy Development



Clinical Assessment of Dyskinesia



In-Clinic Assessment

- Rating scales **only provide a temporal snapshot** of dyskinesia response, limited resolution

Patient Diaries

- Self-assessment at home at regular intervals, **confounded by patient awareness, compliance**

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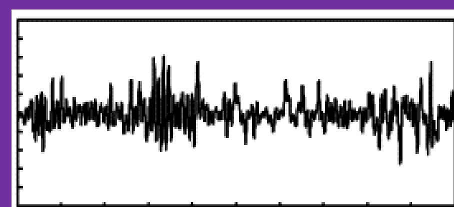
Technology-based Assessment

Touch Interfaces

Motion Sensors



Mobile Data Networking

Objective, high resolution measurement + Remote access

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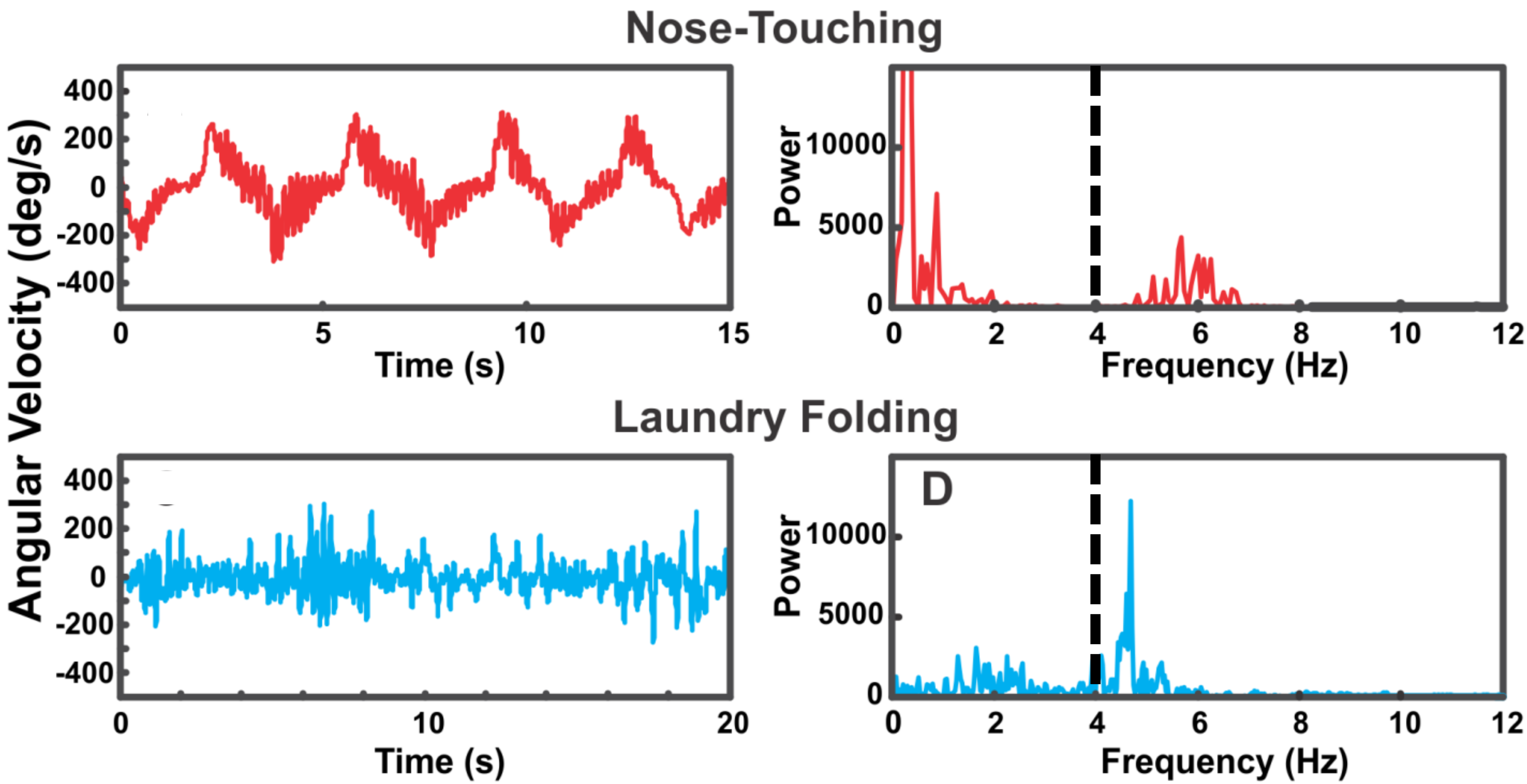
What exactly do motion sensors capture?



Tremor can be differentiated from voluntary motion by taking advantage of separation in the frequency spectrum

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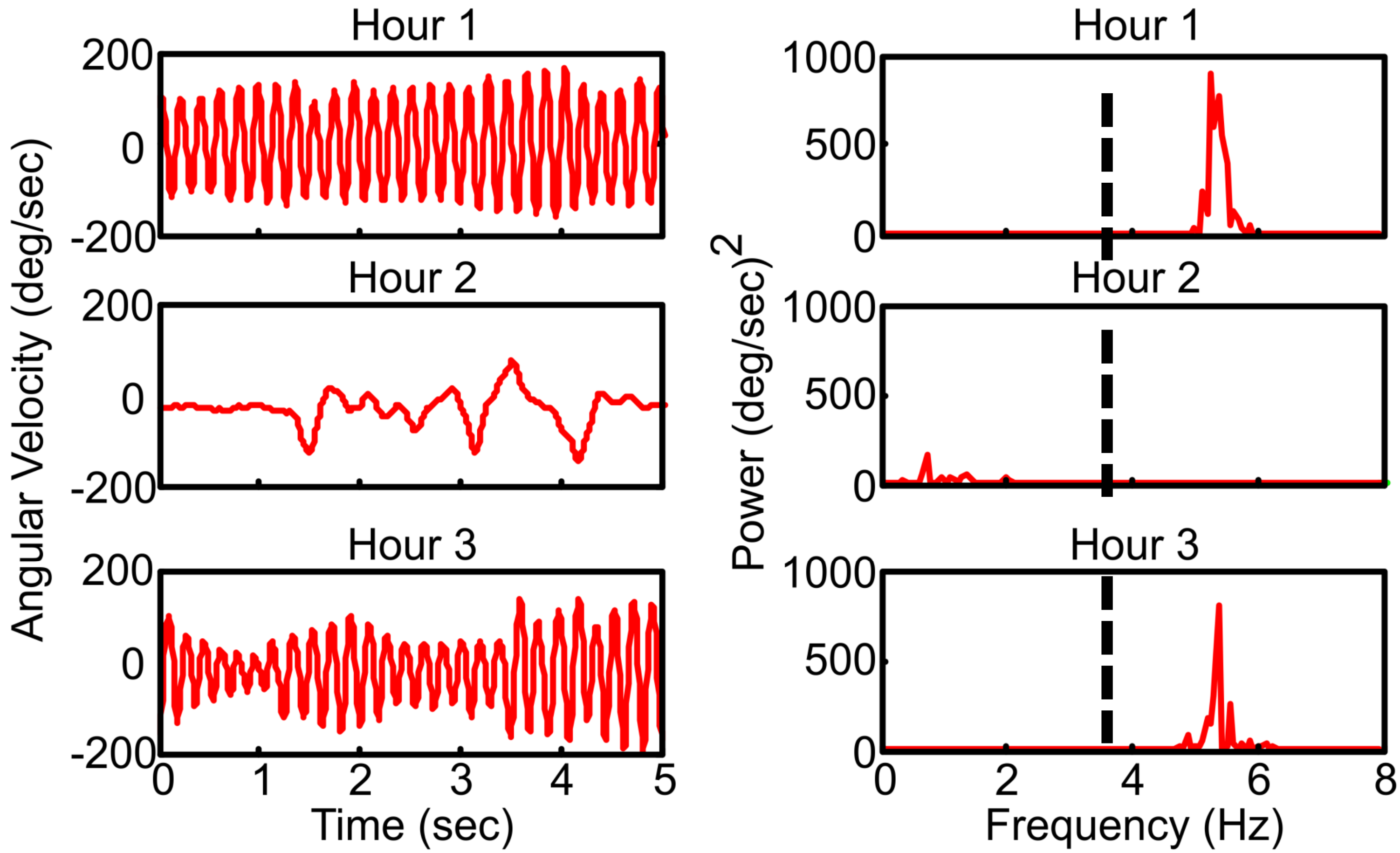
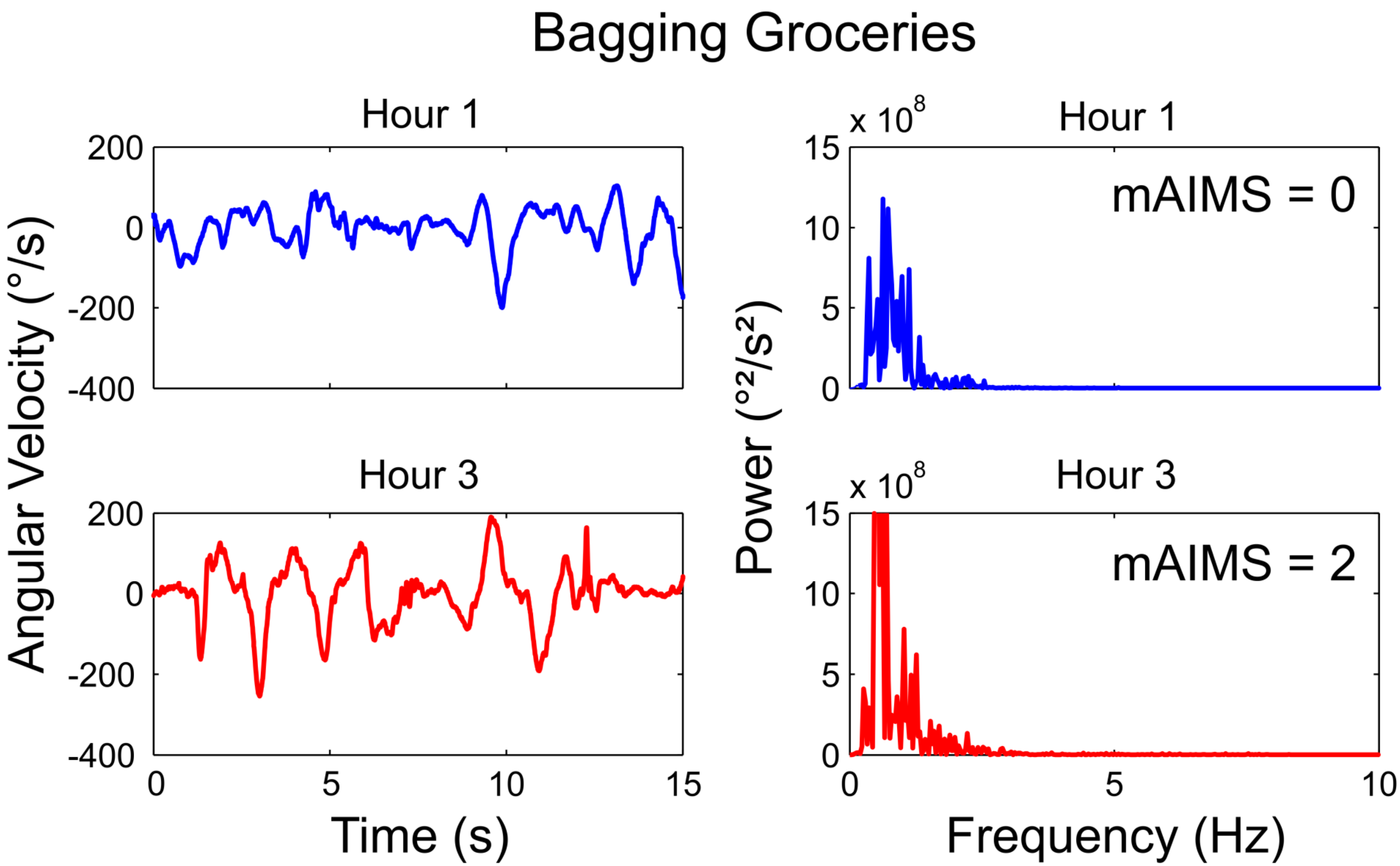
Arms Resting



Same principles can be used to quantify dyskinesia when there is no voluntary motion

Mera et al., Journal of Parkinson's Disease 3(3), 2013



Quantifying dyskinesia during routine activities is significantly more challenging because of kinematic and spectral overlap

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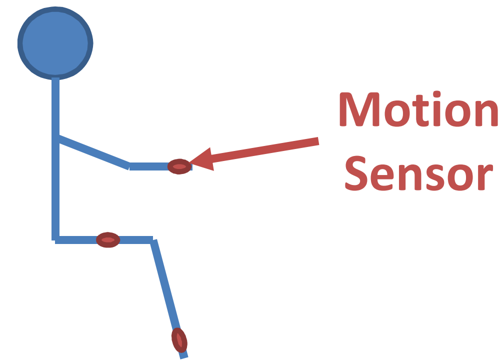
Motion Sensor Dyskinesia Quantification During ADLs

- Motion sensor units positioned on hand, thigh, and heel
- Representative scripted ADLs performed over a 3-hr period after levodopa dose
- Motion sensor data saved, videos scored by blinded raters using m-AIMS



Cutting Food

Drinking

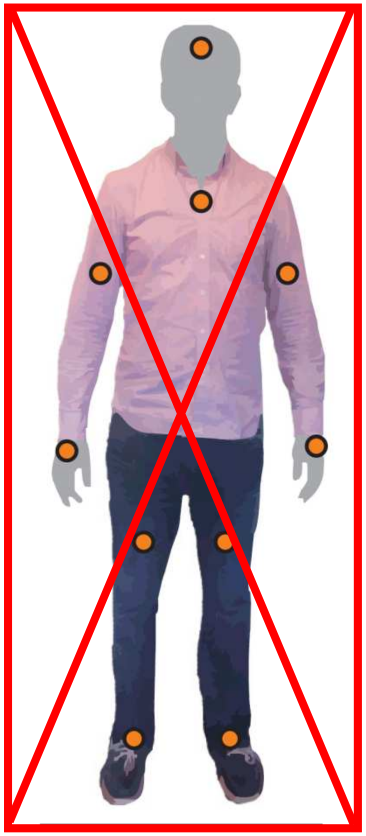
Dressing

Combing Hair

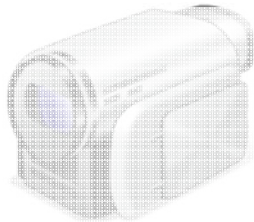
Bagging Groceries

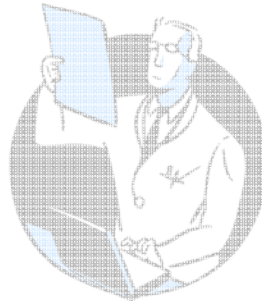
Goals

1. Develop an intelligent algorithm that can rate dyskinesia severity across a range of routine activities
2. Determine a minimal set of motion sensors to minimize patient burden

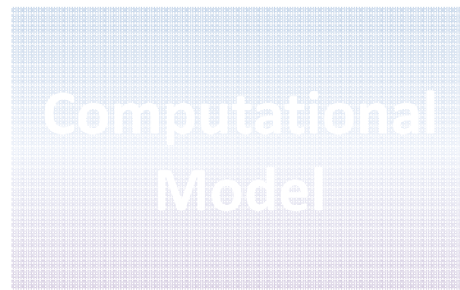


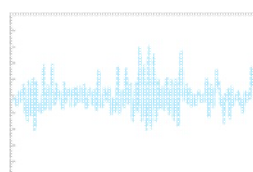
Process Workflow



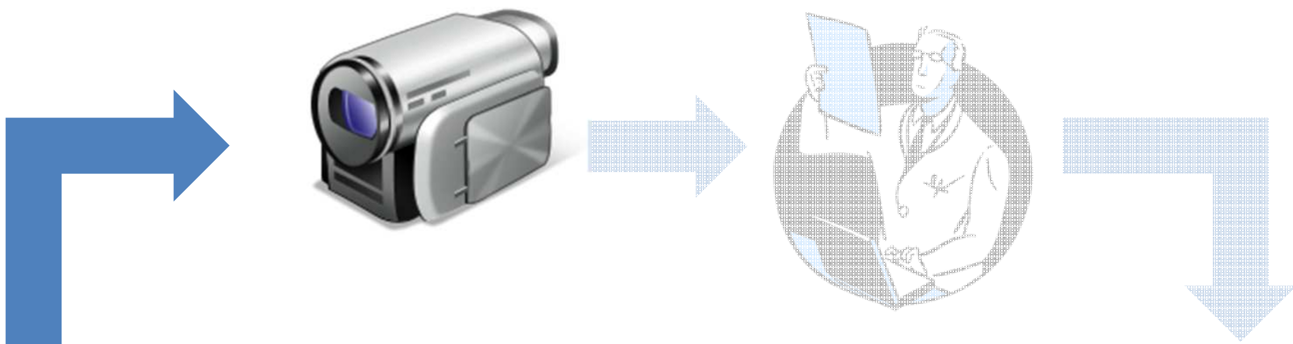


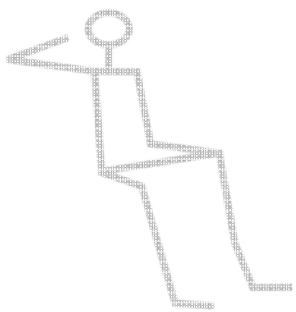
- Patients perform tasks throughout dose cycle, capturing range of severities



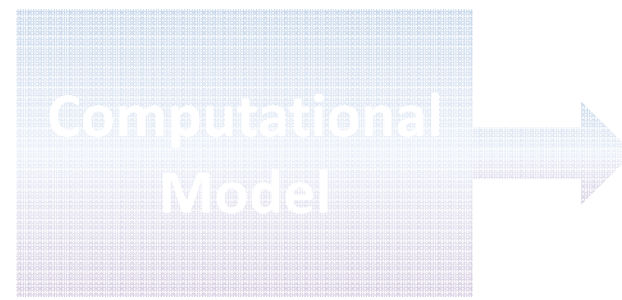


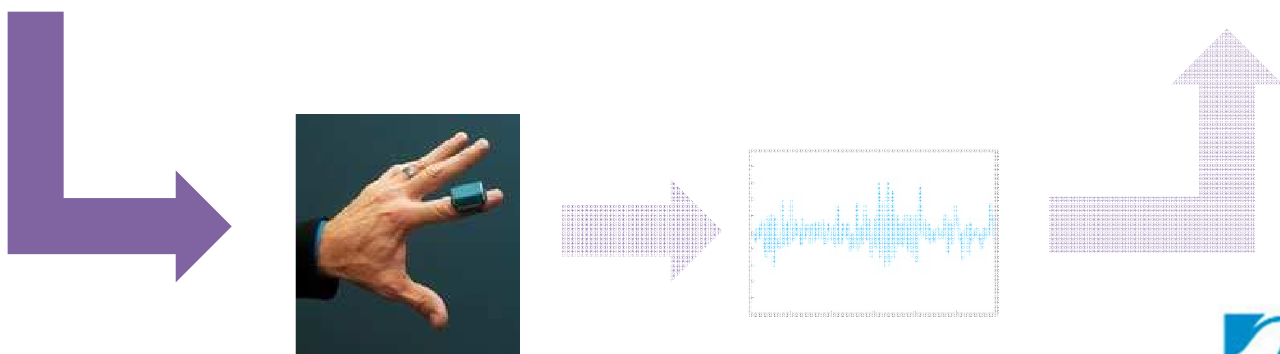
Process Workflow





- Movement recorded by camera and wireless motion sensors





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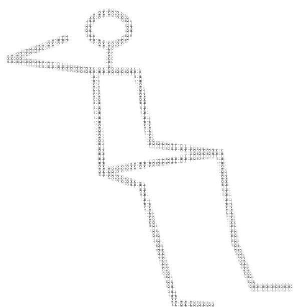
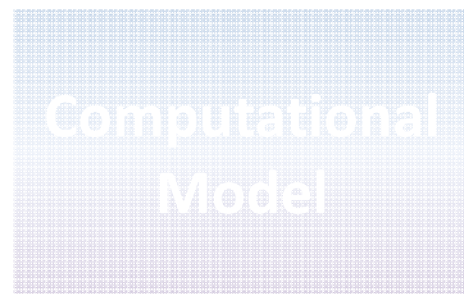
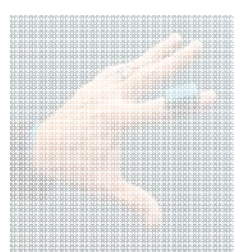
Process Workflow


- Blinded clinicians score dyskinesia using modified AIMS scale

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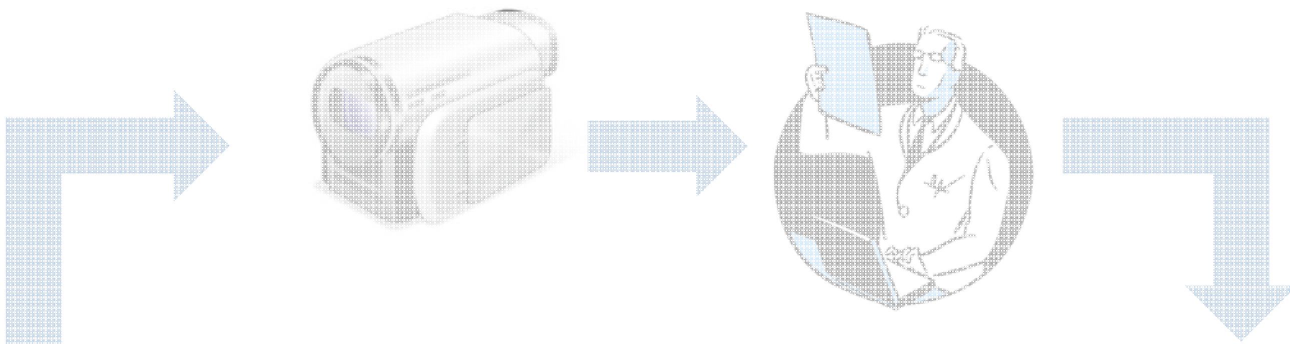
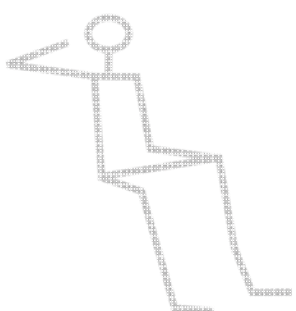
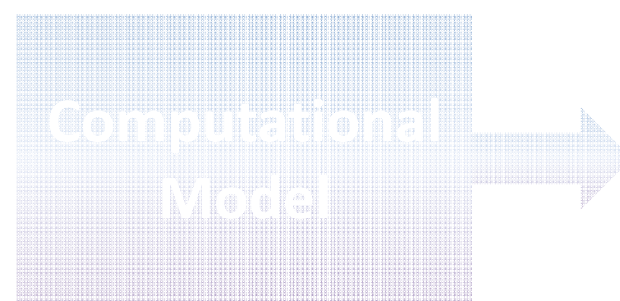
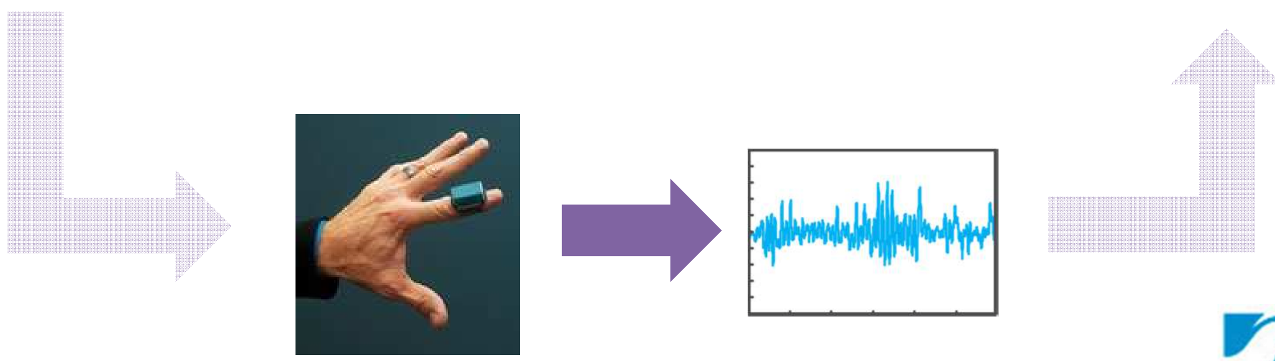
Process Workflow



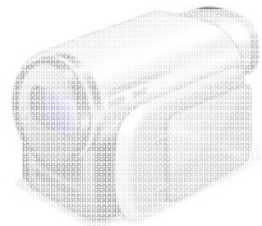


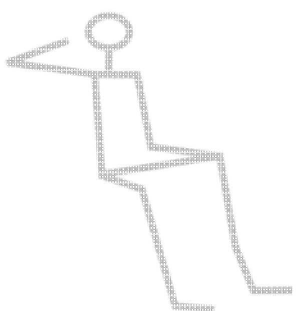
- Kinematic features extracted from motion data using signal processing techniques



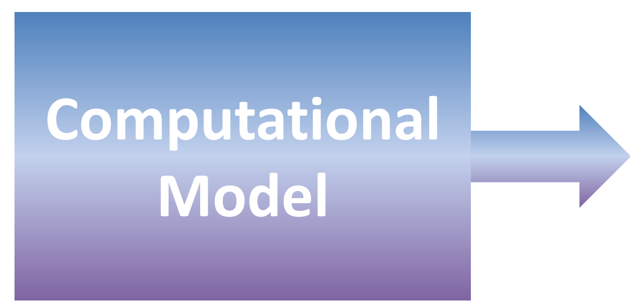


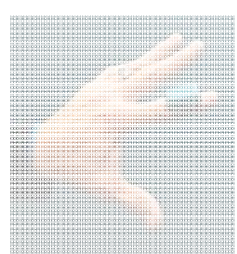
Process Workflow

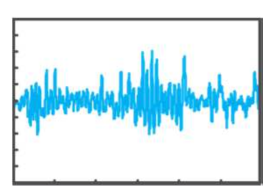




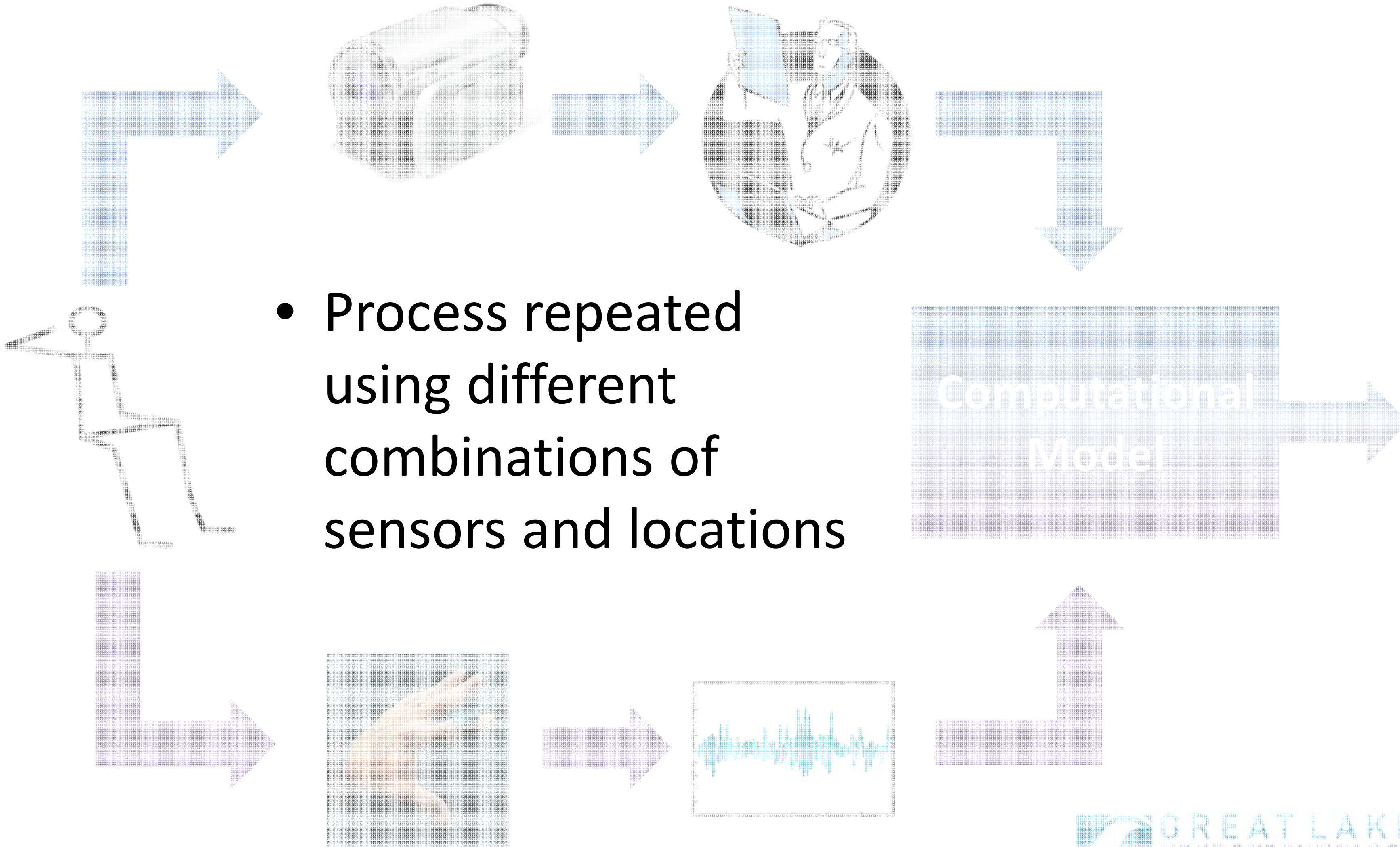
- Algorithms trained to predict dyskinesia severity rating from kinematic feature(s)





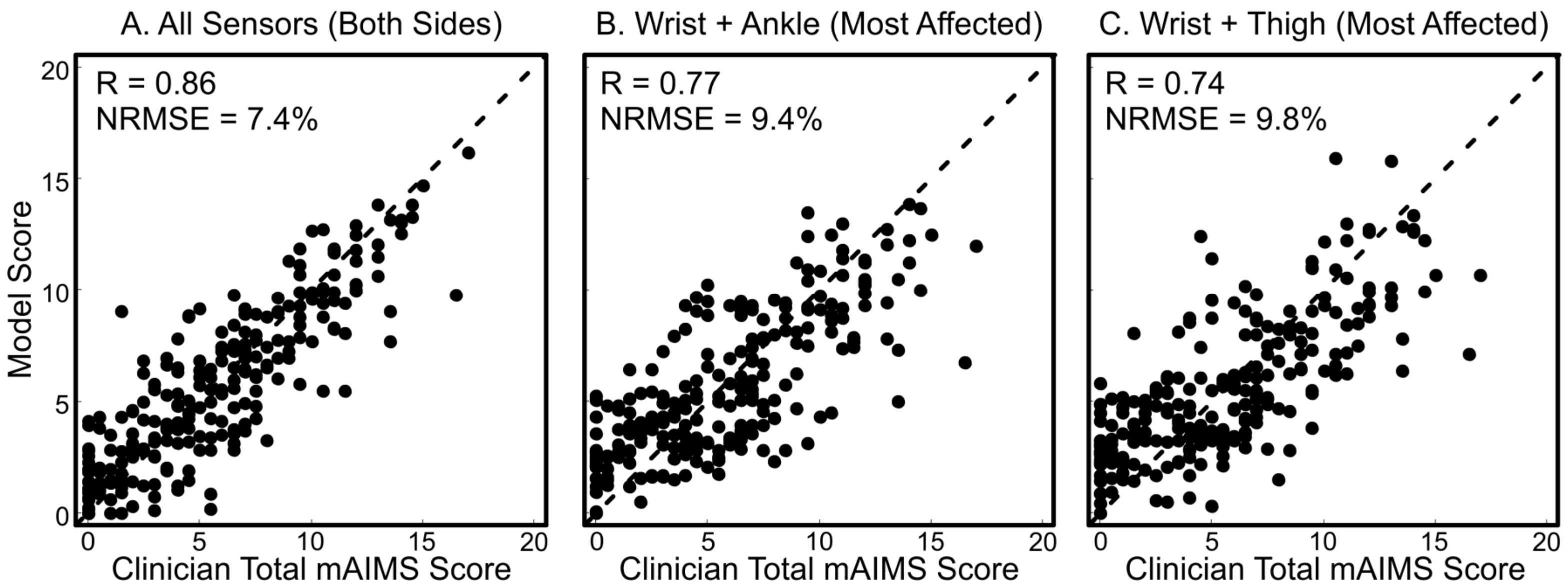


Process Workflow

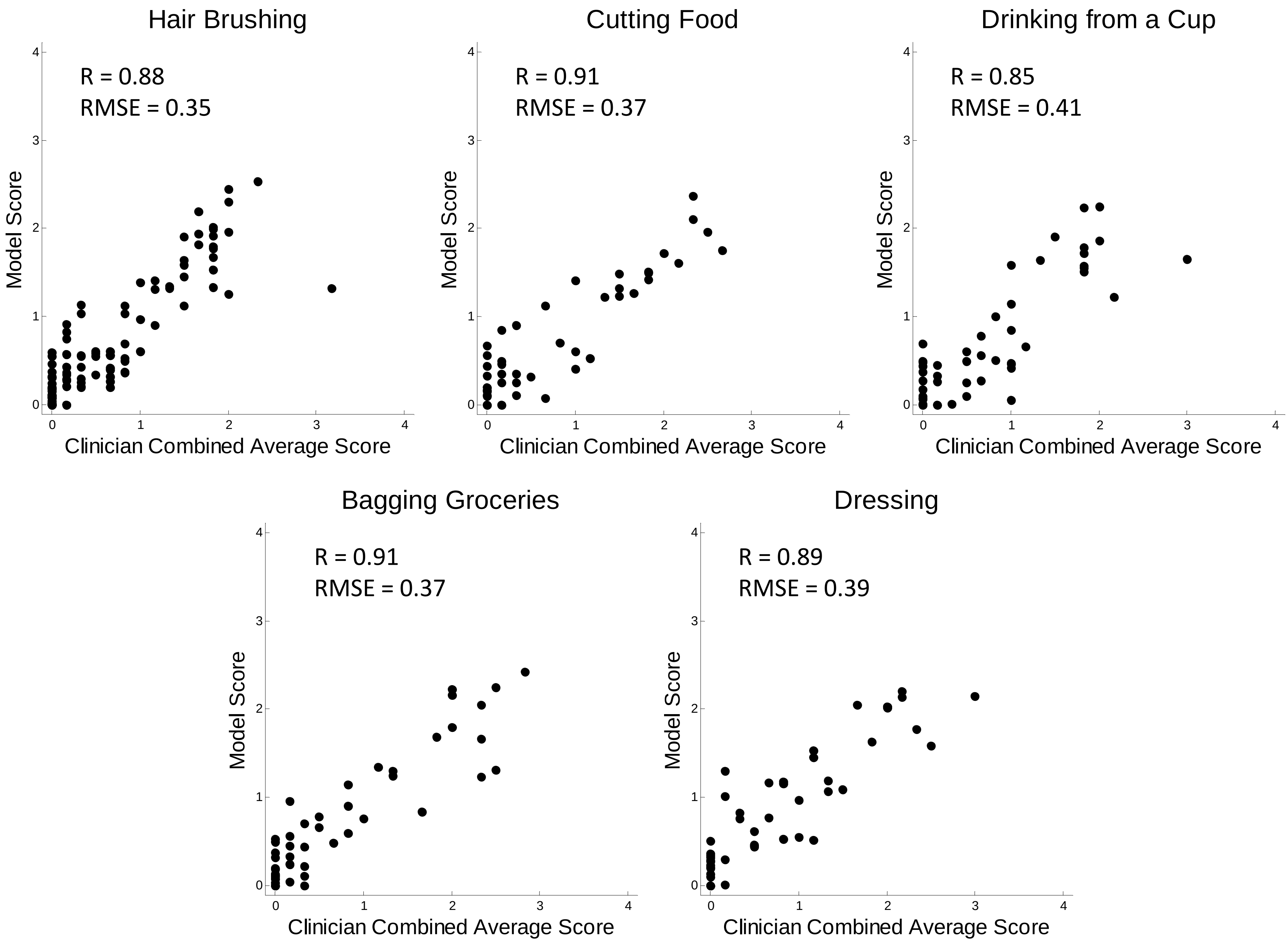


- Process repeated using different combinations of sensors and locations

Severity Scoring Model



- Linear regression models were developed to predict total mAIMS score averaged across both raters using kinematic features as inputs


Hair Brushing
R = 0.88
RMSE = 0.35
Cutting Food
R = 0.91
RMSE = 0.37
Drinking from a Cup
R = 0.85
RMSE = 0.41
Bagging Groceries
R = 0.91
RMSE = 0.37
Dressing
R = 0.89
RMSE = 0.39
Model Score
Clinician Combined Average Score
0
1
2
3
4

Conclusions

- A motion sensor system can accurately capture dyskinesia during routine activities
  - Provide an objective tool for quantifying motor symptom fluctuation in the context of daily life
- Ongoing study to validate algorithms in ambulatory setting

Current Commercial Technology

Kinesia HomeView

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Capturing Fluctuations

Time	Rest Tremor	Postural Tremor	Finger Taps Speed	Finger Taps Amplitude	Finger Taps Rhythm	Dyskinesia
6:55 AM	3.9	3.4	2.6	2.5	2.3	0.0
6:57 AM	**Drug Dose A**					
7:28 AM	2.5	3.0	1.7	1.4	1.0	0.0
7:59 AM	0.5	1.9	1.8	1.5	1.2	1.3
8:30 AM	0.3	0.9	0.3	0.5	1.0	2.9
9:05 AM	0.1	0.5	0.2	0.2	1.2	3.5
9:33 AM	0.3	0.4	0.0	0.0	1.0	3.8
10:02 AM	0.5	0.1	0.5	0.3	1.0	3.7
10:31 AM	0.6	2.0	1.0	0.5	1.5	2.9
10:58 AM	3.0	3.1	2.3	2.2	2.0	0.0
11:35 AM	3.5	3.4	2.0	2.0	1.8	0.0
11:50 AM	**Drug Dose A**					

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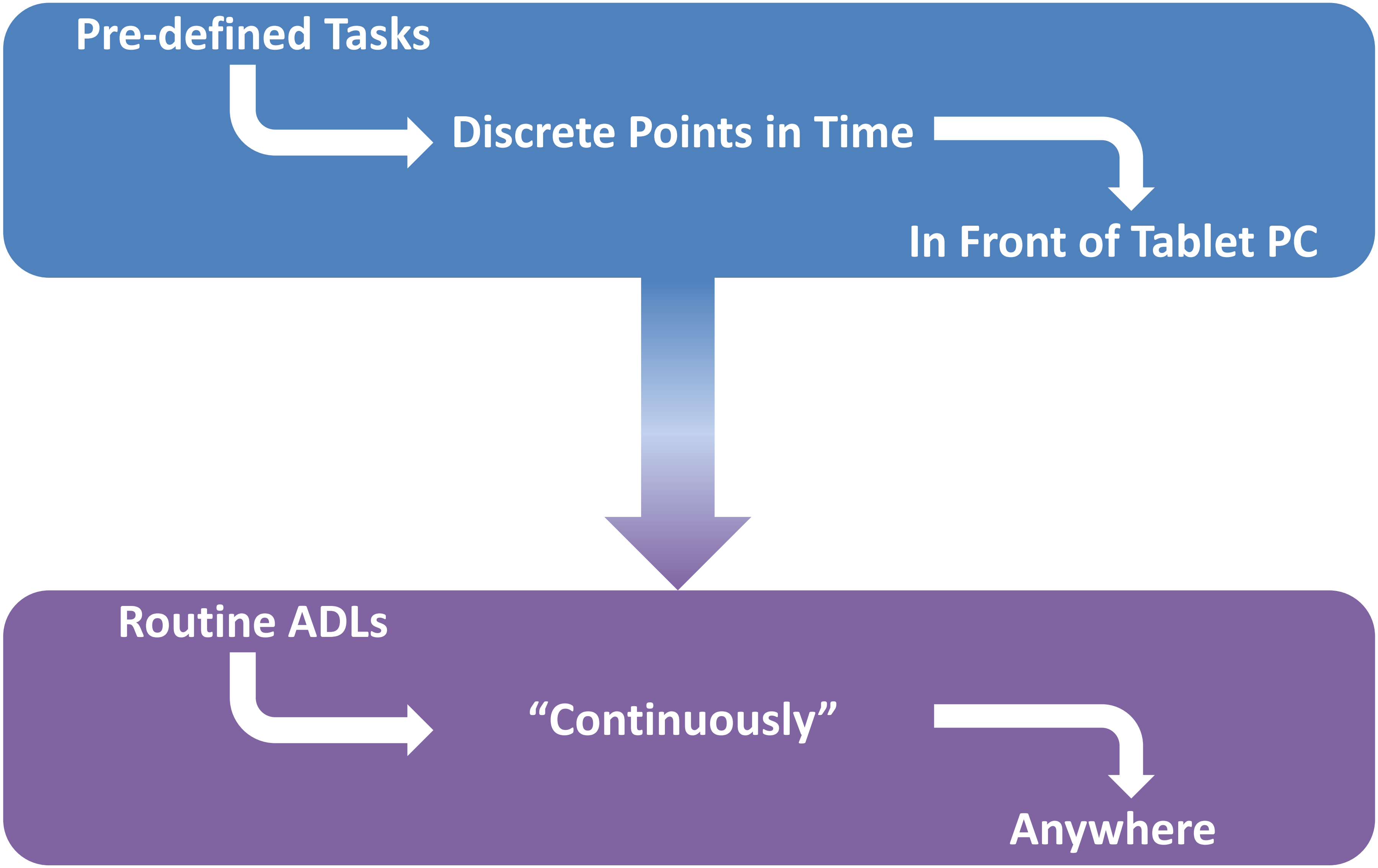

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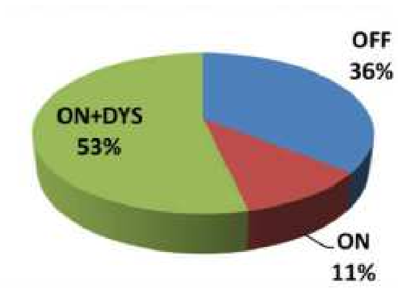
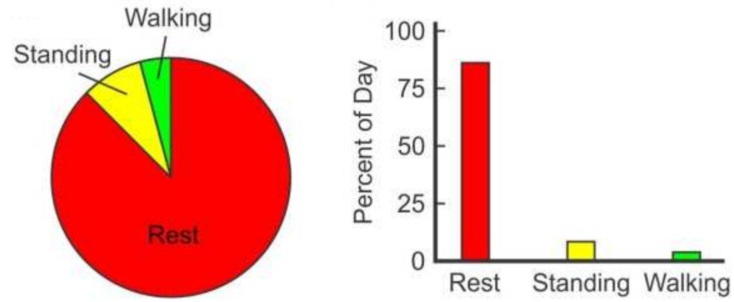
Upcoming Features

- Moving towards system that can easily provide objective measures of **medication state** and **physical mobility** with minimal patient burden through continuous monitoring



Medication State



Physical Activity and Mobility

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Questions?

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