Once upon a time in lovely Kingston... Everyone awake?
Modelling Reaching Behaviour

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Initial Project Idea

- Data-Mining using DREAM Database
- Investigate reaching trajectories in healthy subjects
- Fit data to an arm reaching model
- Study reaching performance of Parkinson subjects
- Use model to reproduce PD subject’s reaching behaviour by introducing noise to the system

(Burns & Blohm, 2010)
Reaching trajectories from DREAM database

DREAM database
Baseline reaching trajectories
Optimal control model

Reaching Parameters: Initial Target and Hand Positions

Optimal Control Policy

State estimator

Motor command

Efference copy

\[ x(\theta_s, \theta_e) = l_1 \cos(\theta_s) + l_2 \cos(\theta_s + \theta_e) \]
\[ y(\theta_s, \theta_e) = l_2 \sin(\theta_s) + l_2 \sin(\theta_s + \theta_e) \]
Iterative LQG

\[ x_k = Ax_k + Bu_k \]
\[ y_k = Hx_k \]

State vector
\[ x_k = \begin{bmatrix} \theta_s, \theta_e, \dot{\theta}_s, \dot{\theta}_e \end{bmatrix}^T \]
\( s \) : shoulder
\( e \) : elbow

Cost function
\[ J_k(x_k, u_k) = x_k Q_k x_k^T + u_k^T R u_k \]

Cost-to-go function
\[ J_N(x_N, u_N) = x_N Q_N x_N^T \]

A : system matrix
B : Input weight matrix
H : feedback matrix

(Todorov & Li, 2005)
Parkinson Disease

- Degenerative disorder of the CNS
- One of the cardinal manifestations of PD is bradykinesia
- Bradykinesia = slowness of movement

(Berardelli et al., 2001)
Control subjects vs PD subjects

(Desmurget, 2004)
**Hypothesis**

**Observation:** Slowness of movement in PD subject

**Possible cause:** Deficient motor command

**Hypothesis:** Noise applied to motor command of arm reaching model affects mainly hand velocity

**Comparison:** Observed velocities of PD subjects with model results
Motivational Curve

\[ R^{\alpha\beta} - \frac{1}{2} R g^{\alpha\beta} + g^{\alpha\beta} \Lambda = \frac{8 \pi G}{c^4 \mu_0} \left( F^{\alpha\psi} F_\psi^\beta + \frac{1}{4} g^{\alpha\beta} F_{\psi\tau} F^{\psi\tau} \right) \]
Model fitted to data of healthy subjects
Hand velocities in healthy subjects

![Graph showing hand velocities over time with various curves and data points.]

Legend:
- Blue dots
- Cyan dots
- Green dots
- Orange dots

DREAM database
Model velocity in healthy subjects
Model trajectories with noise in motor command (PD simulation)
Velocity changes at different noises levels

Noise 0.10

Noise 0.20

Noise 0.30

Noise 0.40

Noise 0.50

Noise 0.60

Noise 0.70

Legend

* p < 0.05
Time for Questions 😊

Thank you!!!