Estimating visual corrective reaction times in double-step paradigms using machine learning: A proof of principle

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Rotman Research Institute at Baycrest Health Sciences

Introduction

The Double-Step Paradigm

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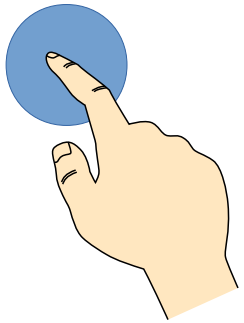

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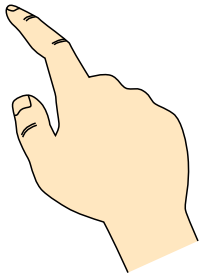

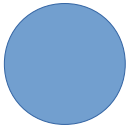

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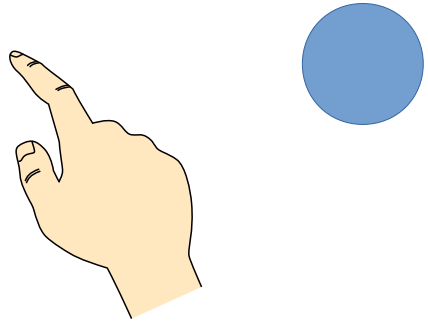

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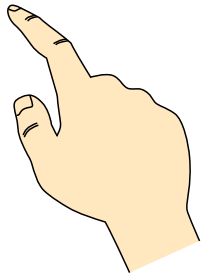

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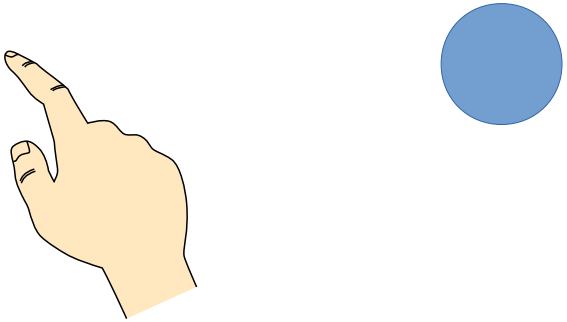

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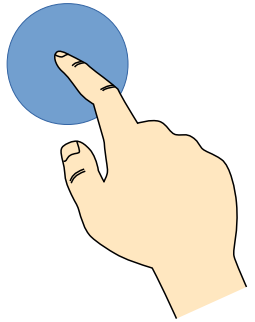

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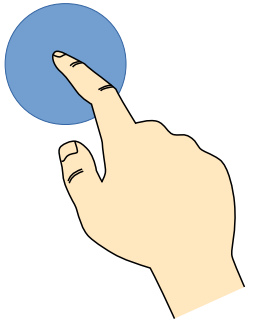
The Double-Step Paradigm

CORRECTIVE REACTION TIME (CRT)



Introduction

Measuring Corrective Reaction-Time?

- Threshold methods (e.g., Briere & Proteau, 2011)
- Multiple T-tests (e.g., Prablanc & Martin, 1992)
- Regression and Extrapolation (e.g., Oostwoud Wijdenes et al., 2011)

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Measuring Corrective Reaction-Time?

- Threshold methods (e.g., Briere & Proteau, 2011)
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- In these cases we are...
  - Fitting a model (setting ‘rules’ OR pre-specifying a pattern)
  - Using this model to estimate the outcome

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Machine Learning

- Rather than setting the rules (as explicitly), in machine learning we can....

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- Give the ‘machine’ data, and let it ‘learn’ the patterns in the data
  - ‘Supervised’ if Data and Labels are provided during learning

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Machine Learning

- We provide data and labels in a TRAINING-SET
  - The ‘machine’ learns patterns in this data-set to maximize prediction accuracy with this data

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Machine Learning

- We provide data and labels in a TRAINING-SET
  - The ‘machine’ learns patterns in this data-set to maximize prediction accuracy with this data
- We then evaluate our model on the remainder of our data, the TEST-SET (or validation-set)
  - Similar in principle to cross-validation from regression

Research Question

- Can we use supervised machine learning to get an estimate of CRT?

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- How early, post-perturbation, will we see an improvement in classification accuracy?

Methods

Methods

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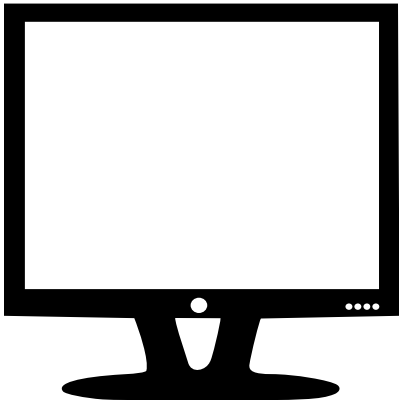
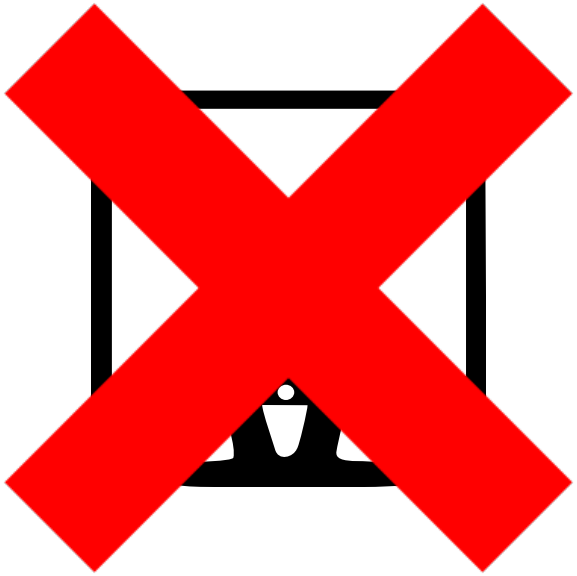


Methods



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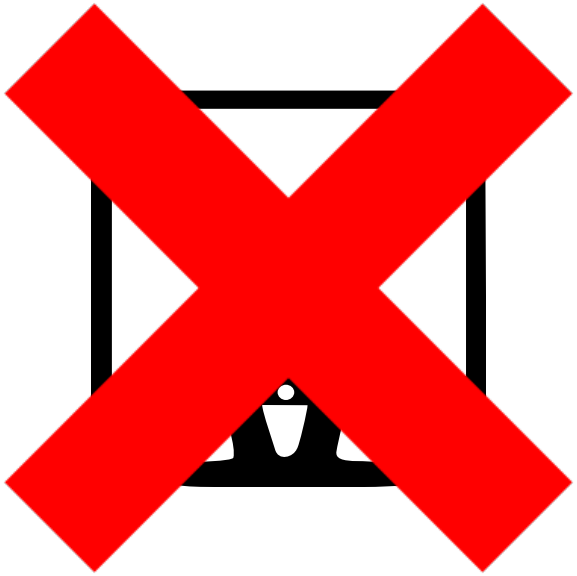

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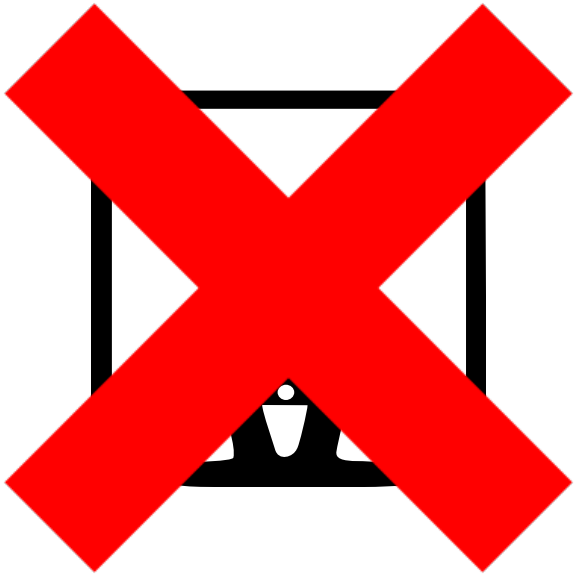
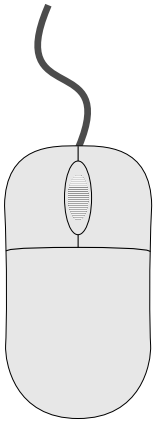


Methods

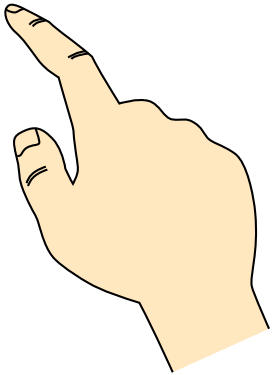
N= 10

Mouse



Stylus

3D-Reach



- Double-Step at 150 or 250 ms relative to go-signal.
- Equal probability of Single- and Double-Step.

Methods

- Data Selection AND Scaling:
  - Only used the 250 ms jump condition
    - RTs < ~240 ms

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    - Movement angle at jump + 250 ms < 45 degrees relative to target

Moher & Song, 2019

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    - Took data from jump – 2 samples to jump + ~270 ms
    - Re-scaled to position at time of jump

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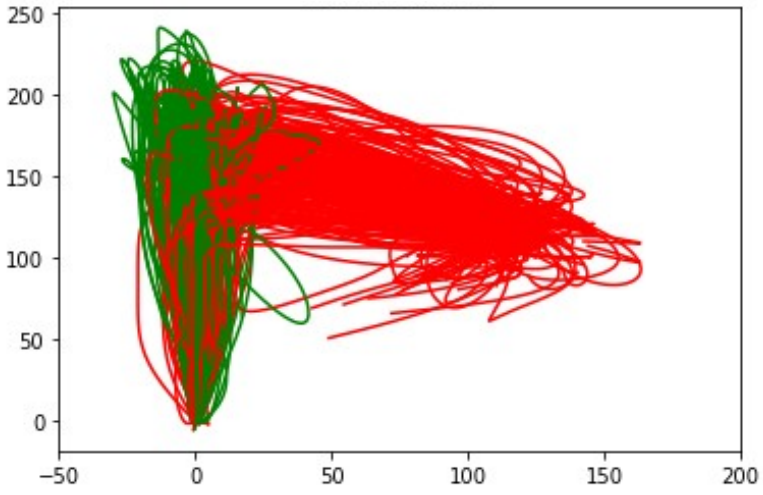
  - Pooled all remaining trials across participants

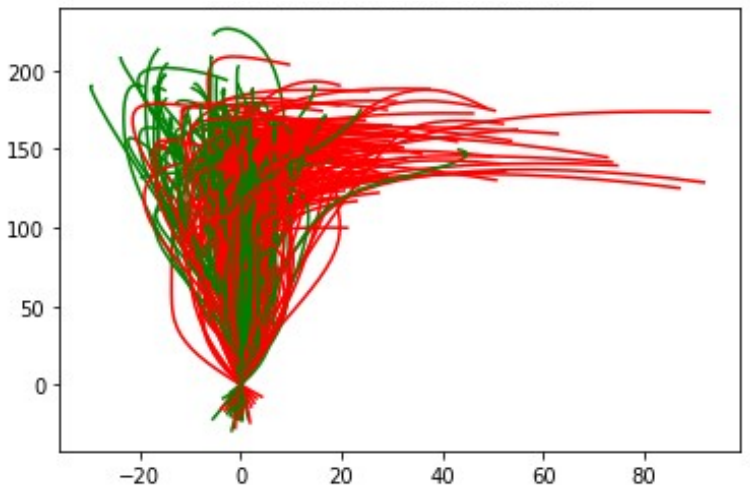
Moher & Song, 2019

Data Reduction

Selected Trials



Re-scaled Relative to Perturbation



Single-Step (NoJump)

Double-Step (Jump)

345 Trials

Analysis

Random Forest Classifier:

Analysis

Random Forest Classifier:

LABEL	SAMPLE-1	SAMPLE-2	SAMPLE-3	...
JUMP	p1	p2	p3	pn
NO-JUMP	p1	P2	p3	pn
...	p1	p2	p3	pn

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Decision Tree

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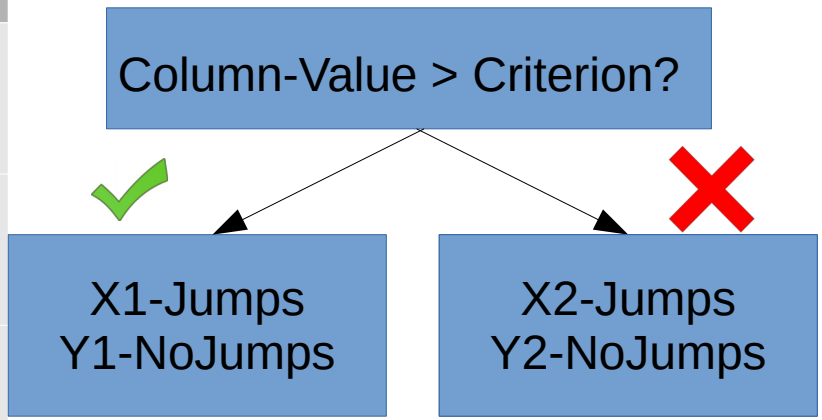

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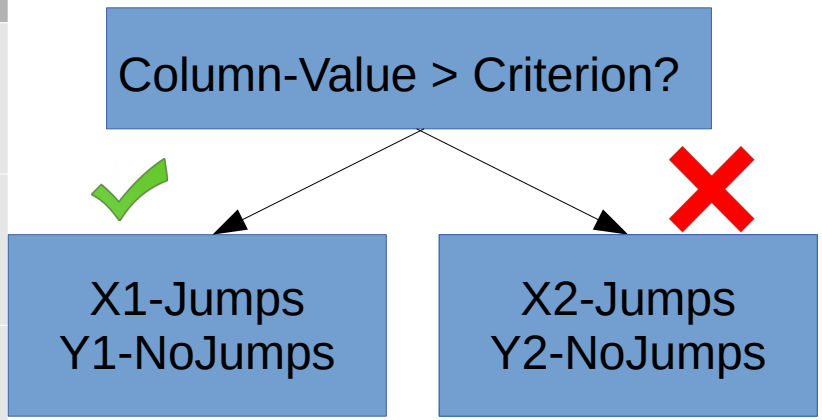

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Random Forest Classifier:

- For both primary (‘Y’) and secondary (‘X’) movement axes

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- Trained Random forests on incrementally larger time-ranges, up to ~270 ms
  - Started with the first 4 samples, worked up to all ‘n’-samples
  - Due to unequal trials in each condition, stratified sampling with 100 re-samplings was used to get an average TEST accuracy estimate

- Python ‘sklearn.RandomForestClassifier’
  - 2000 ‘Trees’
  - 25% of variables in each ‘Tree’
  - Trained on 60 % of the data, tested on 40%

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  - 25% of variables in each ‘Tree’
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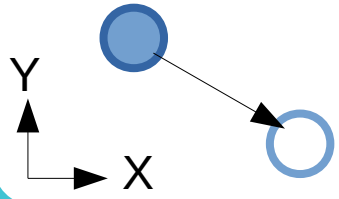
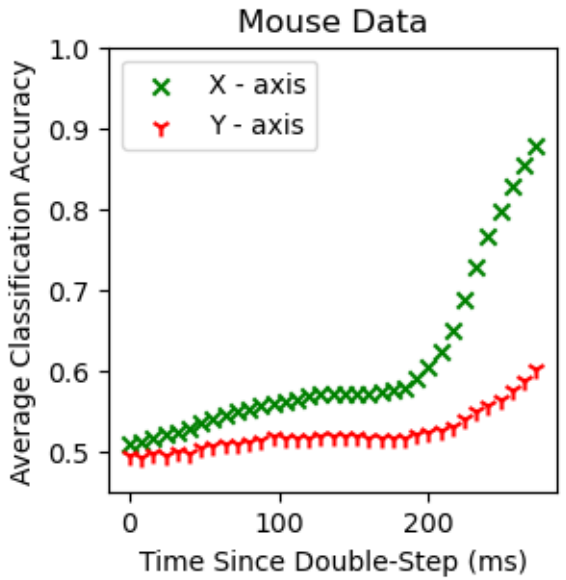
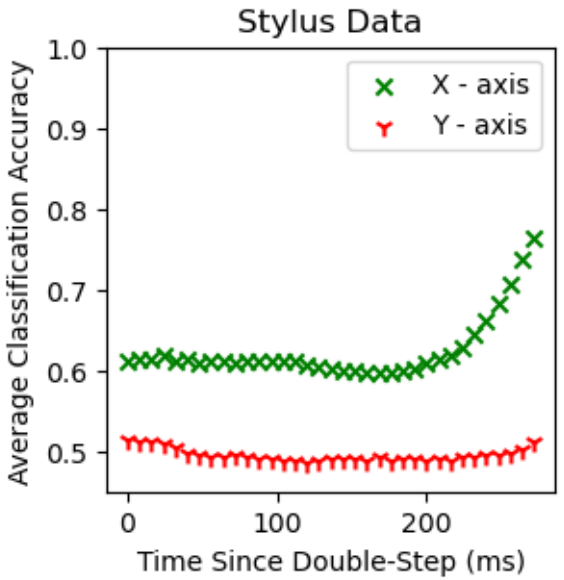
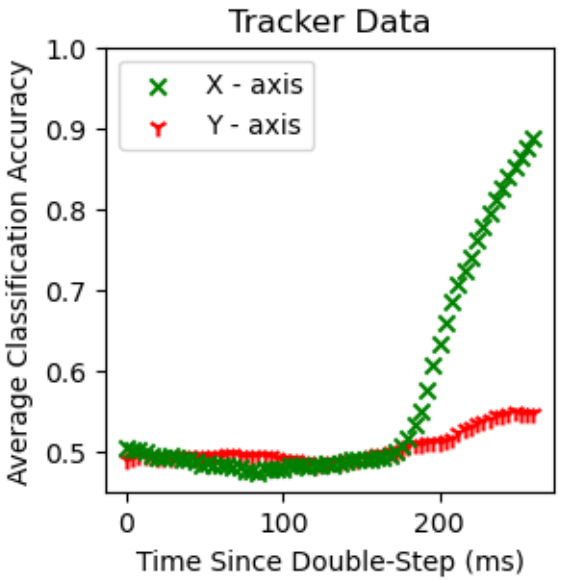
- Hypothesized that TEST accuracy would start to increase at CRT

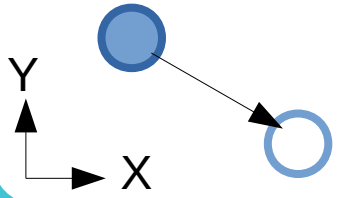

Y
X

Results


Mouse Data
X - axis
Y - axis
Average Classification Accuracy
1.0
0.9
0.8
0.7
0.6
0.5
0
100
200
Time Since Double-Step (ms)


Stylus Data
X - axis
Y - axis
Average Classification Accuracy
1.0
0.9
0.8
0.7
0.6
0.5
0
100
200
Time Since Double-Step (ms)


Tracker Data
X - axis
Y - axis
Average Classification Accuracy
1.0
0.9
0.8
0.7
0.6
0.5
0
100
200
Time Since Double-Step (ms)


Y
X

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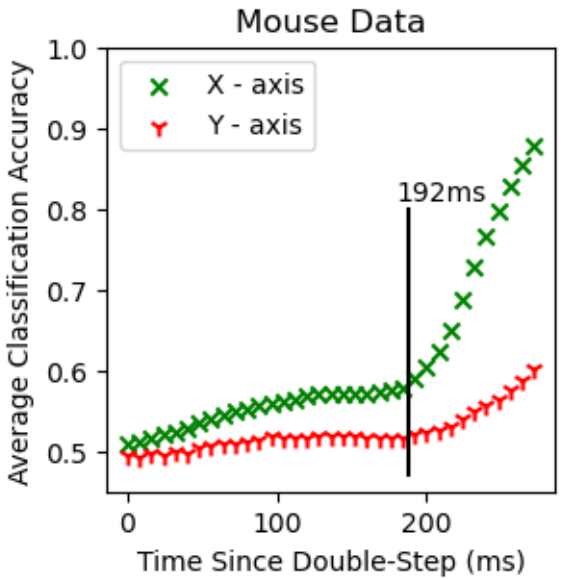
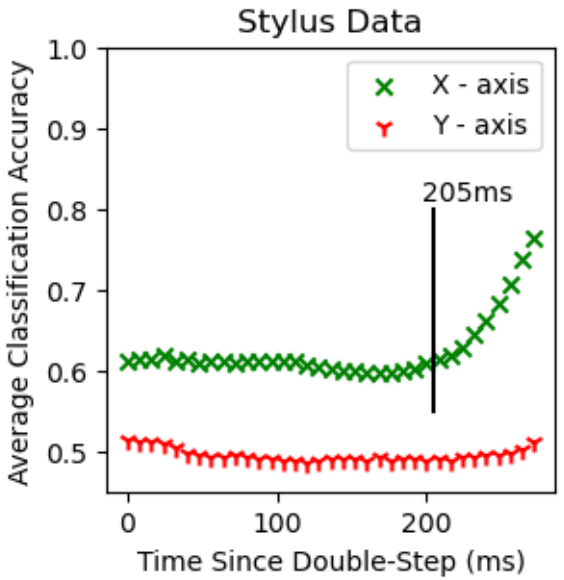
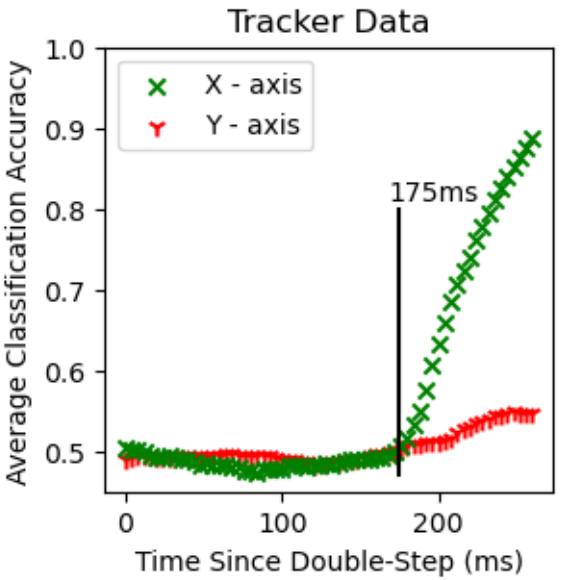

Mouse Data
Average Classification Accuracy
1.0
0.9
0.8
0.7
0.6
0.5
X - axis
Y - axis
192ms
0
100
200
Time Since Double-Step (ms)


Stylus Data
Average Classification Accuracy
1.0
0.9
0.8
0.7
0.6
0.5
X - axis
Y - axis
205ms
0
100
200
Time Since Double-Step (ms)


Tracker Data
Average Classification Accuracy
1.0
0.9
0.8
0.7
0.6
0.5
X - axis
Y - axis
175ms
0
100
200
Time Since Double-Step (ms)

Discussion

- vs Moher and Song (2019)?

Redirection Latency	Device		
	3DReach	Mouse	Stylus
Double Step 250 ms	204 ± 7 ms	222 ± 6 ms	230 ± 8 ms
RF Approach:	**175 ms**	**192 ms**	**205 ms**

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Redirection Latency	Device		
	3DReach	Mouse	Stylus
Double Step 250 ms	204 ± 7 ms	222 ± 6 ms	230 ± 8 ms
RF Approach:	**175 ms**	**192 ms**	**205 ms**

- Limitations? Other Methods? Pooled Data?

Take-Away

- Machine-learning Classifiers may indeed represent an additional avenue With which to dissociate experimental conditions such as quantifying corrective reaction times.

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- Open-science is awesome... please do it more!!!
  - OpenClipart.org
  - Moher & Song (2019)
  - Open Science Framework (http://osf.io)

THANK YOU

Paper

Moher & Song, 2019

Data

https://osf.io/srmhv/

Code

Github Page