



DeepGesture

Improving Touchscreen Gesture Recognition using Convolutional Neural Network for Users with Varying Motor-Skill Levels

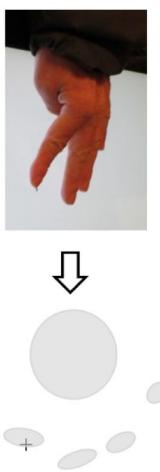
Motivation

Does default mobile system recognize the gesture from motor impairment user's intention successfully?



Related Work

Is it easy for motor impairment user or elderly people to tap on target successfully?



Touchscreen error rates by target size (Users = 32, error bars show standard error).

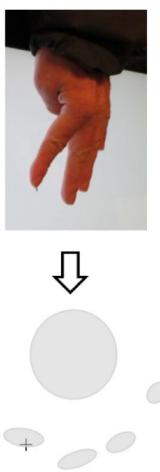
Comparing Touchscreen and Mouse Input Performance by People With and Without Upper Body Motor Impairments
Leah Findlater, Karyn Moffatt, Jon E. Froehlich, Meethu Malu, Joan Zhang



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Related Work

Is it easy for motor impairment user or elderly people to tap on target successfully?



Smart Touch: Improving Touch Accuracy for People with Motor Impairments with Template Matching
Marie E. Mott, Radu-Daniel Vatavu, Shaun K. Kane and Jacob O. Wobbrock

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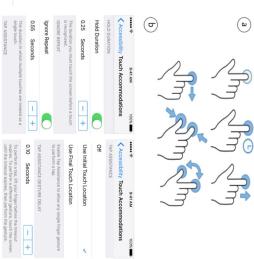
Related Work

Is there accessibility mode or system for people with special need?



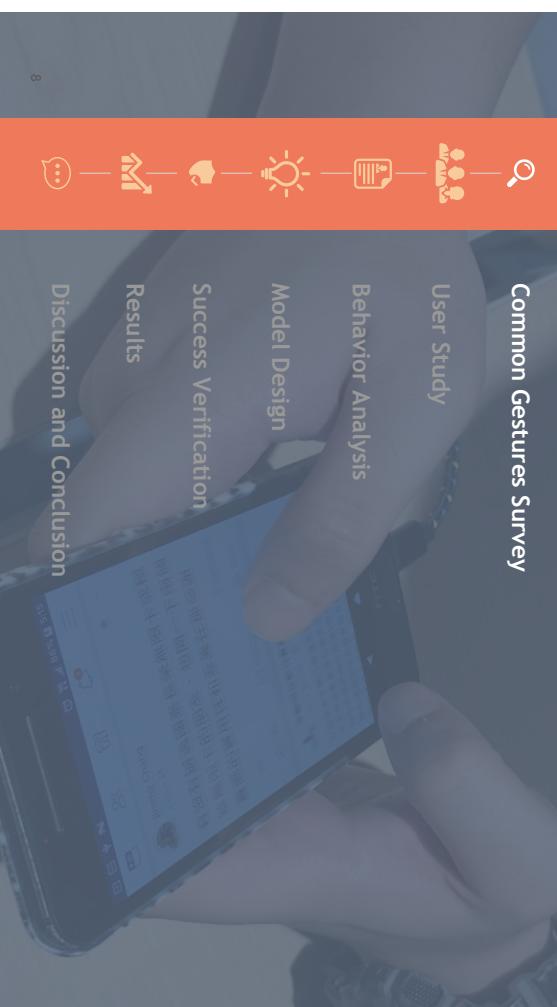
PersonalTouch: Improving Touchscreen Usability by Personalizing Accessibility Settings
based on Individual User's Touchscreen Interaction
Yi-Hao Peng,Mun-Tatng Lin,Yi Chen,TzuChuan Chen,Pin Sung Ku,Paul Taele,Chin Guan Lim,Mike Y. Chen

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Our Work

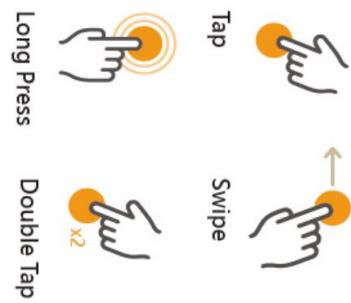
A touch gesture system predicts gesture **type** and precise **touch location**



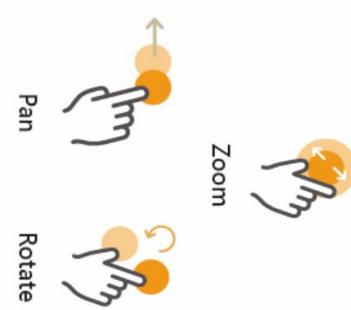
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Touch Gesture Type

Discrete Gesture



Continuous Gesture

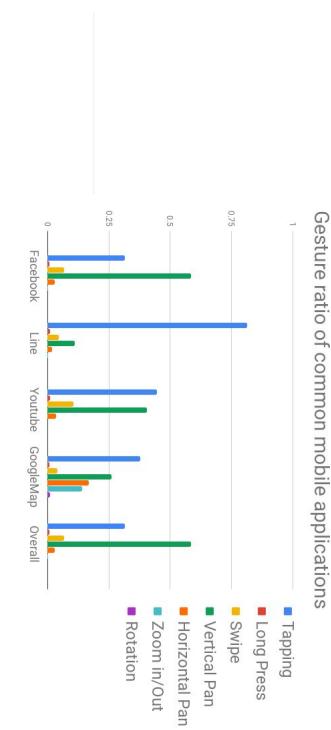


Common-used Touch Gesture Survey

10 Users(5 female vs 5 male)

Procedure:

1. Users use 4 top famous applications (Facebook, Google Map, YouTube, LINE) as usual
2. Ask user to count the gestures based on Video Recording



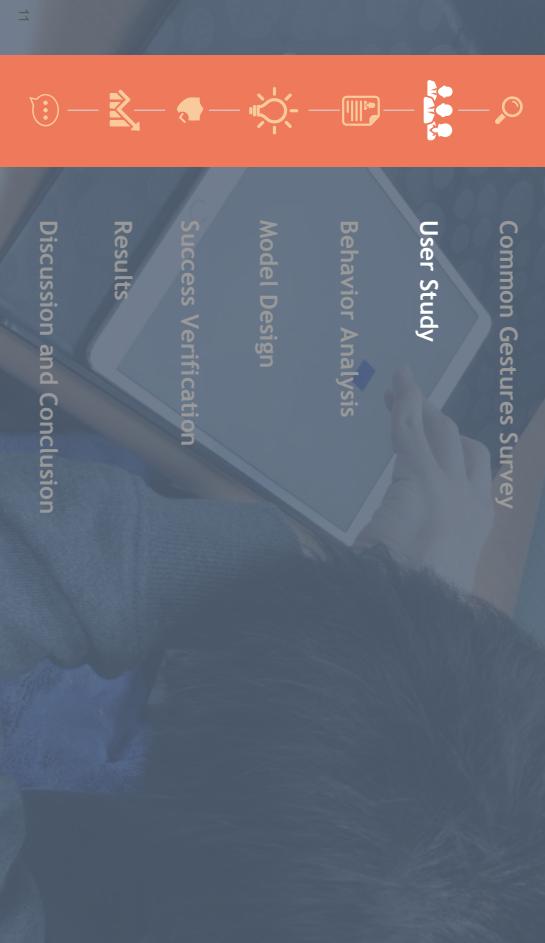
User Study

Tap Task

Pan Task

Swipe Task

Experiment device:
1. 10.5 inch iPad Pro with iOS 12.1
2. Carema



User Study

The interface consists of three main sections: Tap Task, Pan Task, and Swipe Task. Each section contains a smartphone icon with a target area. Below each icon is a list of task details.

- Tap Task:**
 - Target Size: 44pt and 76 pt
 - 25 positions
 - repeats:2
- Pan Task:**
 - 2 directions: Horizontal , Vertical
 - 20 different distance:
-220,-198,...,198,220
 - repeats:2
- Swipe Task:**
 - Total:100 Trials

Cite:
<https://developer.apple.com/design/human-interface-guidelines/>

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User Study

The interface consists of three main sections: Tap Task, Pan Task, and Swipe Task. Each section contains a smartphone icon with a target area. Below each icon is a list of task details.

- Tap Task:**
 - 2 directions: Horizontal , Vertical
 - 20 different distance:
-220,-198,...,198,220
 - repeats:2
- Pan Task:**
 - Total: 80 Trials
- Swipe Task:**
 -

Cite:
<https://developer.apple.com/design/human-interface-guidelines/>

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The interface consists of three main sections: Tap Task, Pan Task, and Swipe Task. Each section contains a smartphone icon with a target area. Below each icon is a list of task details.

- Tap Task:**
 - 1. 4 directions:Up , Down , Right ,Left
 - 2. Repeats: 15
- Pan Task:**
 - Total:60 Trials
- Swipe Task:**
 - Take a break anytime if user wanted to.

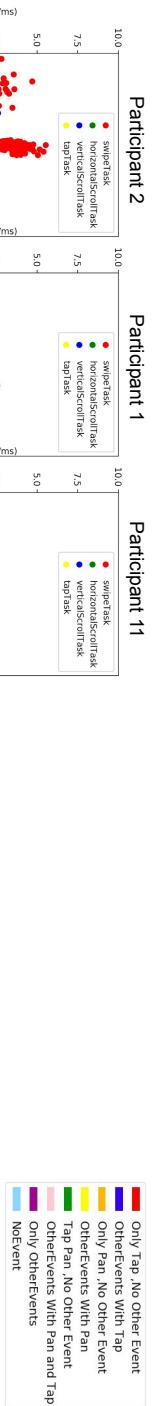
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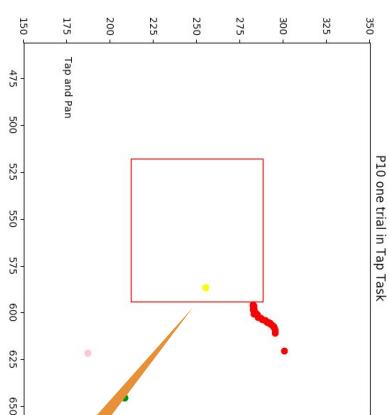
Kinematics Features

Touch Event in Task

Default system events in tap task for all users



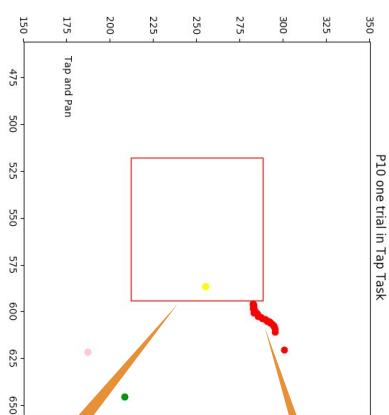
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Target

Fail Tap Task

Wrong Position

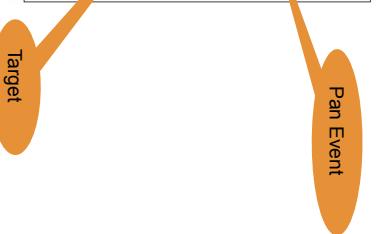


Target

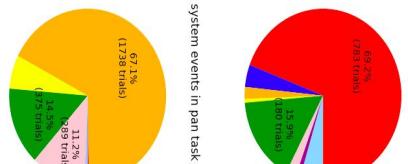
Fail Tap Task

Large Movement

Wrong Position



Pan Event



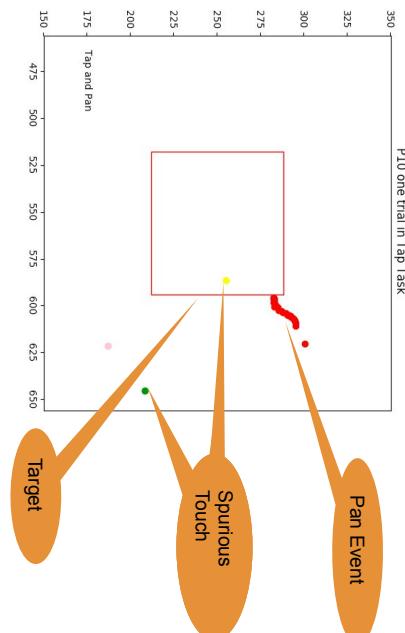
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Fail Tap Task

P10 one trial in Tap Task



Fail Tap Task-Spurious Touch

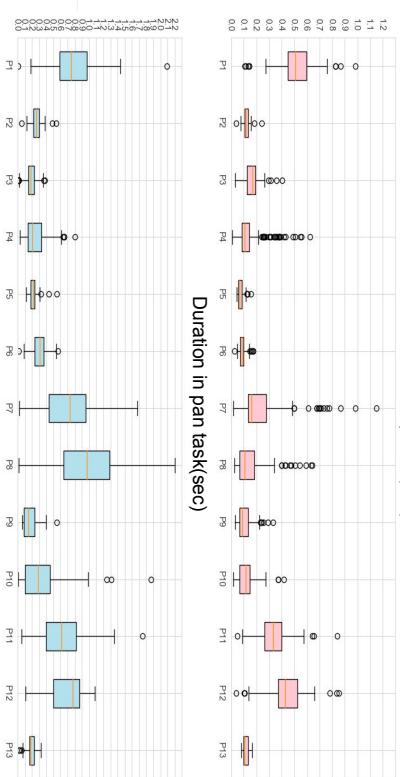
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Fail Tap Task- Spurious Touch

Duration

Duration in tap task(sec)



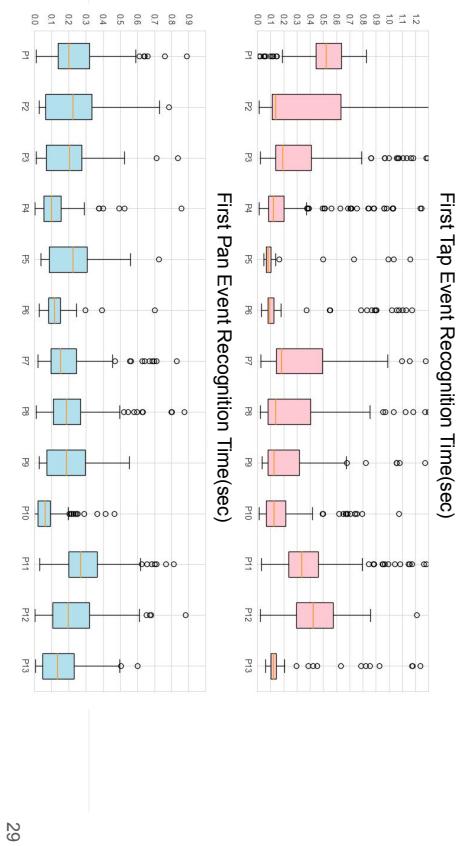
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User	P1	P2	P3	P4	P5	P6	P7
Spurious Touch occurrence rate	0.03	0	0.05	0.14	0	0	0.05
User	P8	P9	P10	P11	P12	P13	
Spurious Touch occurrence rate	0.03	0	0.72	0.02	0.04	0	

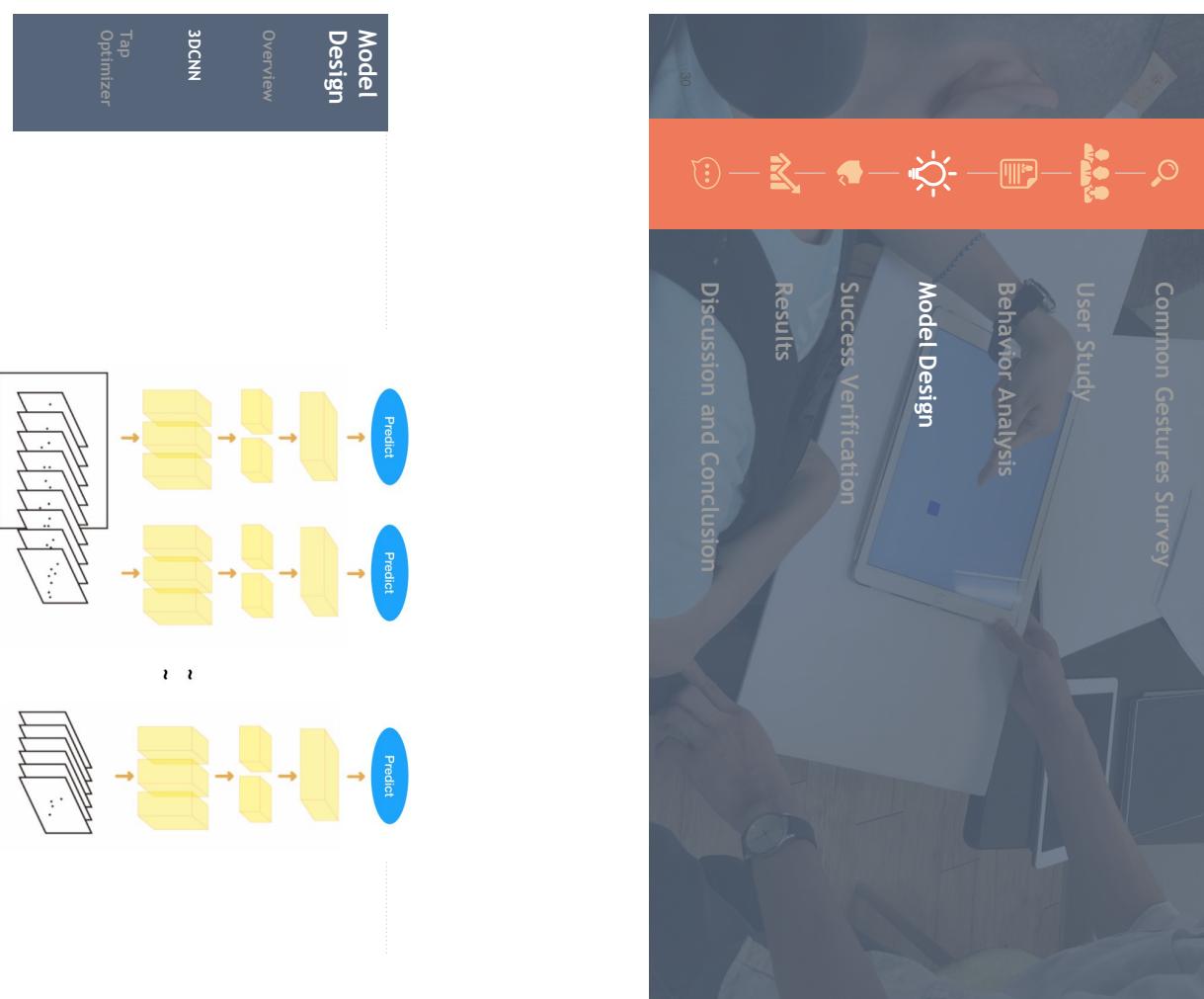
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Recognition Time

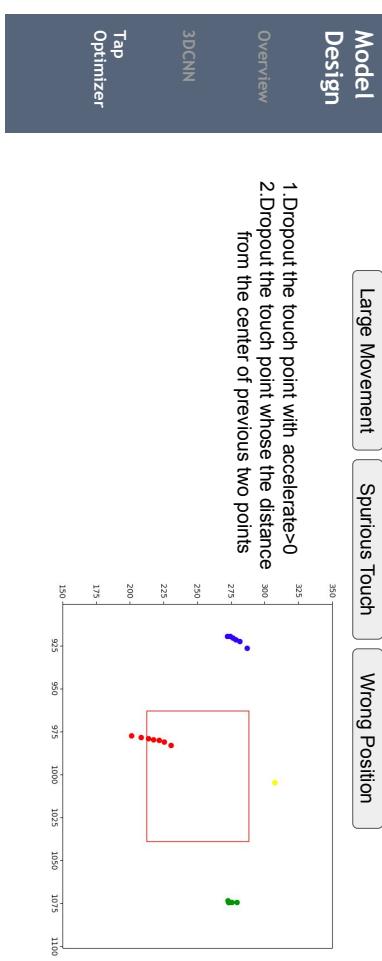
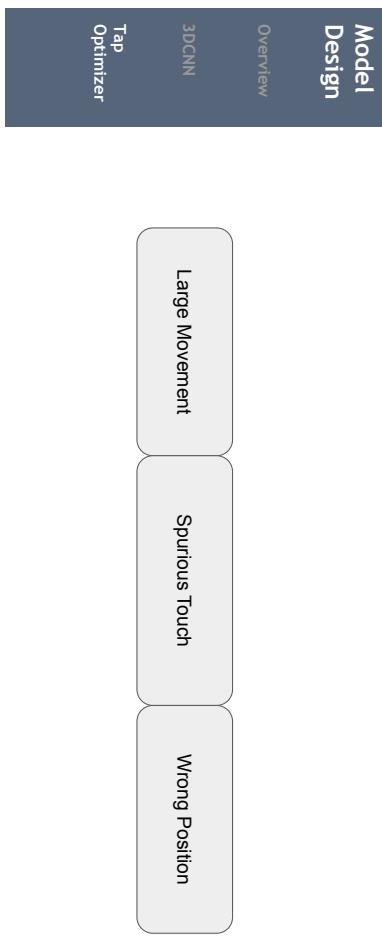
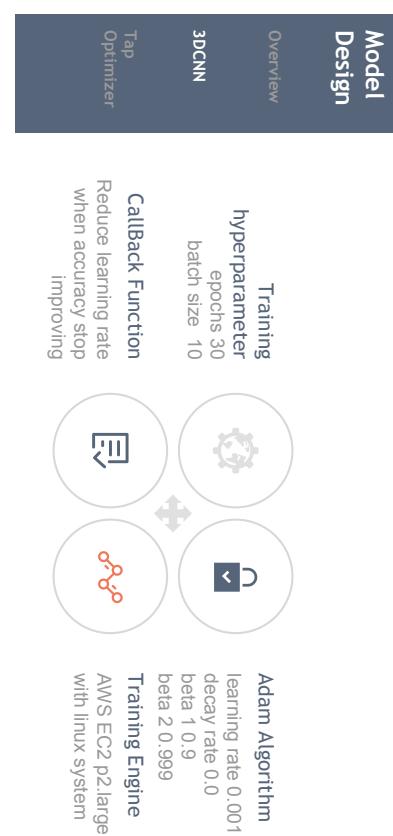
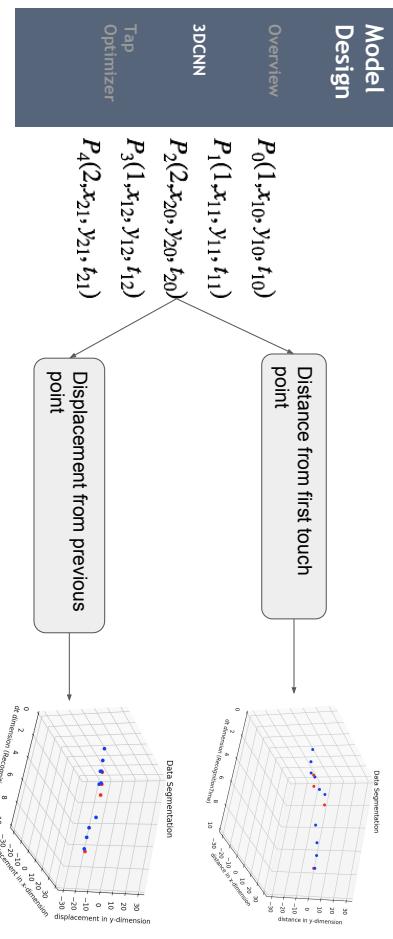


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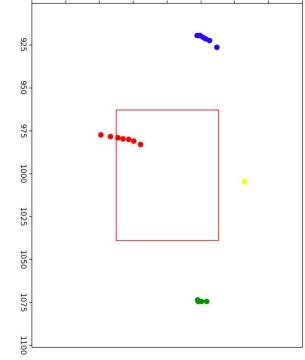
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Data Segmentation

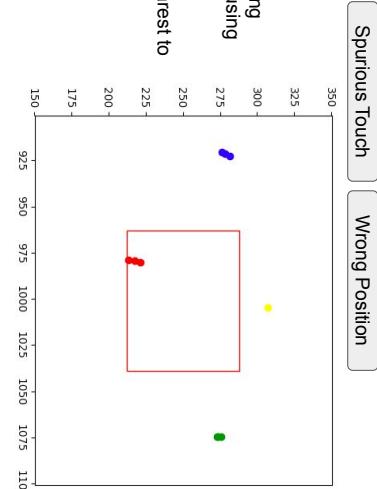




- 1 Dropout the touch point with accelerate >0
- 2 Dropout the touch point whose the distance from the center of previous two points



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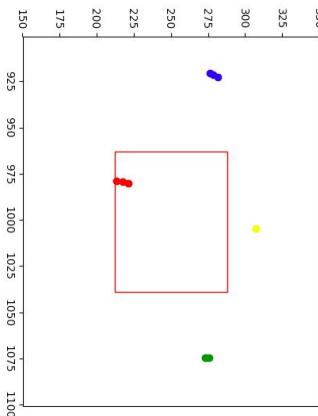
- Spurious Touch
- Wrong Position
- 1.For each finger tracks clustering the remaining touch point data using K-Means(k)
 - 2.Choose the point which is nearest to the cluster center



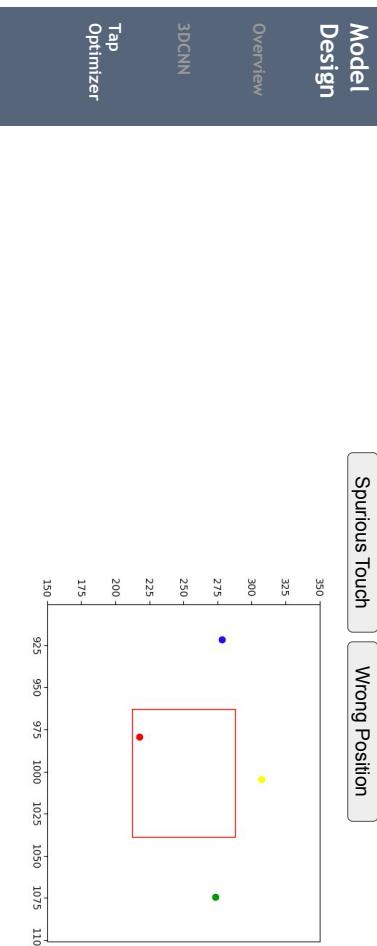
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- Spurious Touch
- Wrong Position
- 1 Dropout the touch point with accelerate >0
2 Dropout the touch point whose the distance from the center of previous two points



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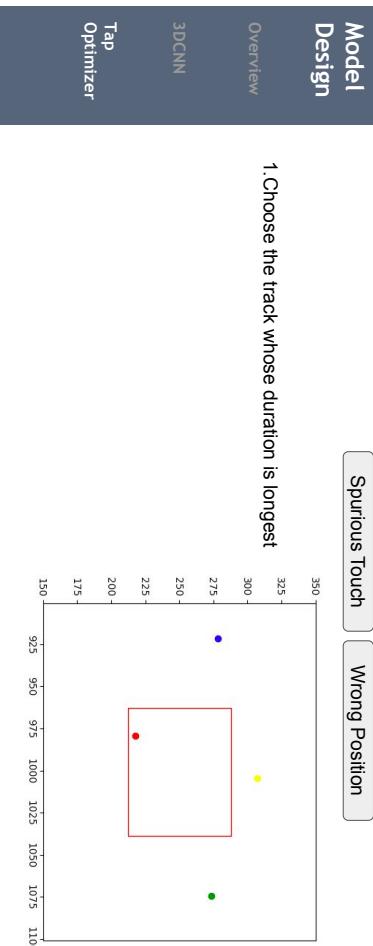
- Spurious Touch
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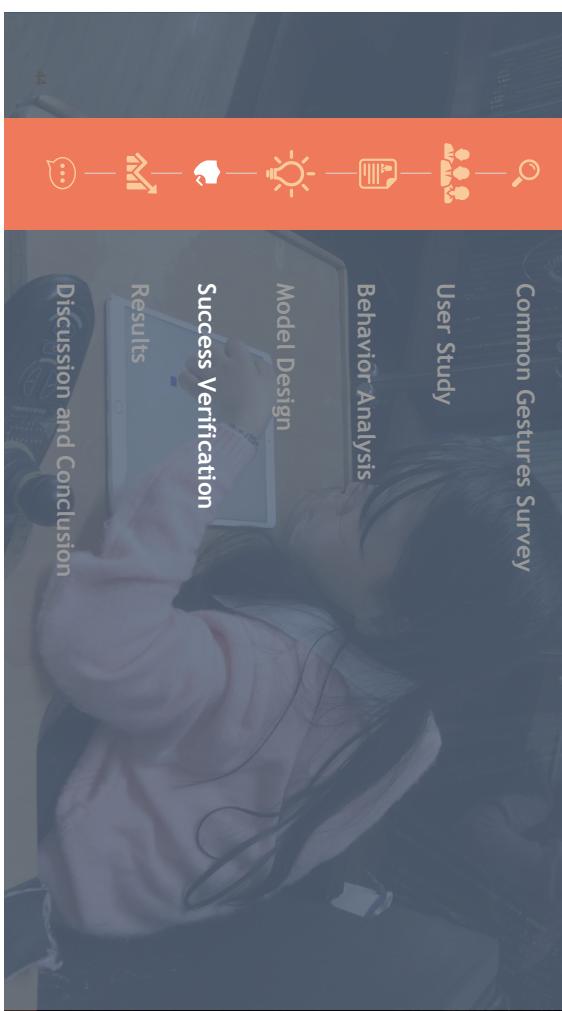
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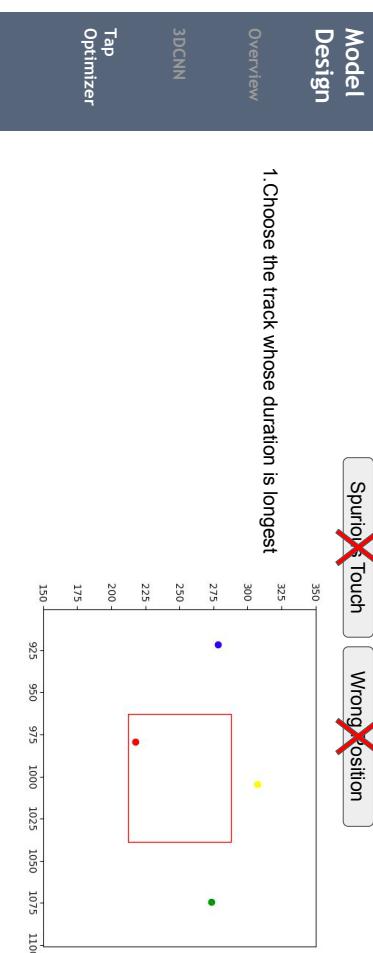
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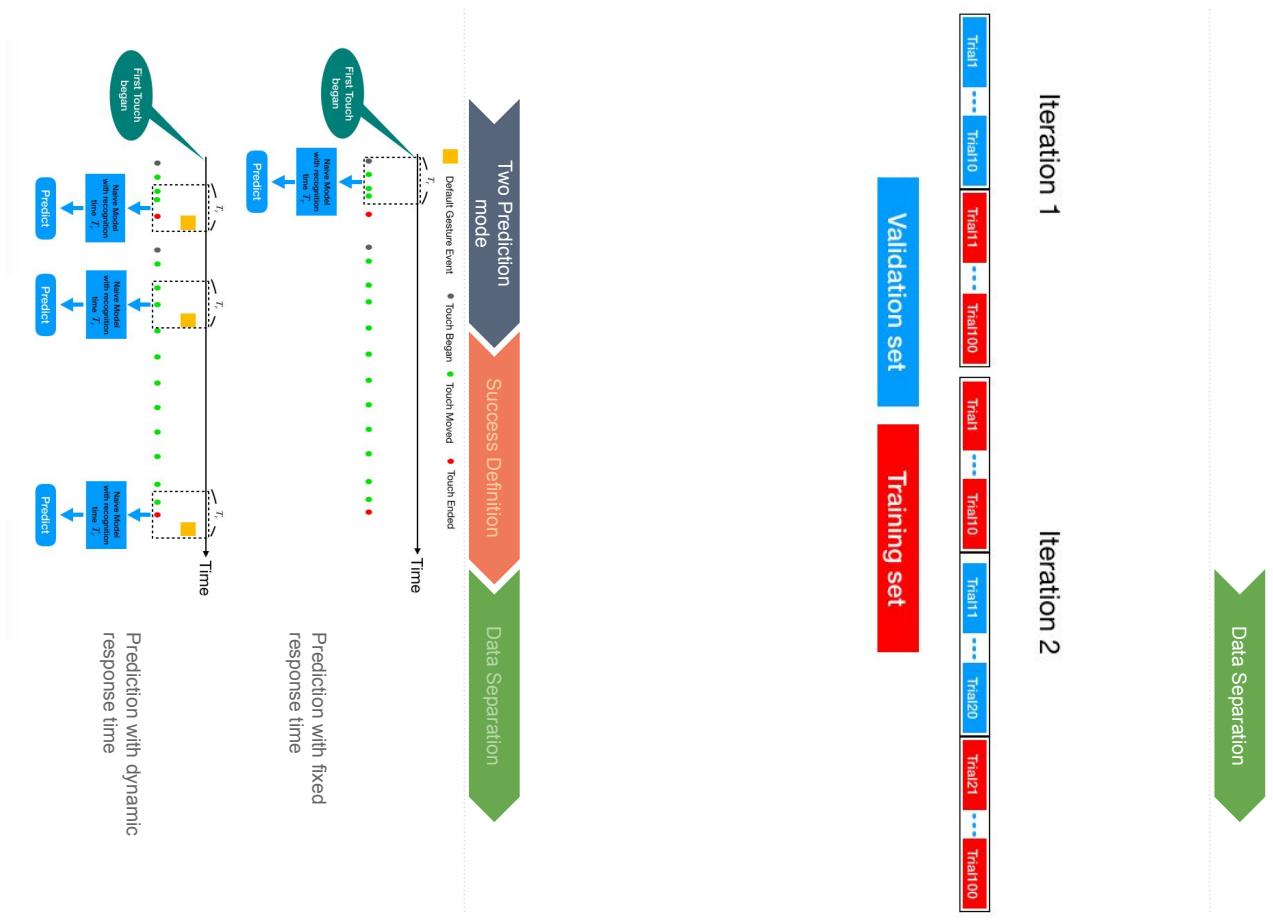
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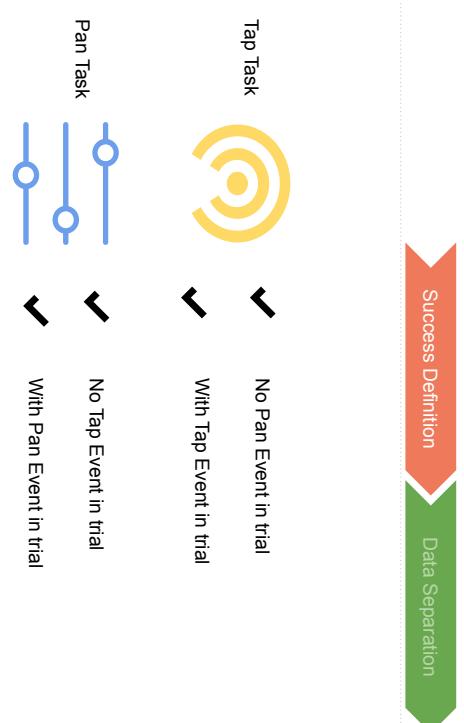
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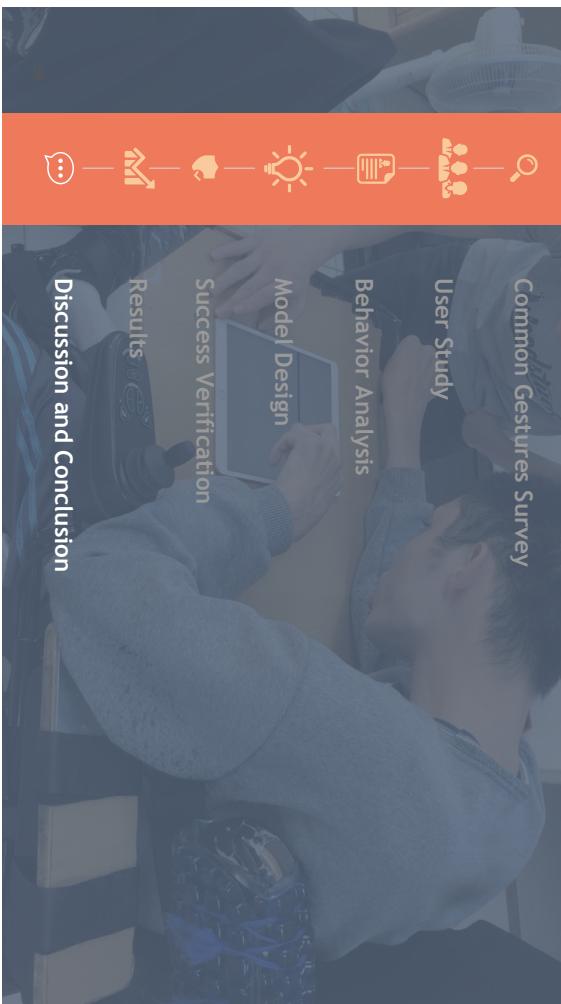
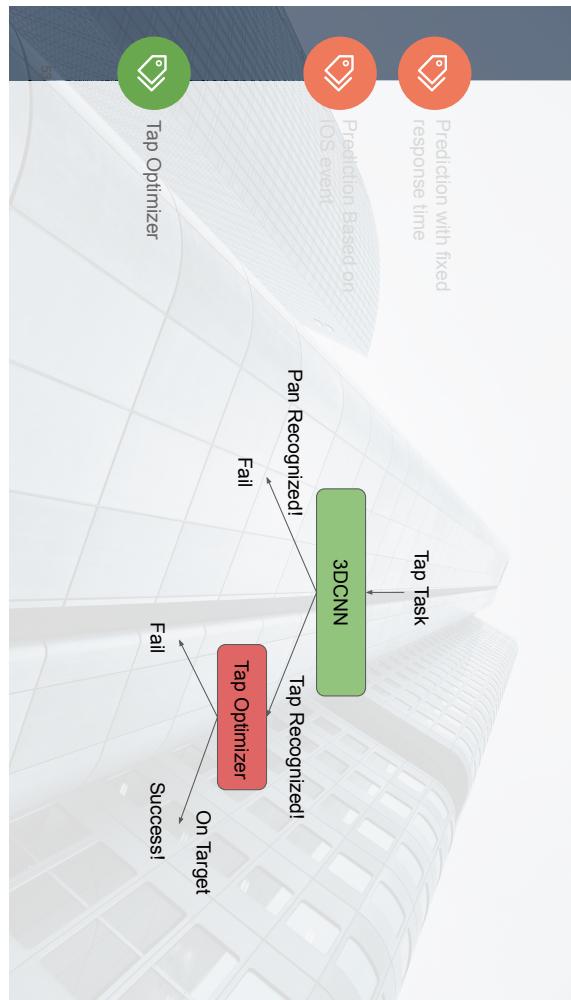
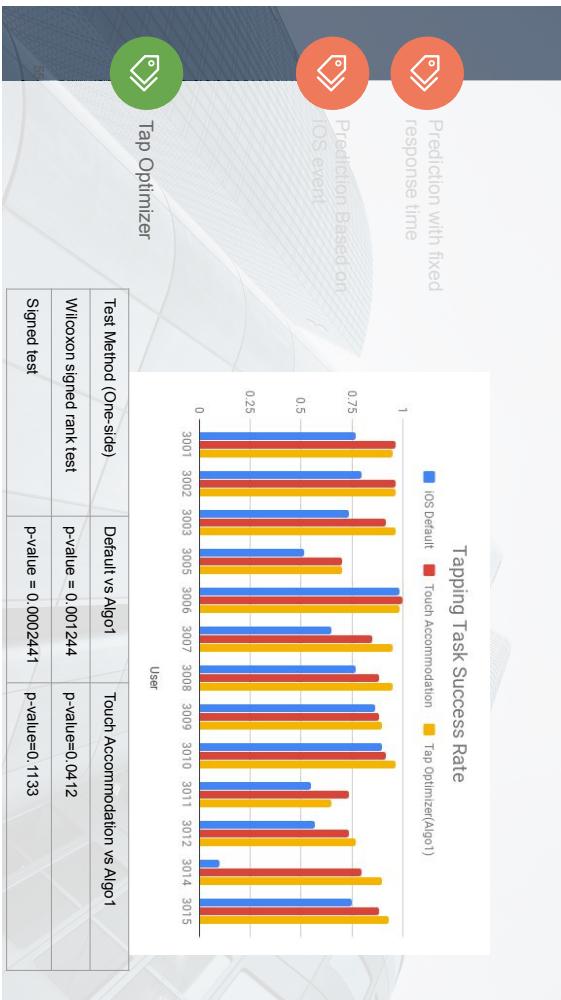
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Tap Optimizer

Test Method (One-side)	Default vs Algo1
Wilcoxon signed rank test	p-value = 0.2771
Signed test	p-value = 0.2266

Discussion and Conclusion

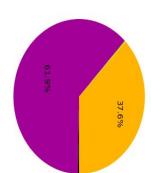
Discussion

How does 3DCNN improve accuracy of task classification?

Improvement Trial in Tap Task



Improvement Trial in Pan Task



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Sample Size

Customized Recognition Time

- Deep Learning Model needs large sample size
- Large data collection is hard
- There are still about 10% other gesture used in real application
- It is worth to survey specific recognition time for each user.

More gesture classes

Tap Optimizer

- Prediction model for tapping

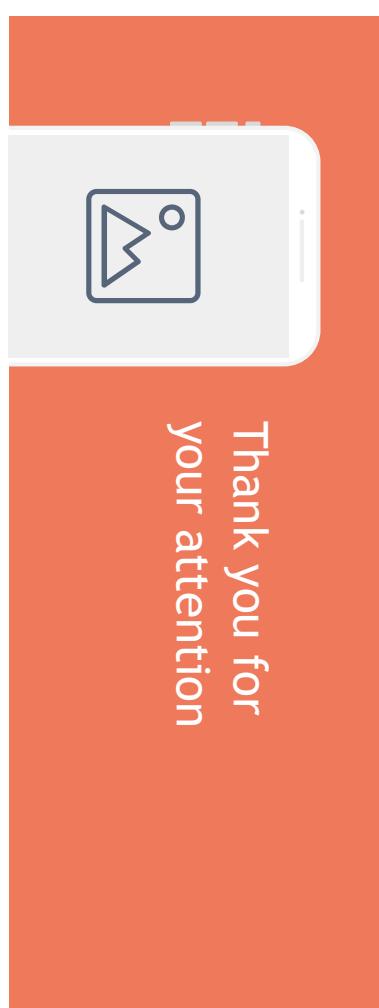
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Discussion and Conclusion

Discussion

Discussion and Conclusion

Conclusion



Tapping Optimizer

An unsupervised algorithm

Behavior Analysis

Duration, Movement, Velocity and Error analysis

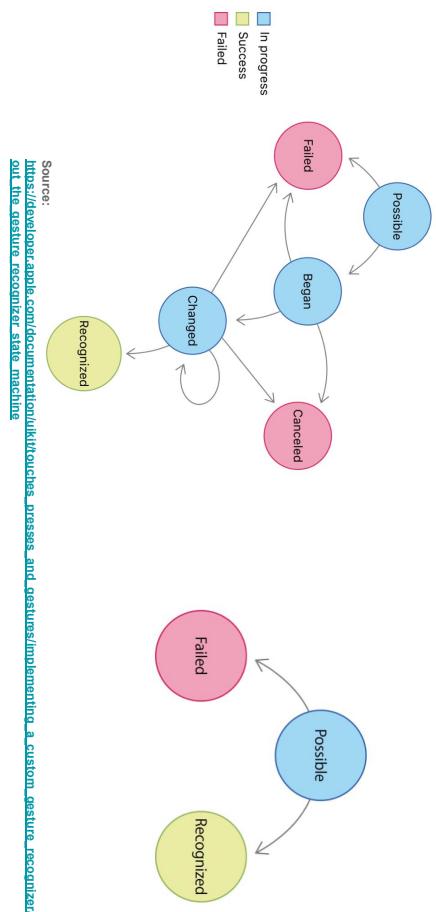
Learning Model

Three Dimensional Convolution Neural Network with novel interpolation and data segmentation

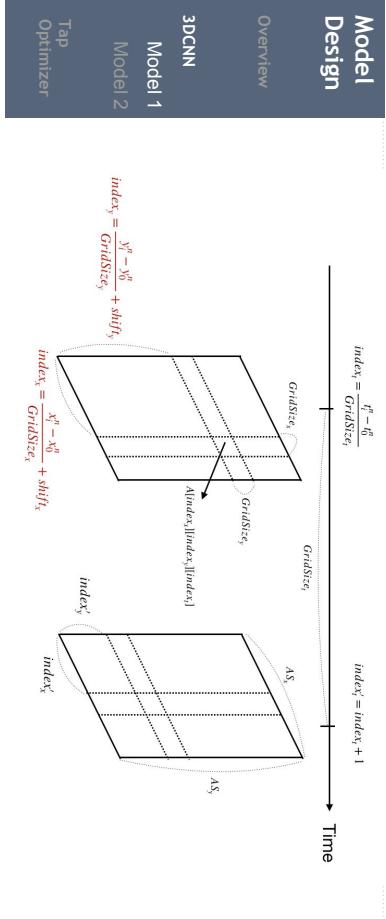
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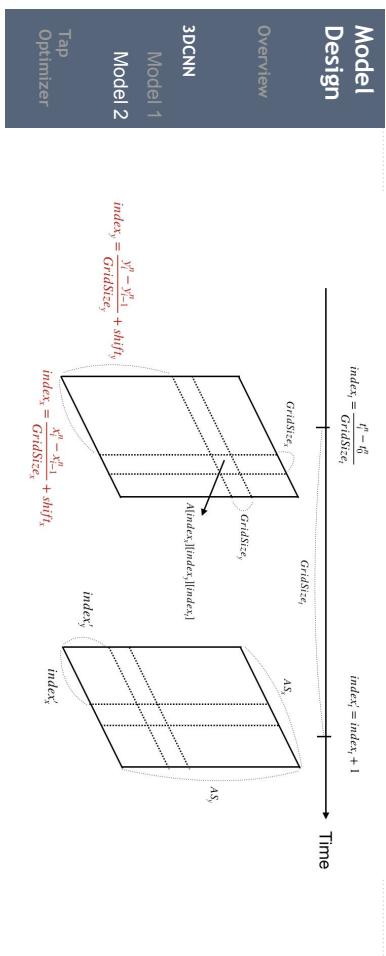
iOS Gesture Recognizer



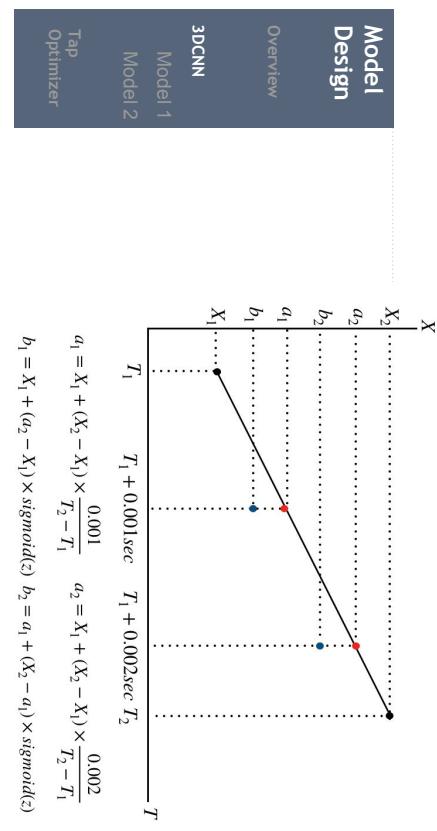
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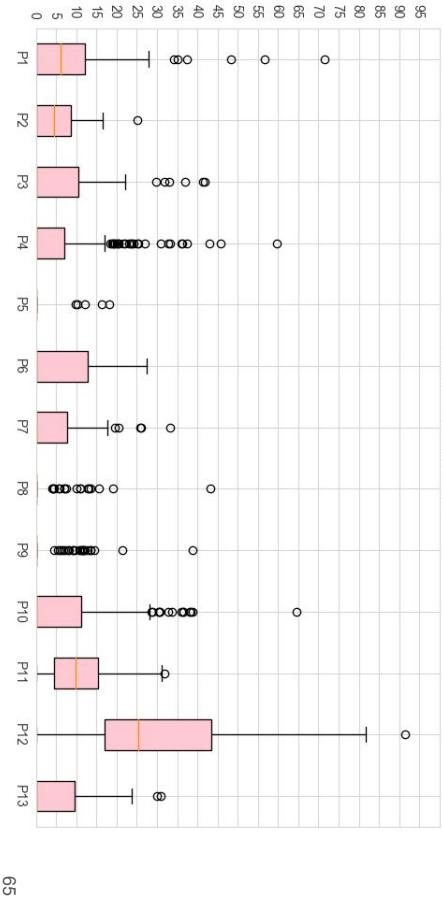
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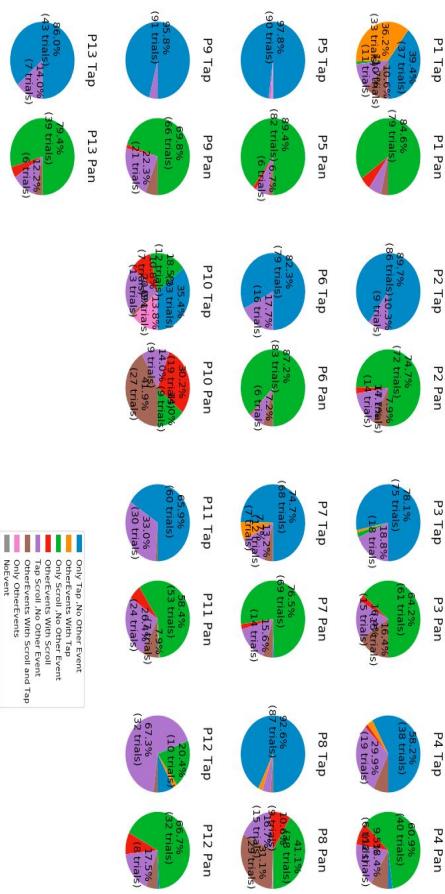
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Movement in Tap Task

Movement in tap task (pt)



Error Analysis



Error Analysis

