



DeepGesture

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

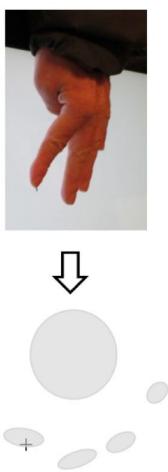
Motivation

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



Related Work

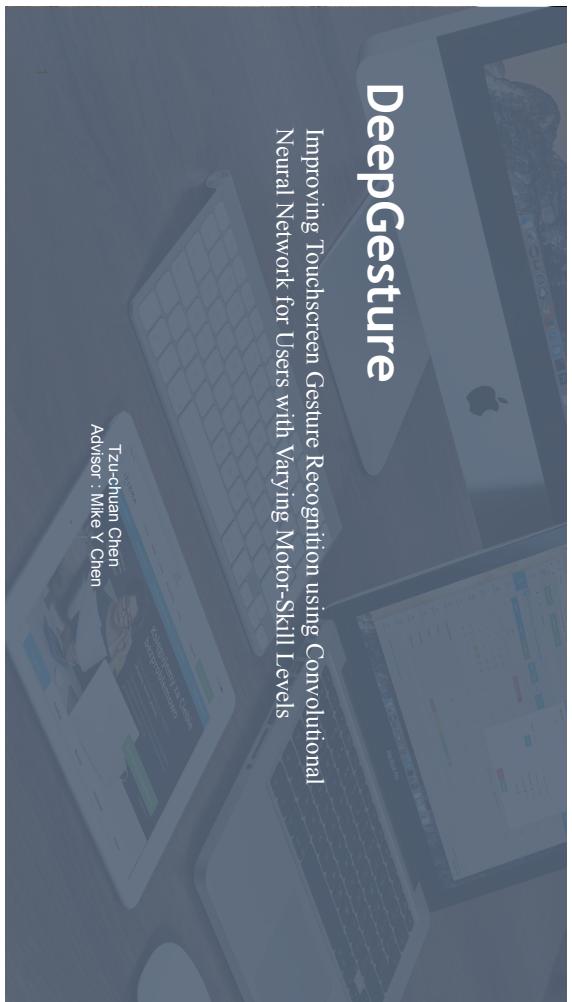
Is it easy for motor impairment user or elderly people tapping on target successfully?



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

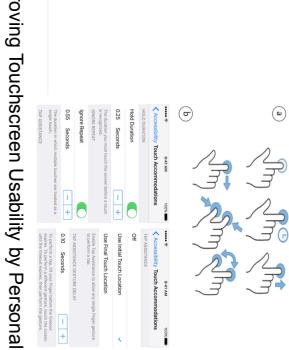
Comparing Touchscreen and Mouse Input Performance by People With and Without Upper Body Motor Impairments
Leah Findlater, Karyn Moffatt, Jon E. Froehlich, Meethu Malu, Joan Zhang

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



Related Work

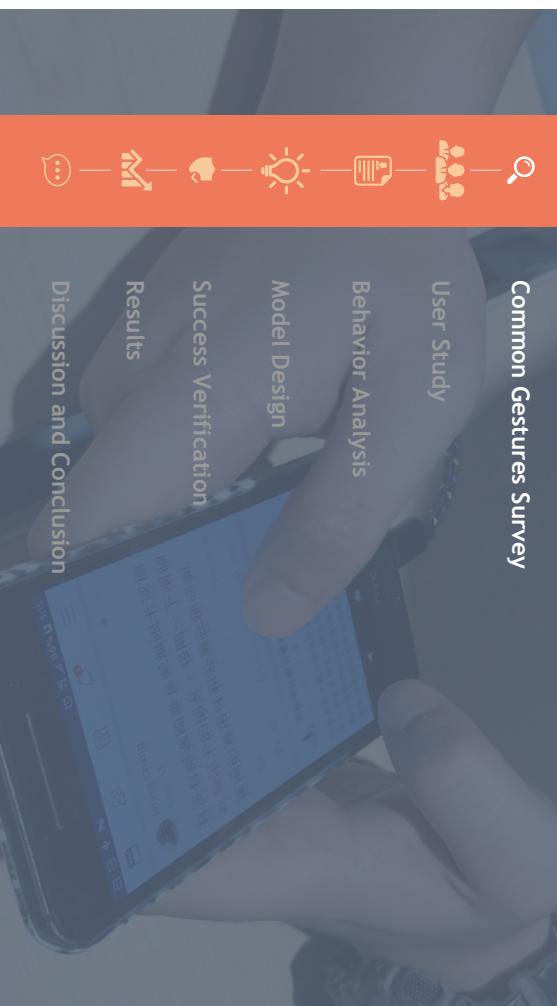
Is there accessibility mode or system for people with special need?



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

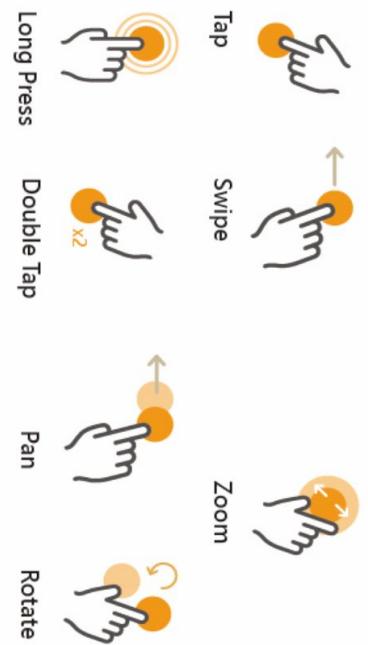
Our Work

A touch gesture system predict gesture type and precise touch location



Touch Gesture Type

Discrete Gesture Continuous Gesture

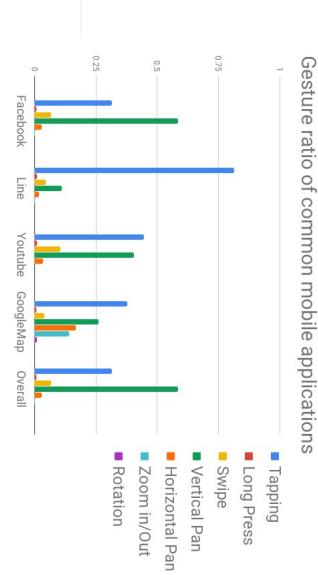


Common-used Touch Gesture Survey

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

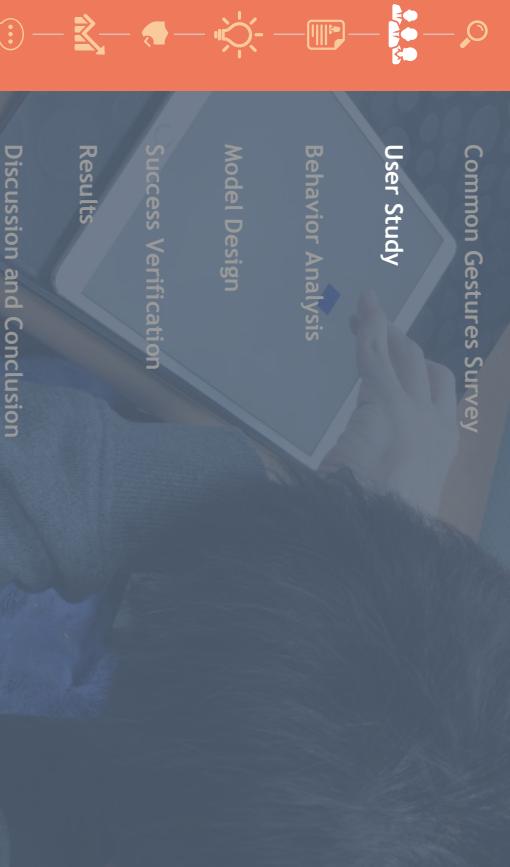
Pan Task

Swipe Task

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

Results
Success Verification
Discussion and Conclusion

Common Gestures Survey
User Study
Behavior Analysis



User Study

The interface consists of three main sections: Tap Task, Pan Task, and Swipe Task. Each section features a smartphone icon with a blue arrow pointing up, down, right, or left respectively. Below each icon is a list of task details and a total trial count.

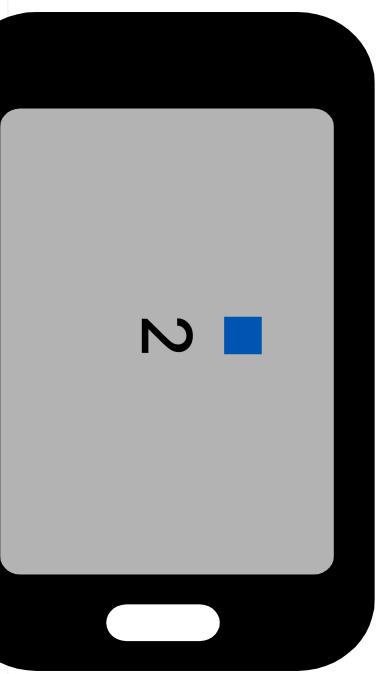
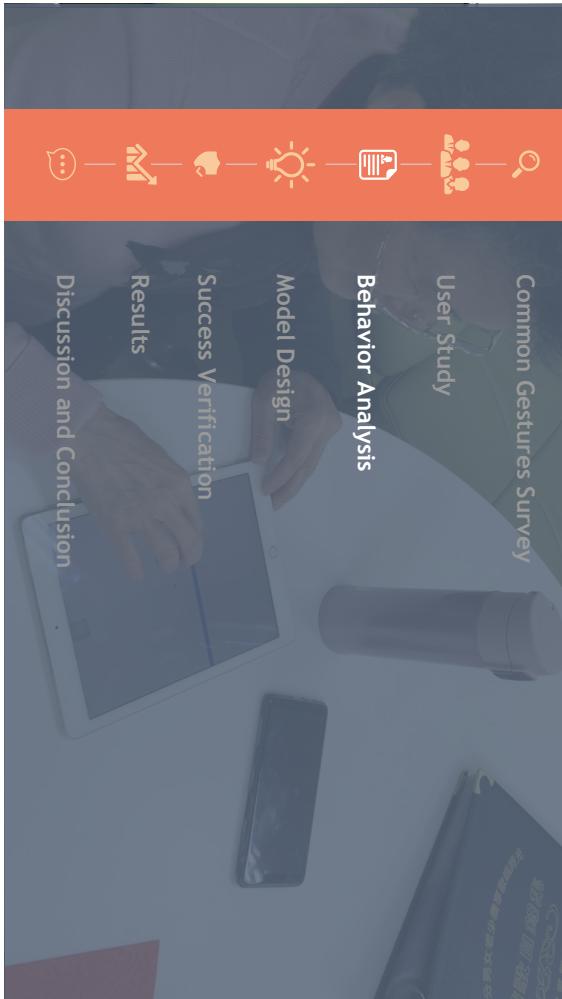
Task Type	Description	Total Trials
Tap Task	1. Target Size: 44pt and 76 pt 2. 25 positions 3. repeats:2	Total:100 Trials
Pan Task	1. 2 directions: Horizontal ,Vertical 2. 20 different distance: -220,-198,...,198,220 3. repeats:2	Total: 80 Trials
Swipe Task	Cite: https://developer.apple.com/design/human-interface-guidelines/	

User Study

The interface includes a flowchart at the bottom showing the sequence of tasks: User Information → Task Illustration → Practice Mode. The flowchart has arrows pointing from one step to the next. A note on the left says "Take a break anytime if user wanted to."

Task Type	Description	Total Trials
Tap Task	1. 2 directions: Horizontal ,Vertical 2. 20 different distance: -220,-198,...,198,220 3. repeats:2	Total: 80 Trials
Pan Task	1. 2 directions: Horizontal ,Vertical 2. 20 different distance: -220,-198,...,198,220 3. repeats:2	
Swipe Task	Cite: https://developer.apple.com/design/human-interface-guidelines/	

Before each trial



After each trial



User Information

Table 1. User information of the participants.

ID	Age	Gender	Device	Health Condition	Self-Reported impairments								
					Mo	Fa	Co	St	Gt	Ho	Tr	Sp	
P1	24	M	S	HSP	Y	Y	Y	Y	Y	Y	Y	Y	
P2	60	F	S	--									
P3	81	F	S/T	Parkinson's	Y	Y	Y				Y	Y	
P4	24	M	S	Cerebral Palsy	Y	Y					Y		
P5	71	F	T	--									
P6	76	F	S/T	--									
P7	85	F	T	--							Y	Y	
P8	79	F	T	--									
P9	74	F	T	--									
P10	28	F	S/T	Spinal Cord Injury	Y	Y	Y	Y	Y	Y	Y	Y	
P11	25	M	T	Cerebral Palsy	Y	Y	Y	Y	Y	Y	Y	Y	
P12	76	M	S/T	--									
P13	75	F	S	--									

Mo: slow movements

Fa: rapid fatigue

St: low strength
Gr: difficulty gripping
Ho: difficulty holding

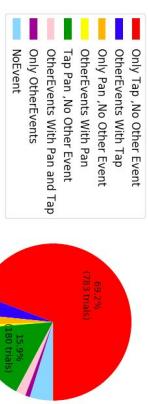
T: tremor
Sp: spasm
S: Smart phone
M: Male

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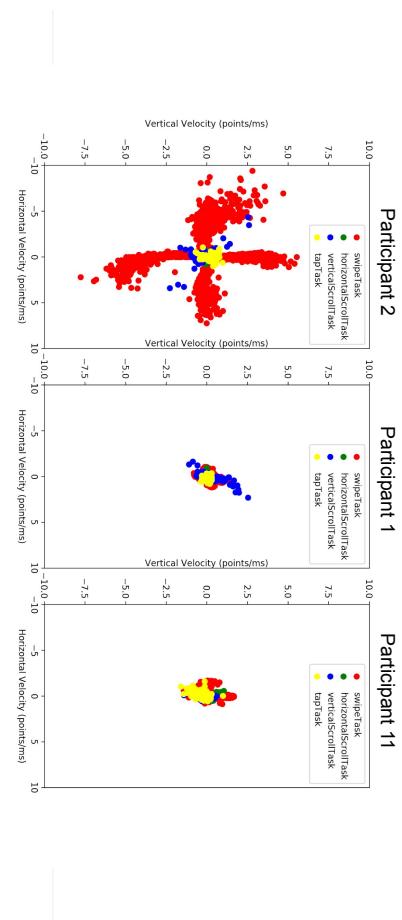
Kinematics Features

Touch Event in Task

Default system events in tap task for all users



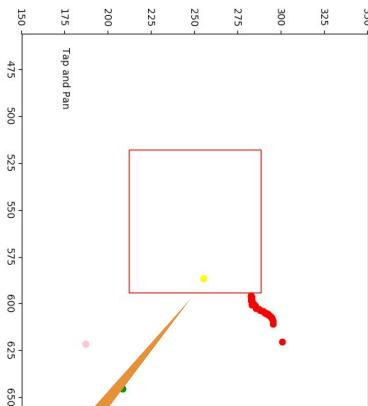
Default system events in pan task for all users



Fail Tap Task

Wrong Position

P1.0 one trial in Tap Task

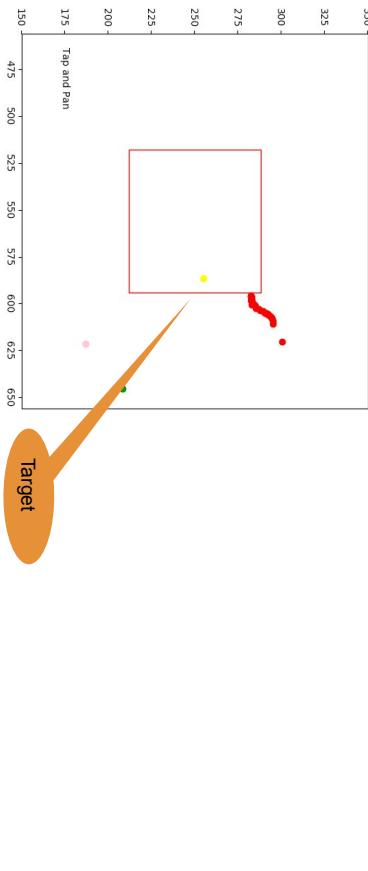
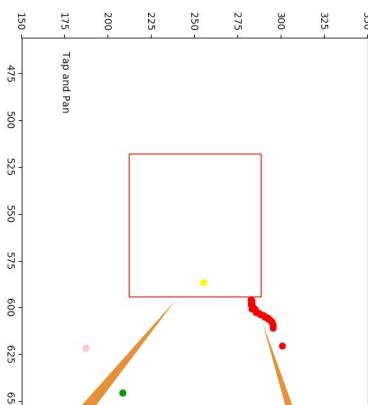


Fail Tap Task

Large Movement

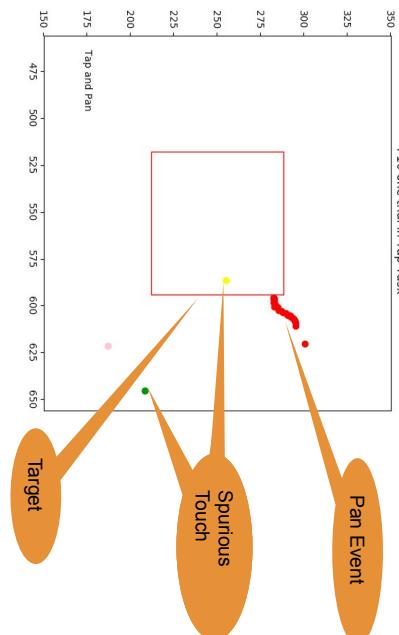
P1.0 one trial in Tap Task

Wrong Position



Fail Tap Task

P10 one trial in Tap Task



Fail Tap Task- Spurious Touch

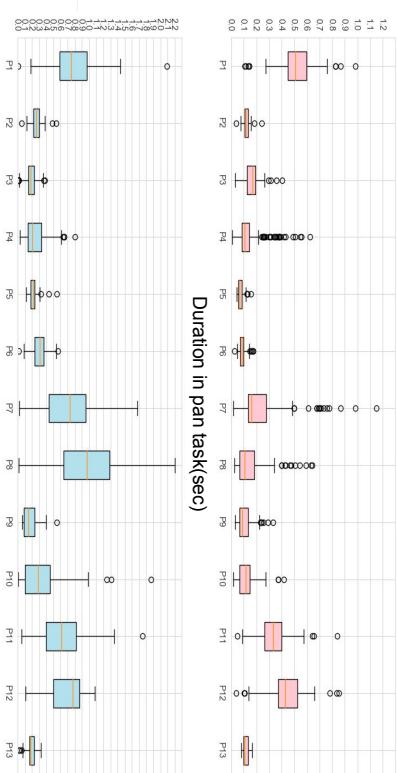
User	P1	P2	P3	P4	P5	P6	P7
Spurious Touch occurrence rate	0.03	0	0.05	0.14	0	0	0.05
User	P8	P9	P10	P11	P12	P13	
Spurious Touch occurrence rate	0.03	0	0.72	0.02	0.04	0	

Fail Tap Task-Spurious Touch

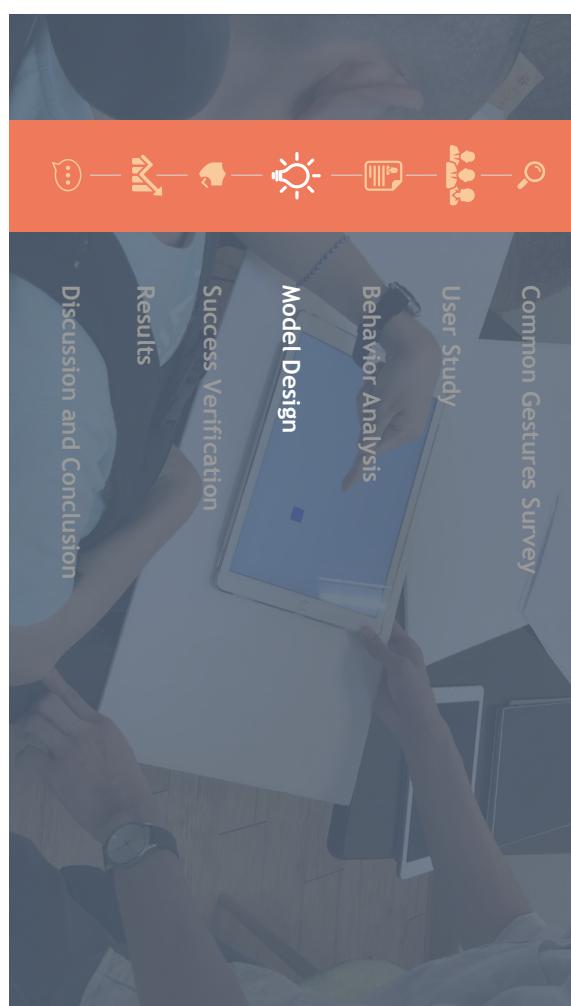
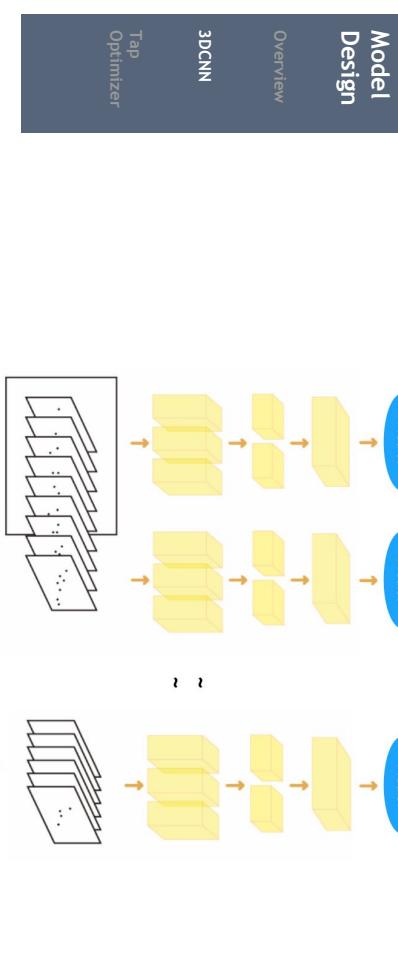
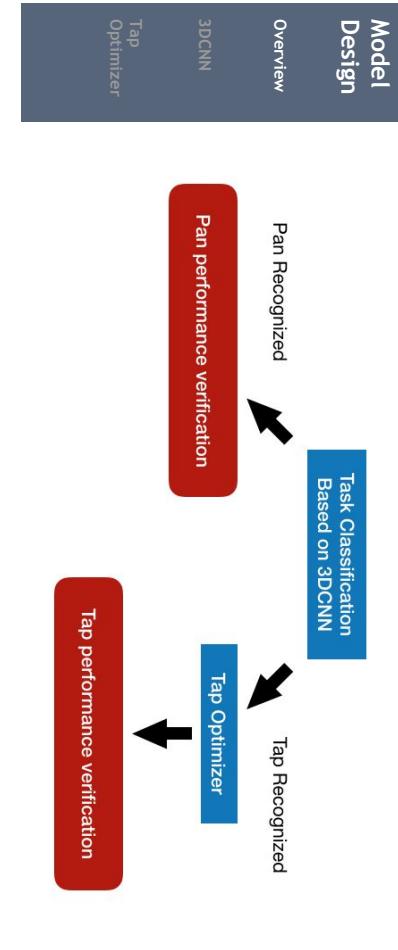
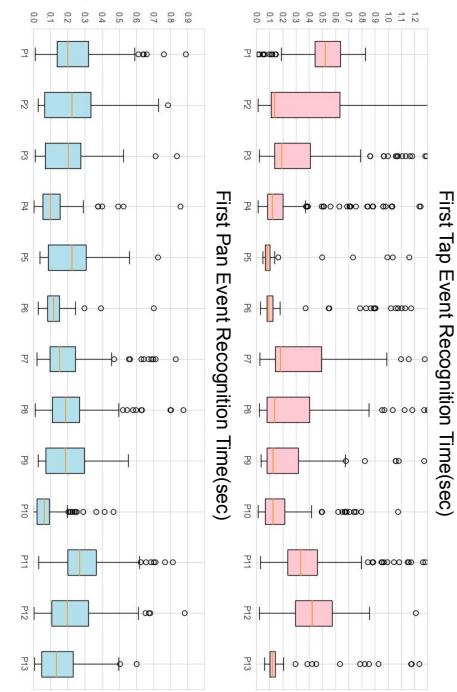


Duration

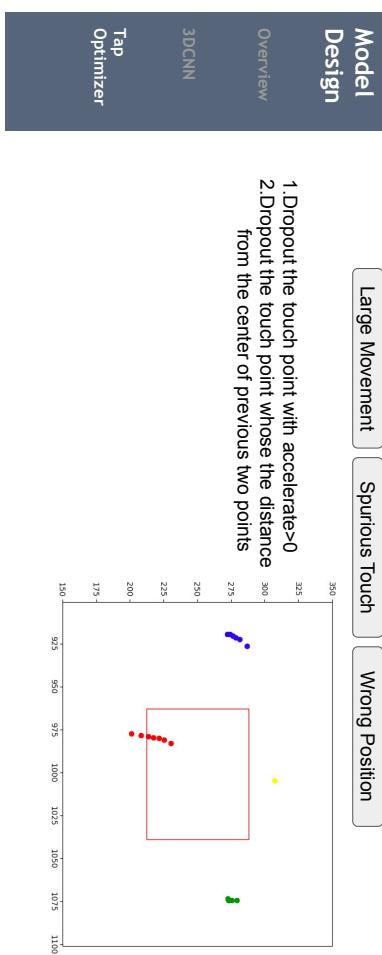
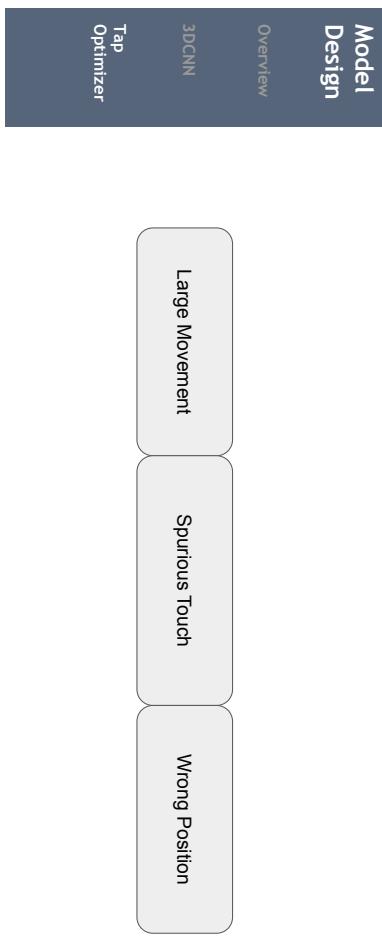
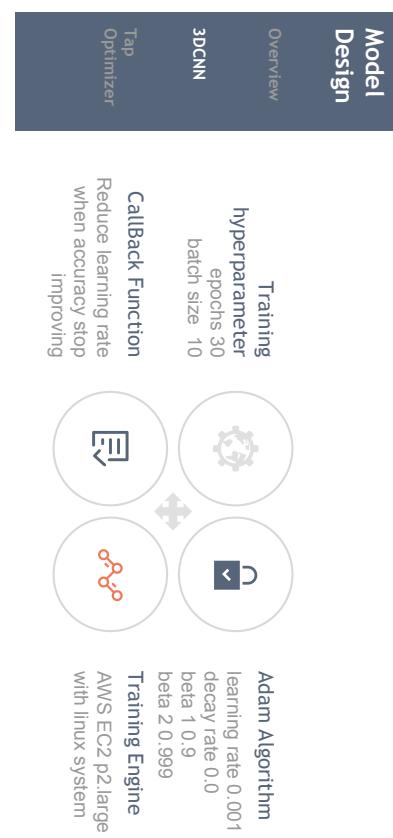
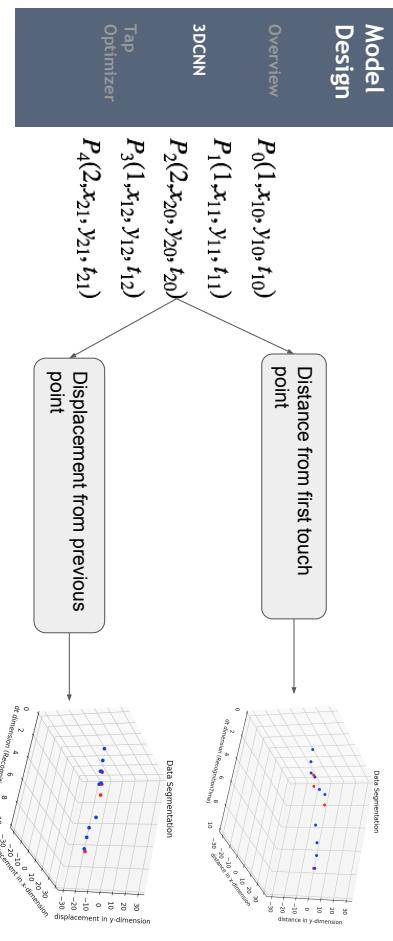
Duration in tap task(sec)

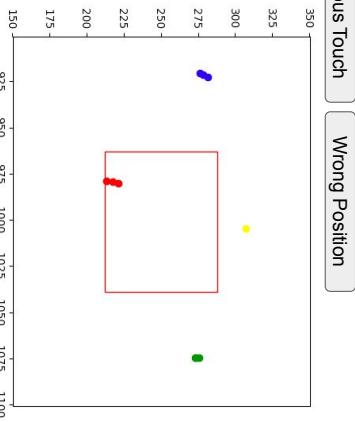
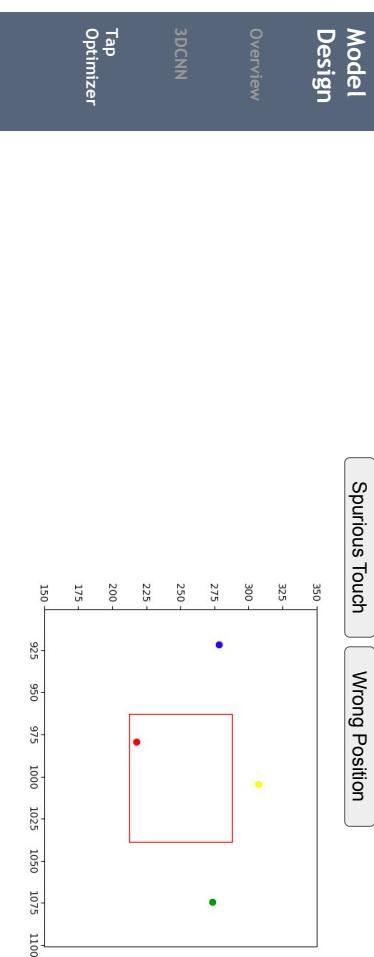
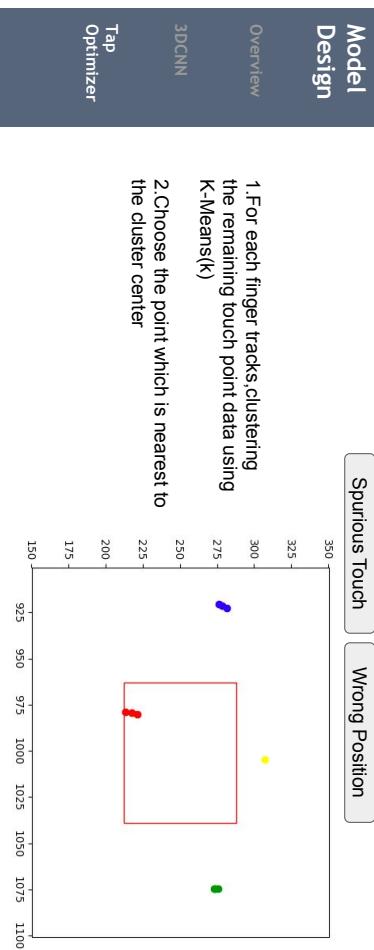
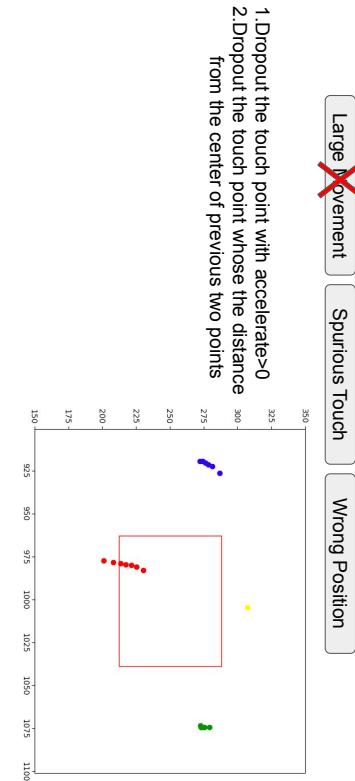


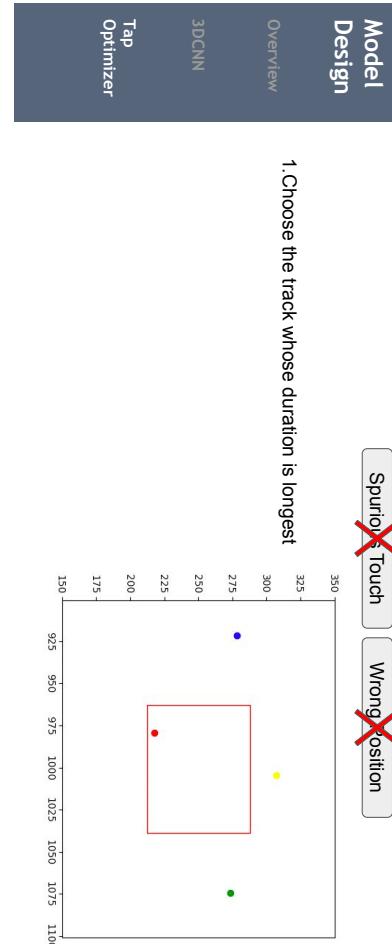
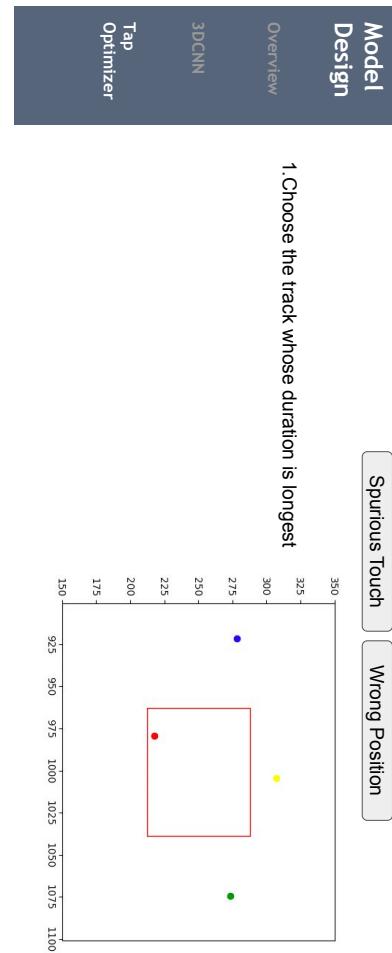
Recognition Time

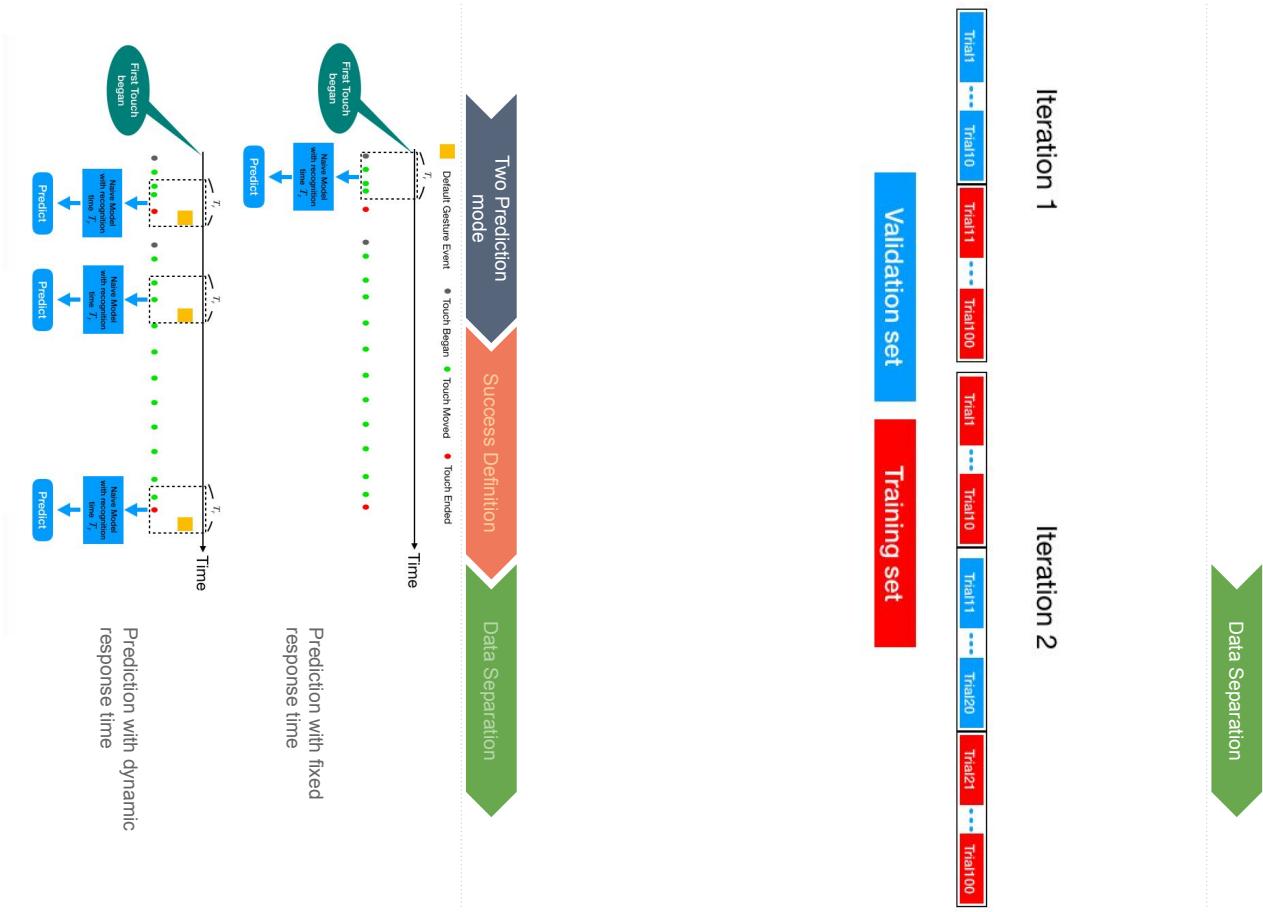
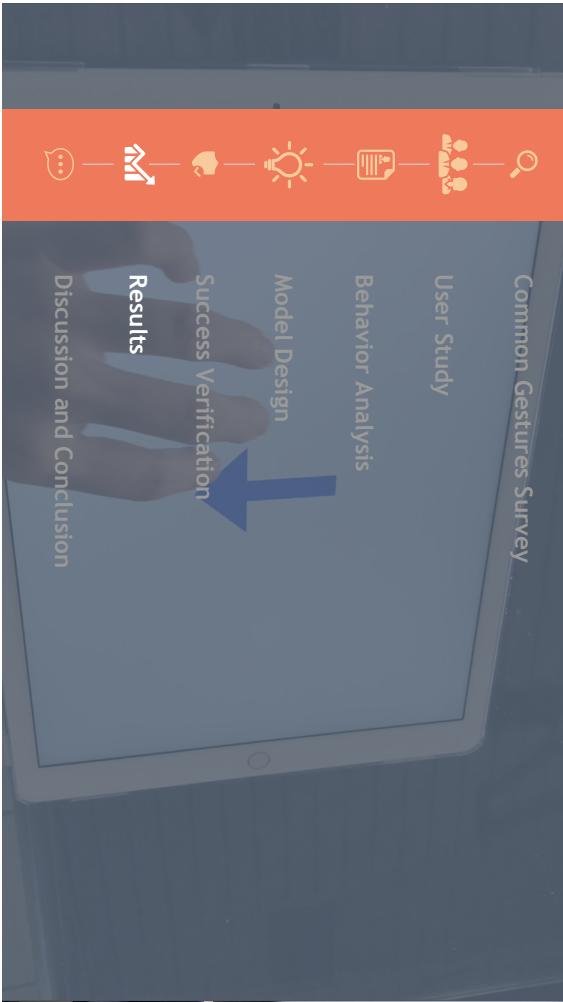


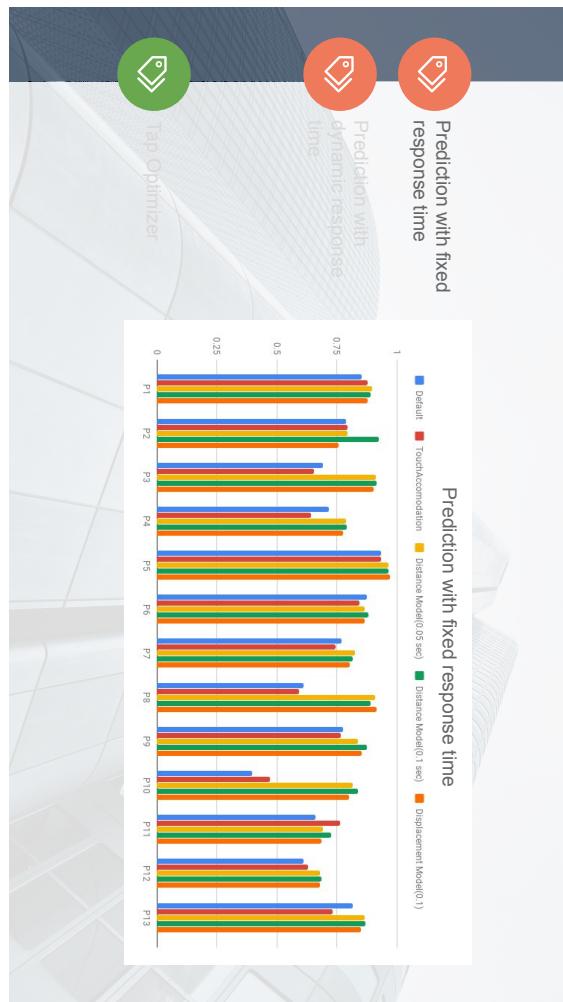
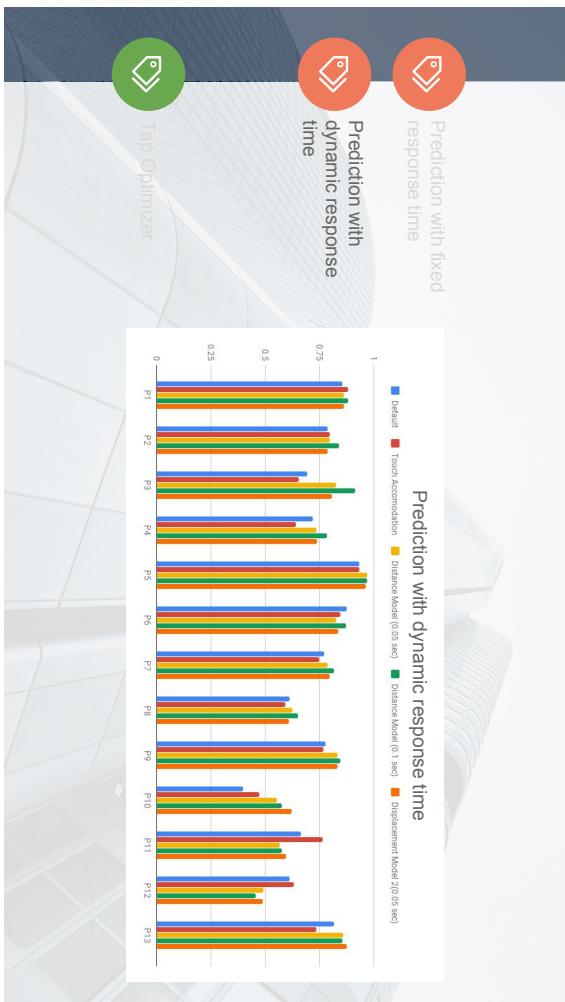
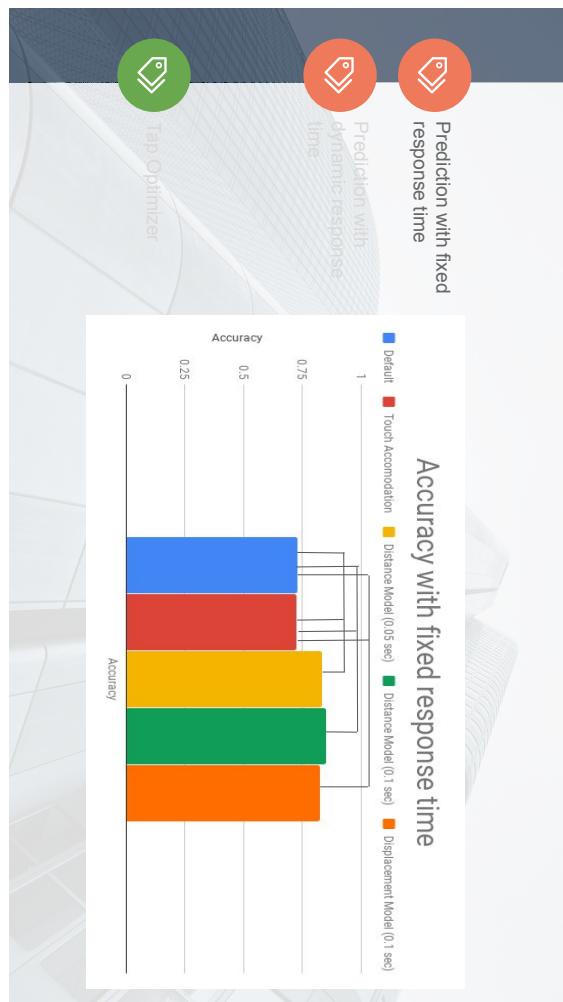
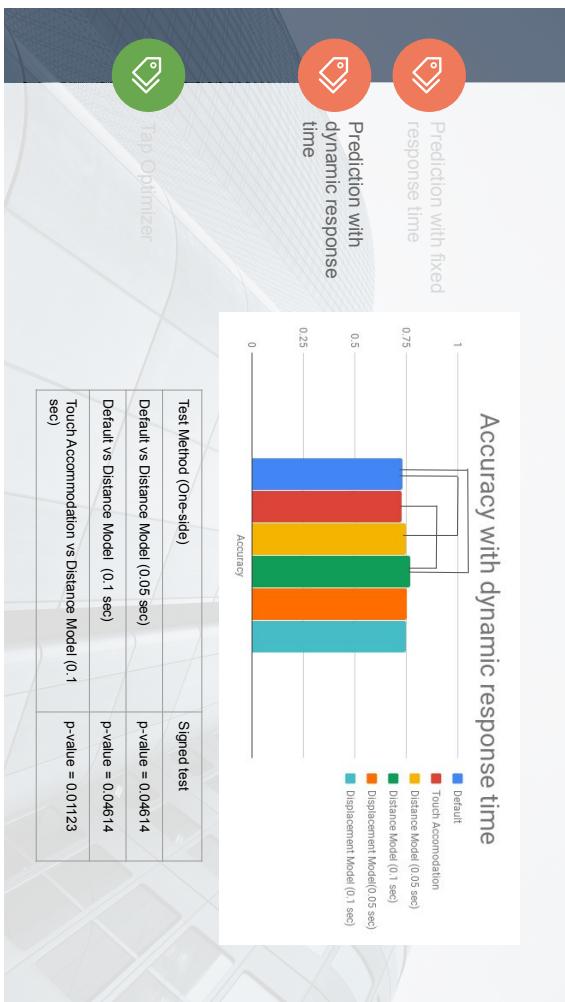
Data Segmentation

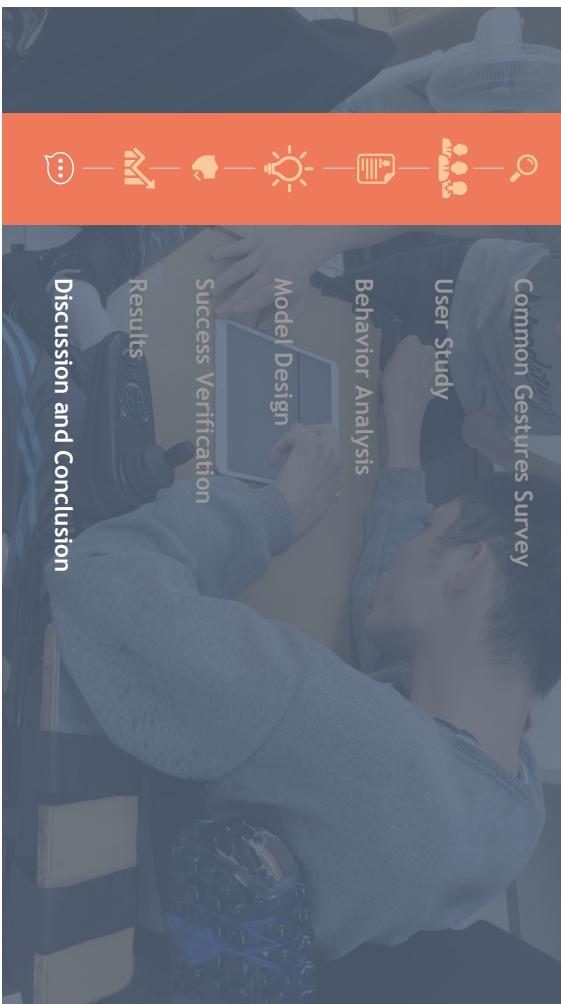
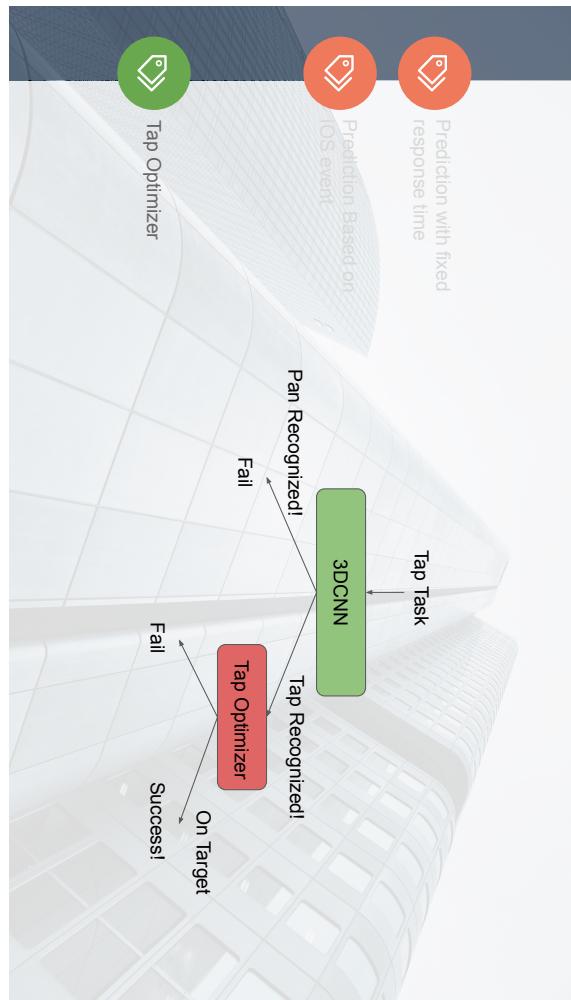
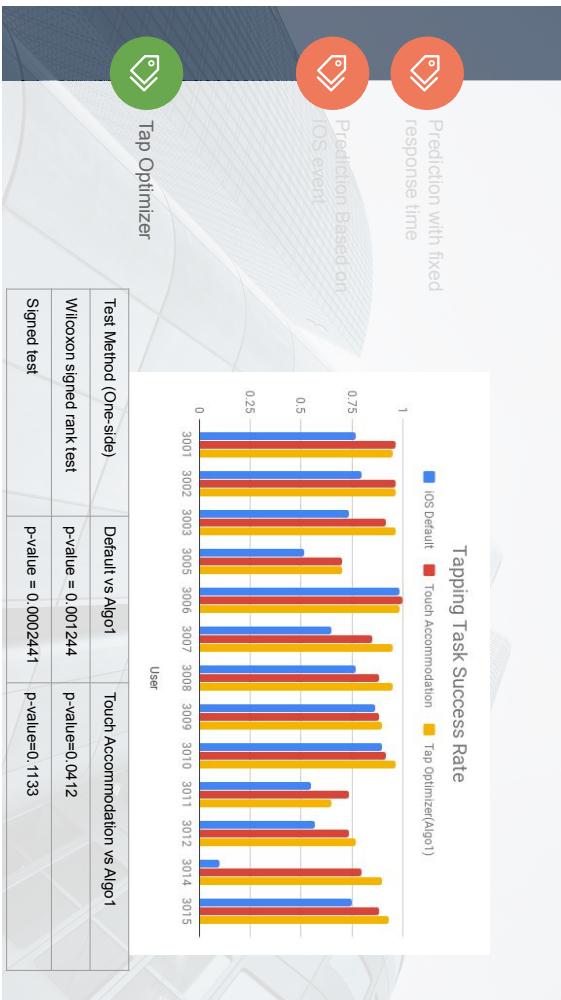












Tap Optimizer

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

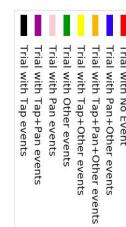
User	P1	P2	P3	P4	P5	P6	P7
First Touch	0.955	1	0.983	0.630	1	0.963	0.926
Tap Optimizer	0.910	1	0.983	0.697	1	0.983	0.926
User	P8	P9	P10	P11	P12	P13	All
First Touch	0.944	0.981	0.921	0.743	0.790	0.865	0.900
Tap Optimizer	0.944	0.981	0.759	0.903	0.948	0.886	0.916

Discussion and Conclusion

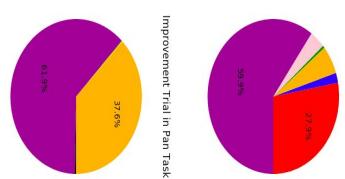
Discussion

How does 3DCNN improve accuracy of task classification?

Improvement Trial in Tap Task



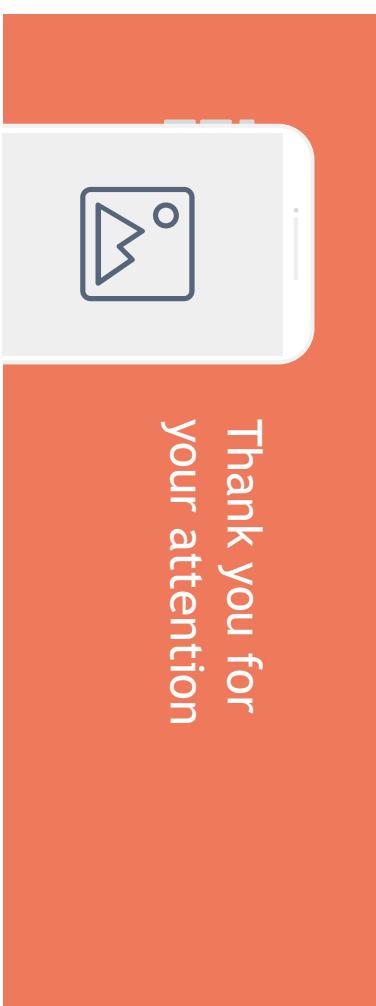
Improvement Trial in Pan Task



→ Displacement Model with 0.05 recognition time

Discussion and Conclusion

Conclusion



Discussion and Conclusion

Discussion

Sample Size

Customized Recognition Time

- Deep Learning Model needs large sample size
- Large data collection is hard

- It is worth to survey specific recognition time for each user.

More gesture classes

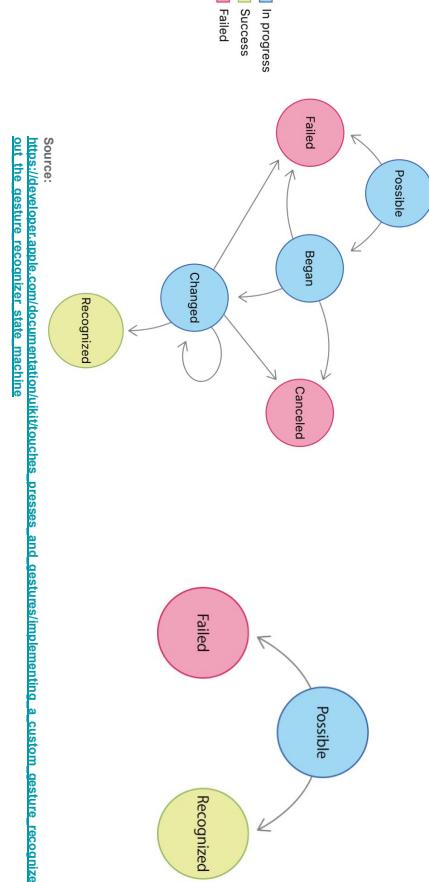
Tap Optimizer

- There are still about 10% other gesture used in real application

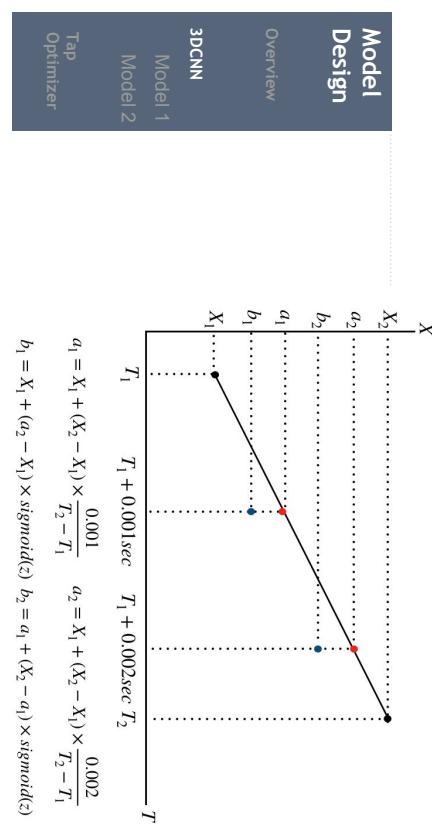
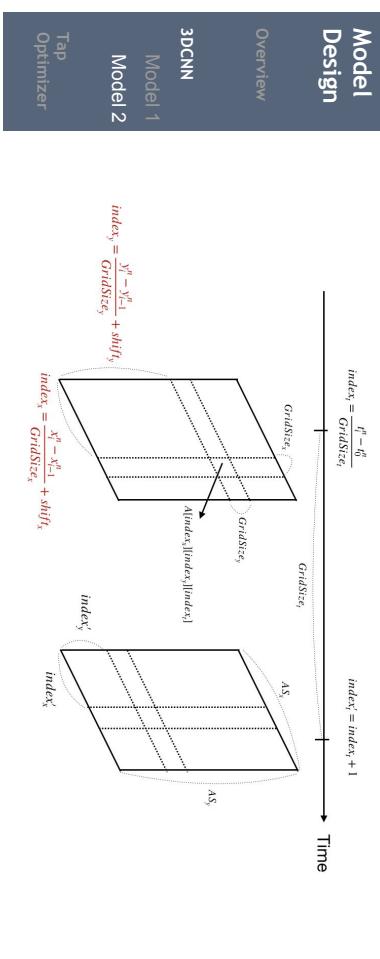
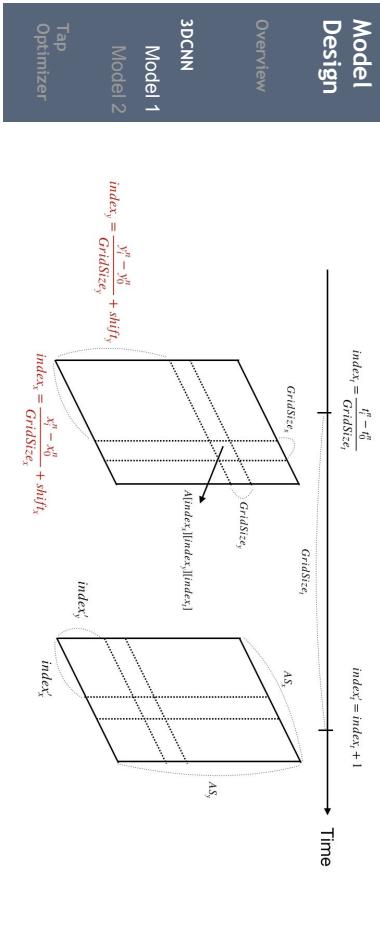
- Prediction model for tapping

	Learning Model	Behavior Analysis	Tapping Optimizer
Conclusion	Three Dimensional Convolution Neural Network with novel interpolation and data segmentation	Duration, Movement, Velocity and Error analysis	An unsupervised algorithm
→ Displacement Model with 0.05 recognition time			

iOS Gesture Recognizer

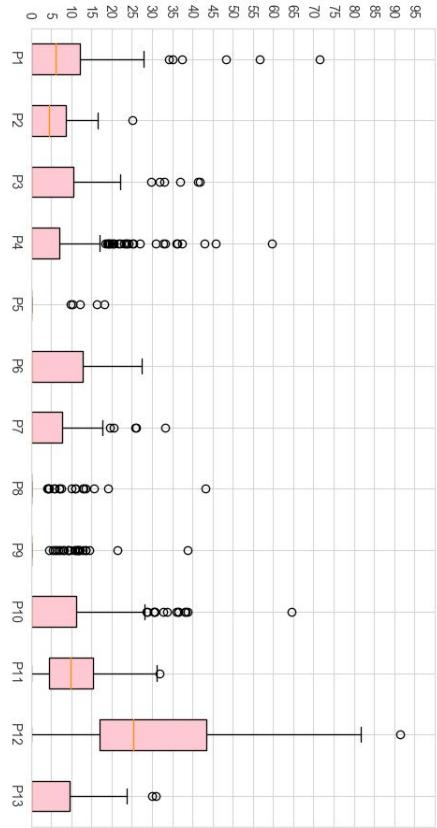


Source:
https://developer.apple.com/documentation/uikit/touches_presses_and_gestures/implementing_a_custom_gesture_recognizer#lab

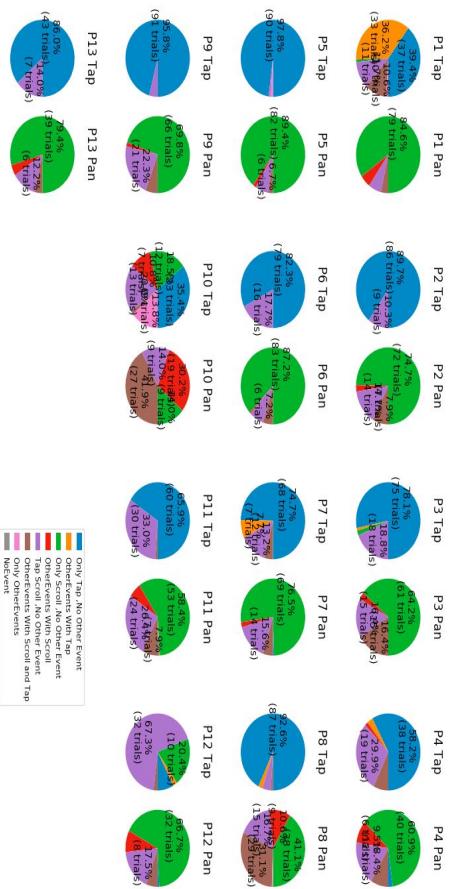


Movement in Tap Task

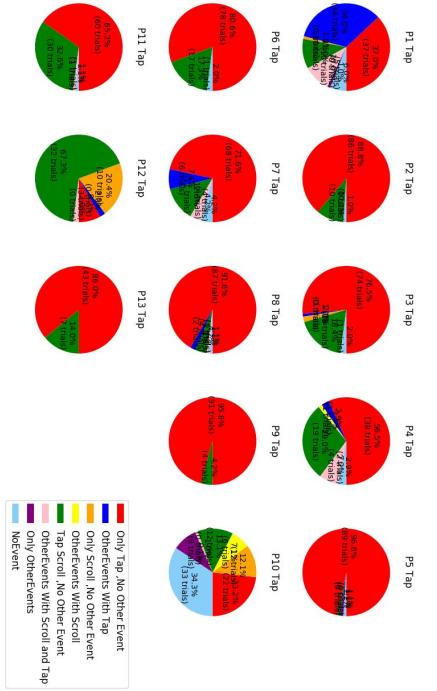
Movement in tap task (pt)



Error Analysis



Error Analysis



Legend:

- Only Tap No Other Event
- OnlyEvents With Tap
- Only Scroll No Other Event
- OnlyEvents With Scroll
- Tap Scroll No Other Event
- OnlyEvents With Scroll and Tap
- Only OtherEvents
- None