

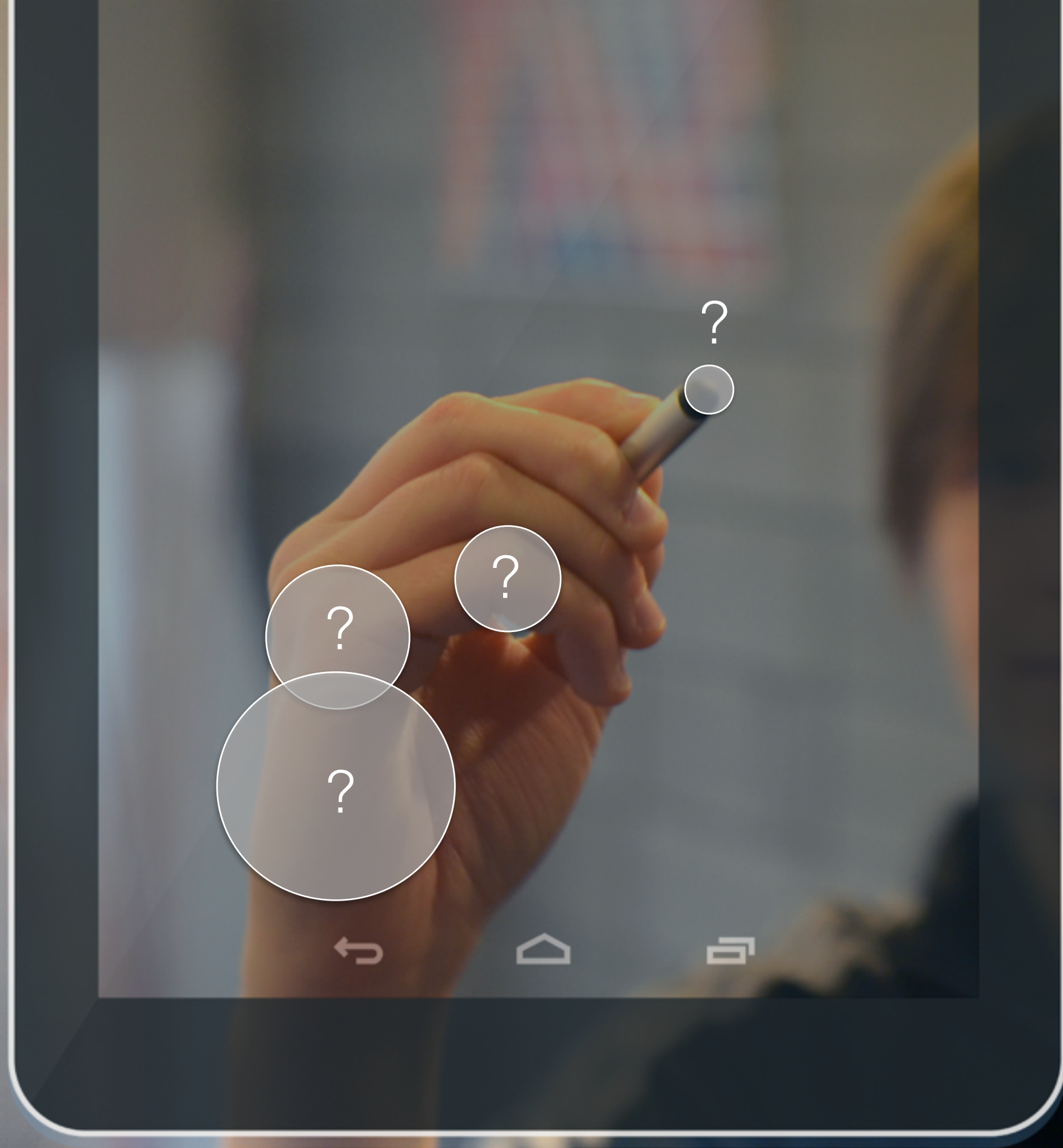
Probabilistic Palm Rejection Using Spatiotemporal Touch Features and Iterative Classification

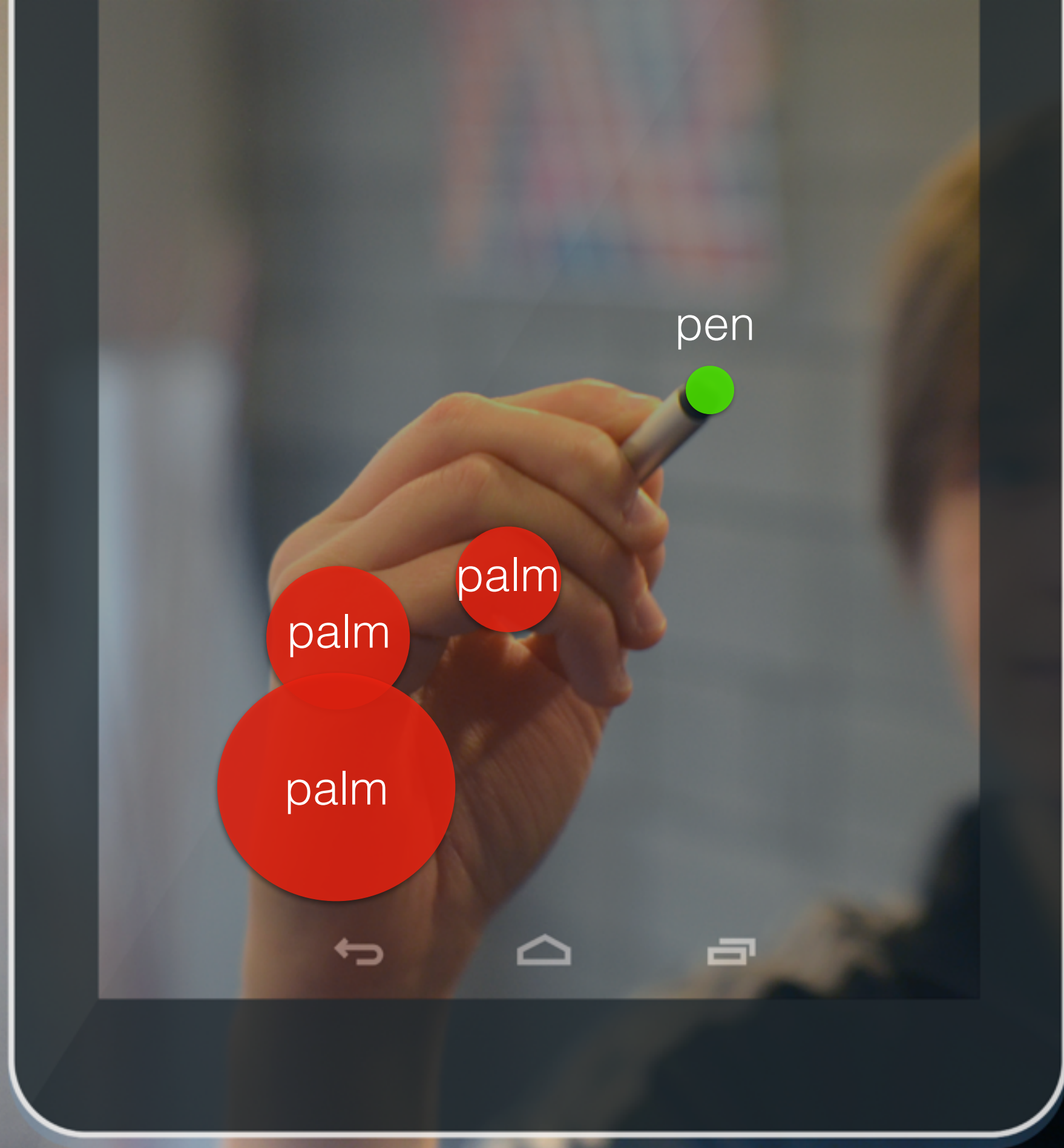
Julia Schwarz, Robert Xiao, Jennifer Mankoff,
Scott E. Hudson, Chris Harrison



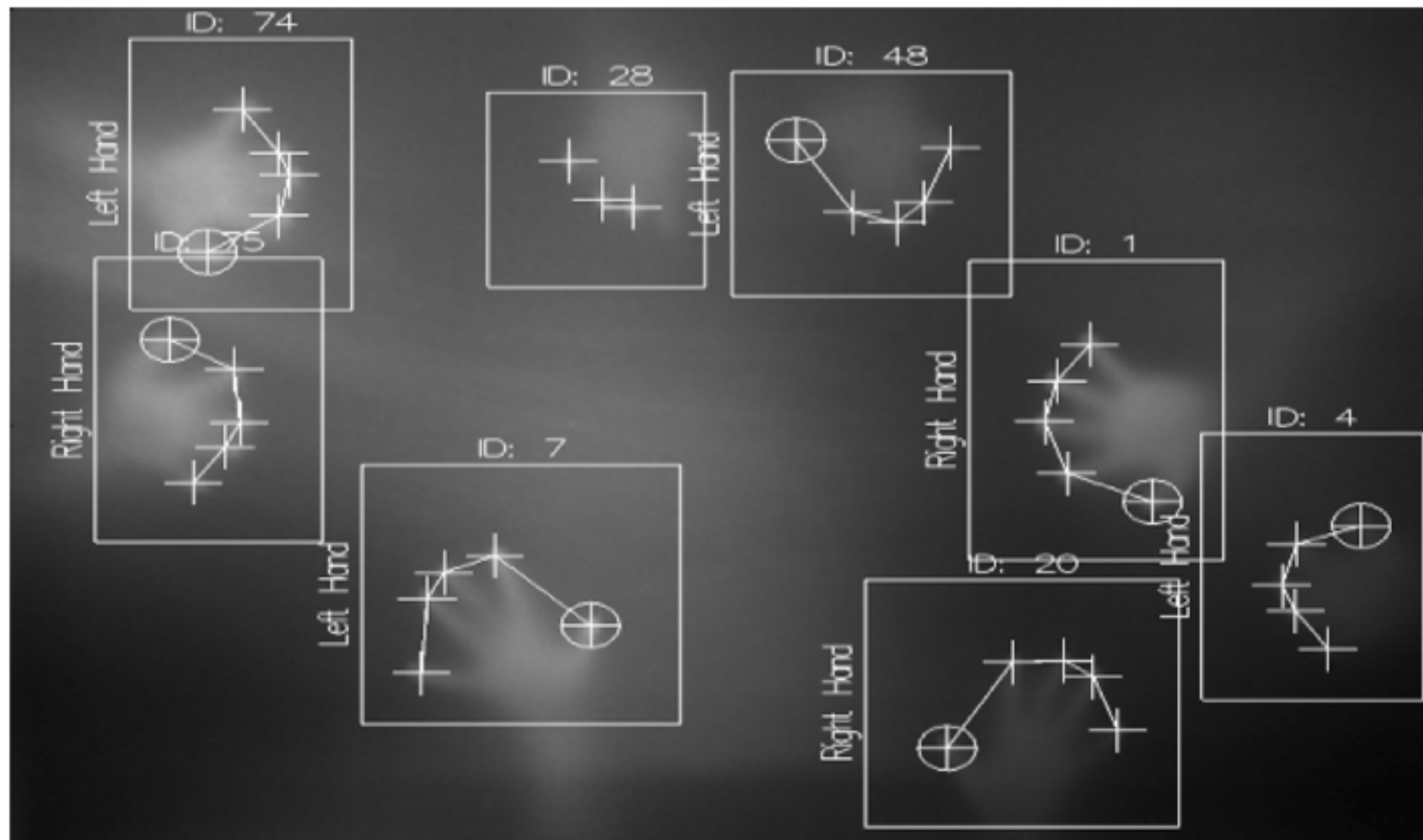








Prior Software-Only Approaches

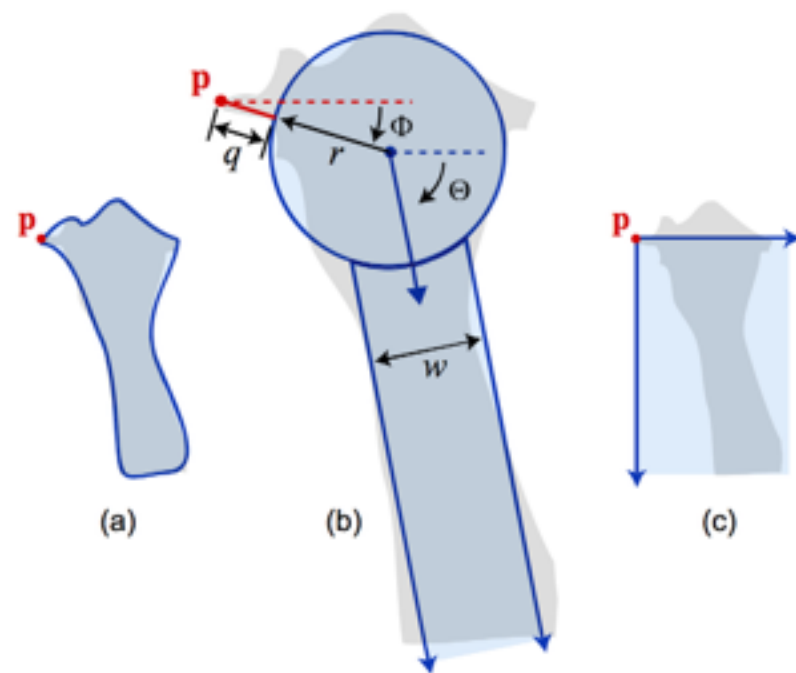


Ewerling et. al, ITS '12

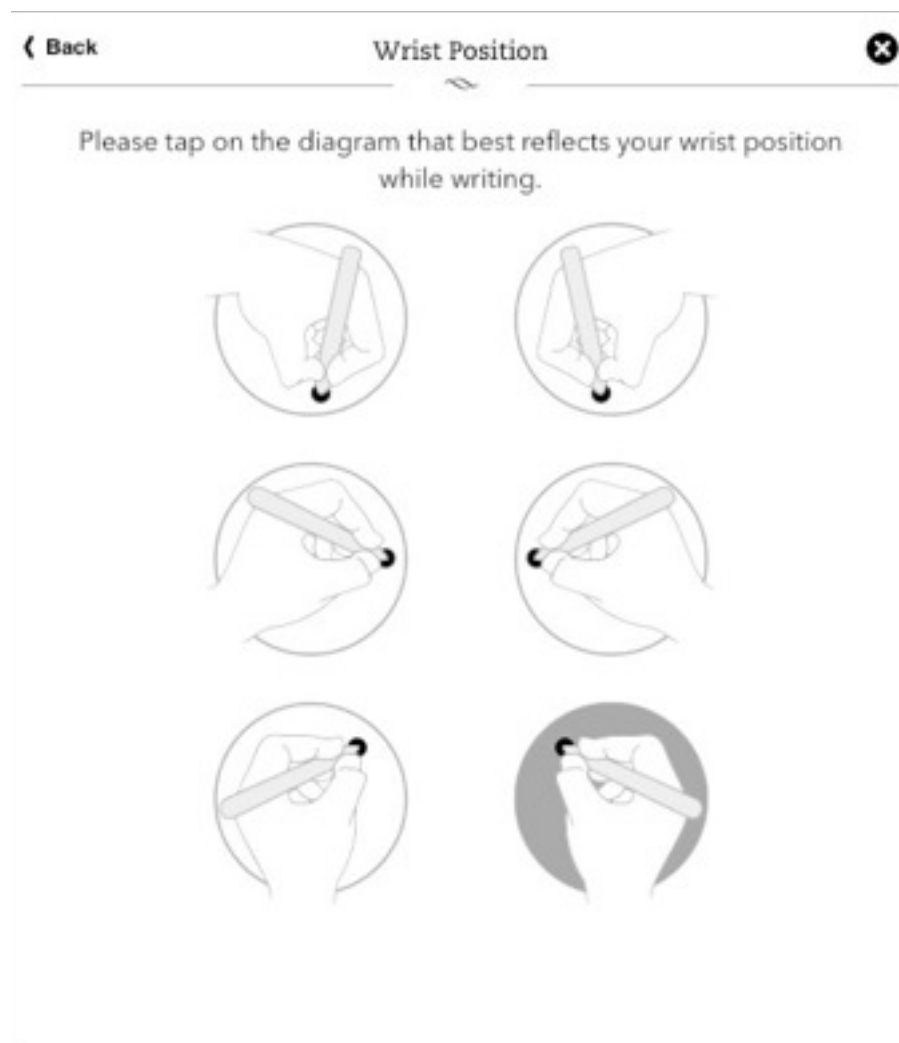


palm rejection region

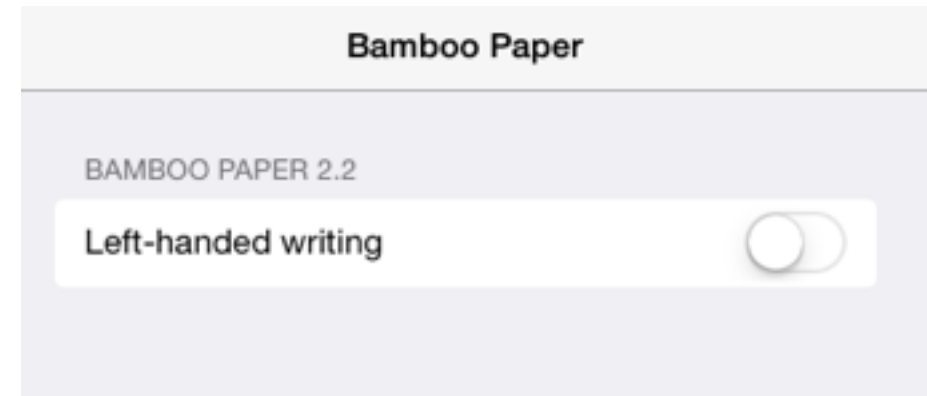
Notability by Ginger Labs, Inc.



Vogel et al. CHI '09



Penultimate for iOS



Bamboo Paper for iOS



Our Approach

Collection of decision trees, spatiotemporal features.

Handedness and orientation agnostic.

No calibration required.



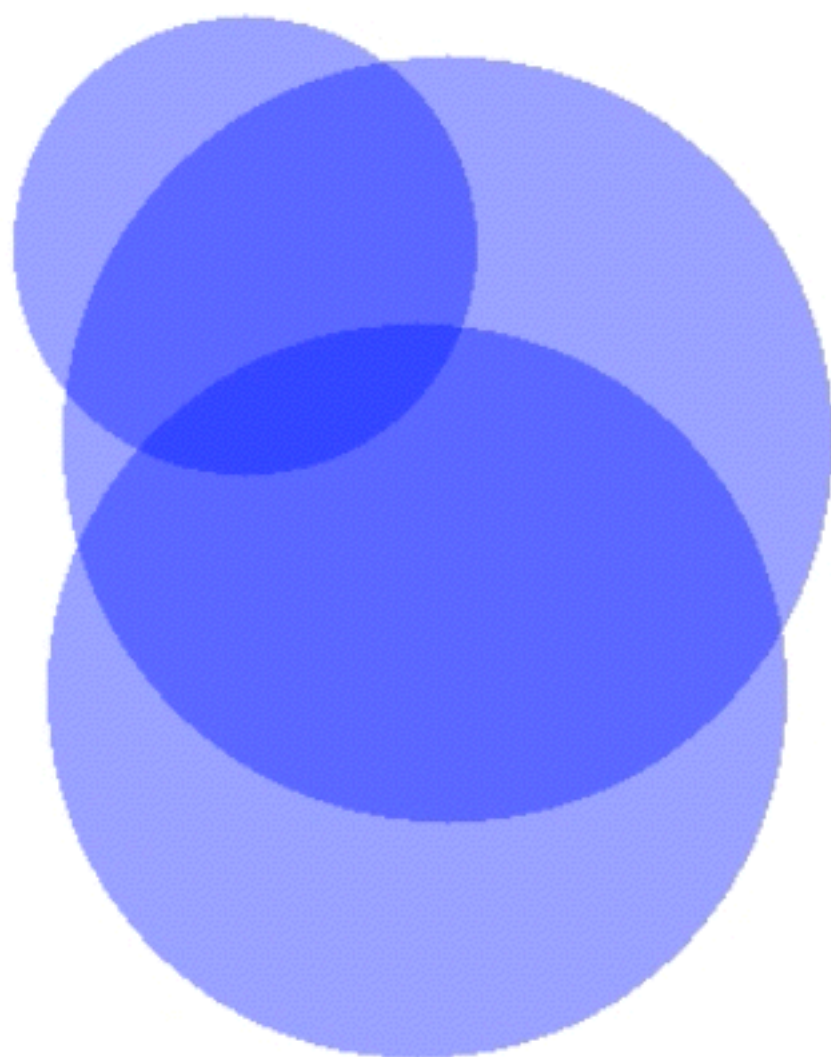
green = stylus
blue = palm

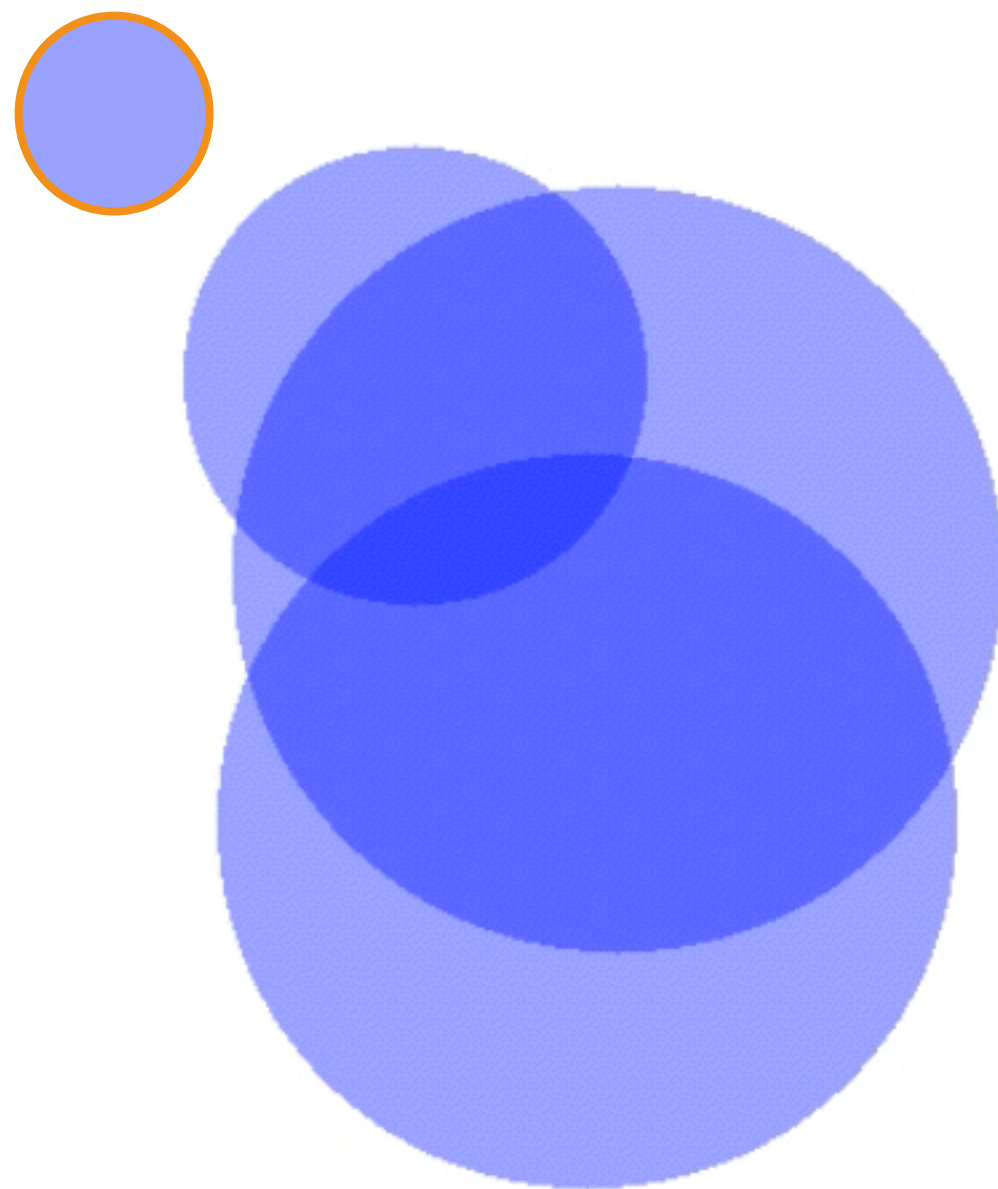
Palms have large radius.

Palms flicker in and out.

Stylus is isolated.

Palms move little, styluses have
smooth trajectories.



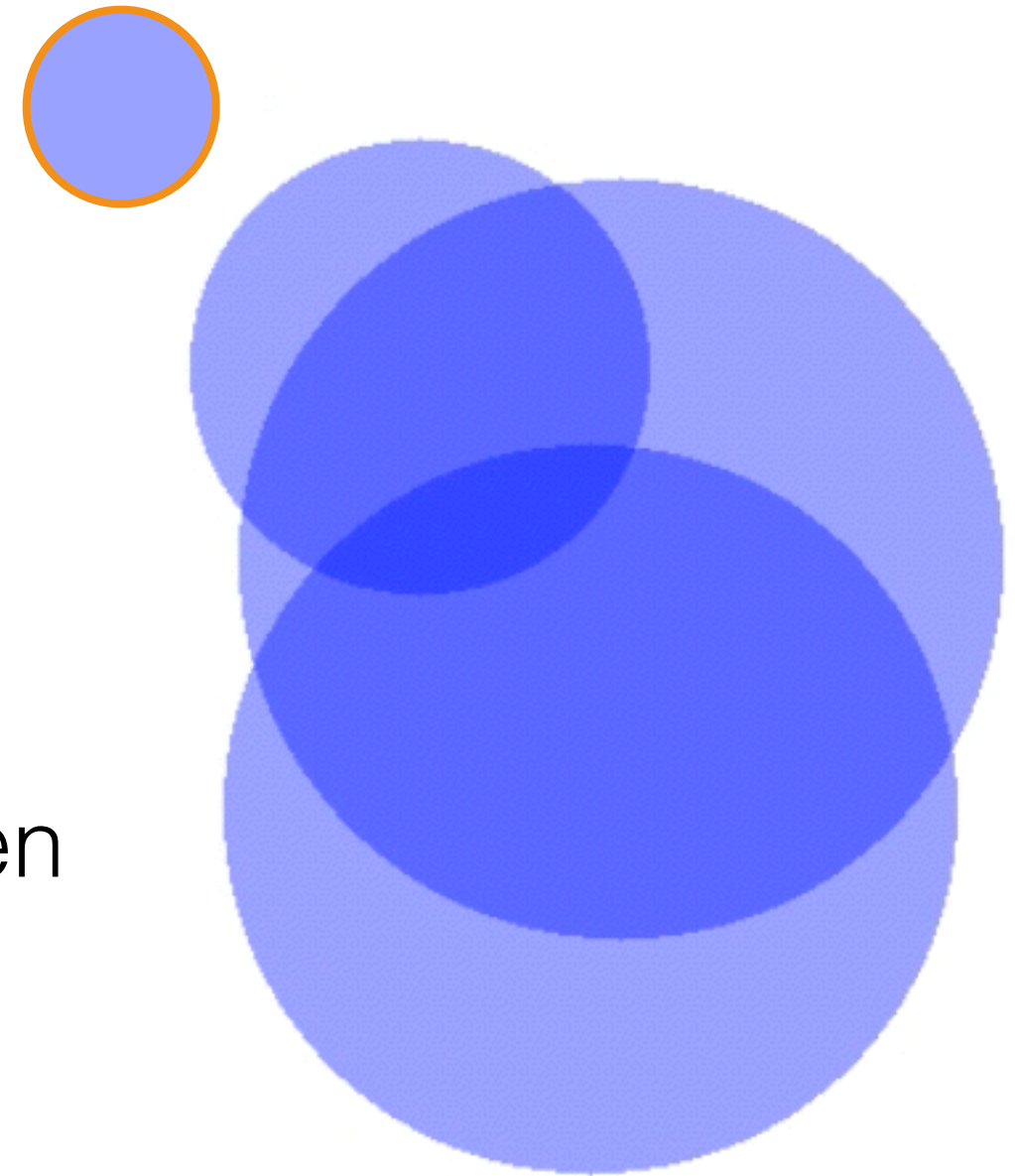


$t = 0$

Instantaneous Features

Touch radius

Distance to other touches on screen



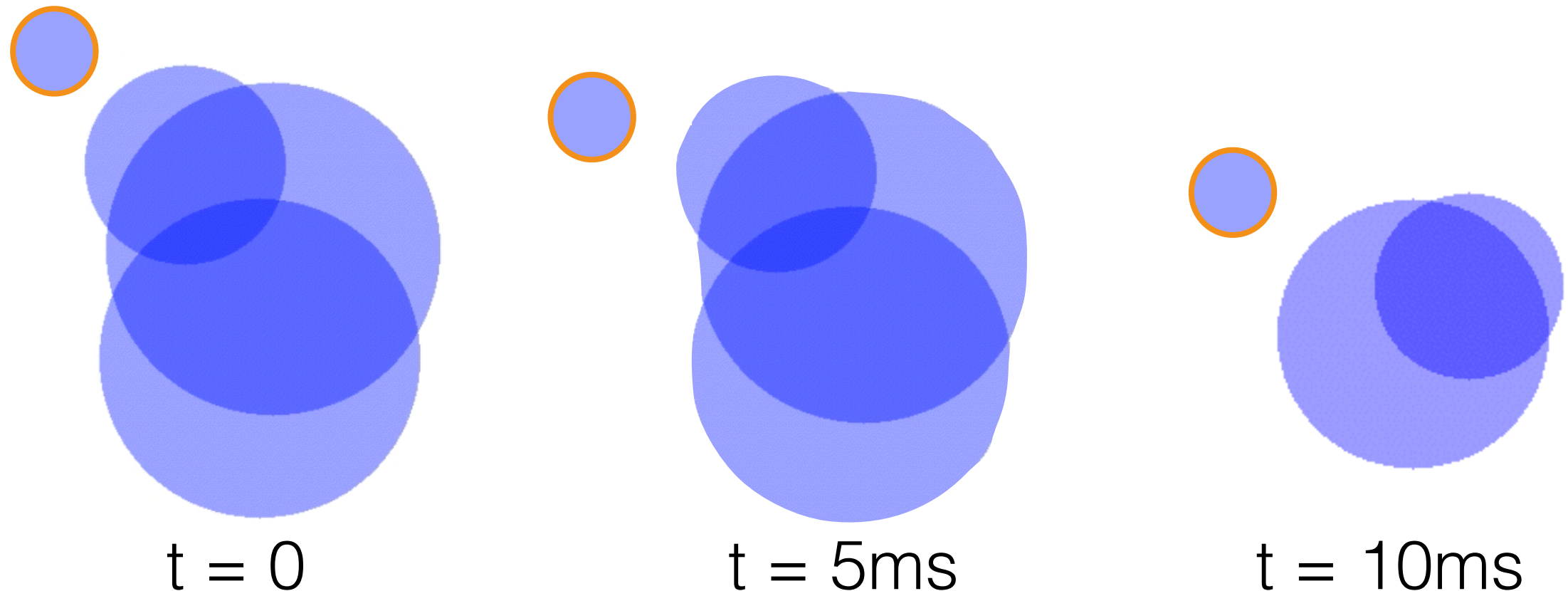
$t = 0$

Touch Sequence Features

$[\mu, \sigma, \min, \max]$ touch radius over sequence

$[\mu, \sigma, \min, \max]$ distance to other touches in sequence

$[\mu, \sigma, \min, \max]$ velocity, acceleration

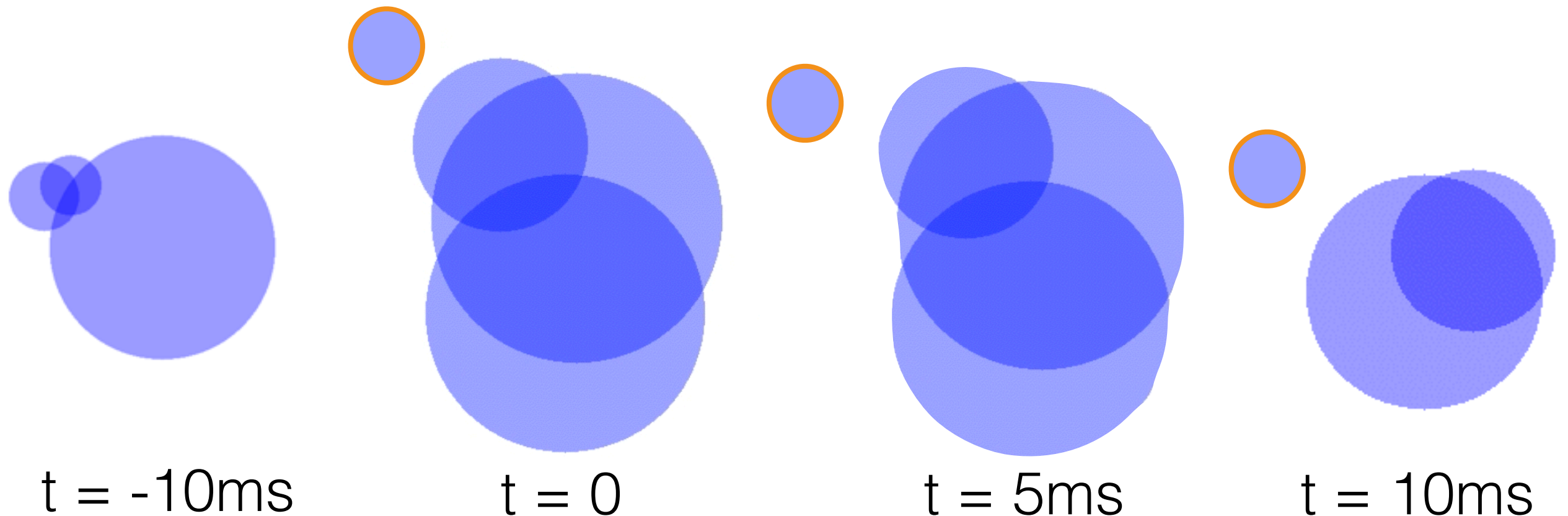


Touch Sequence Features

$[\mu, \sigma, \min, \max]$ touch radius over sequence

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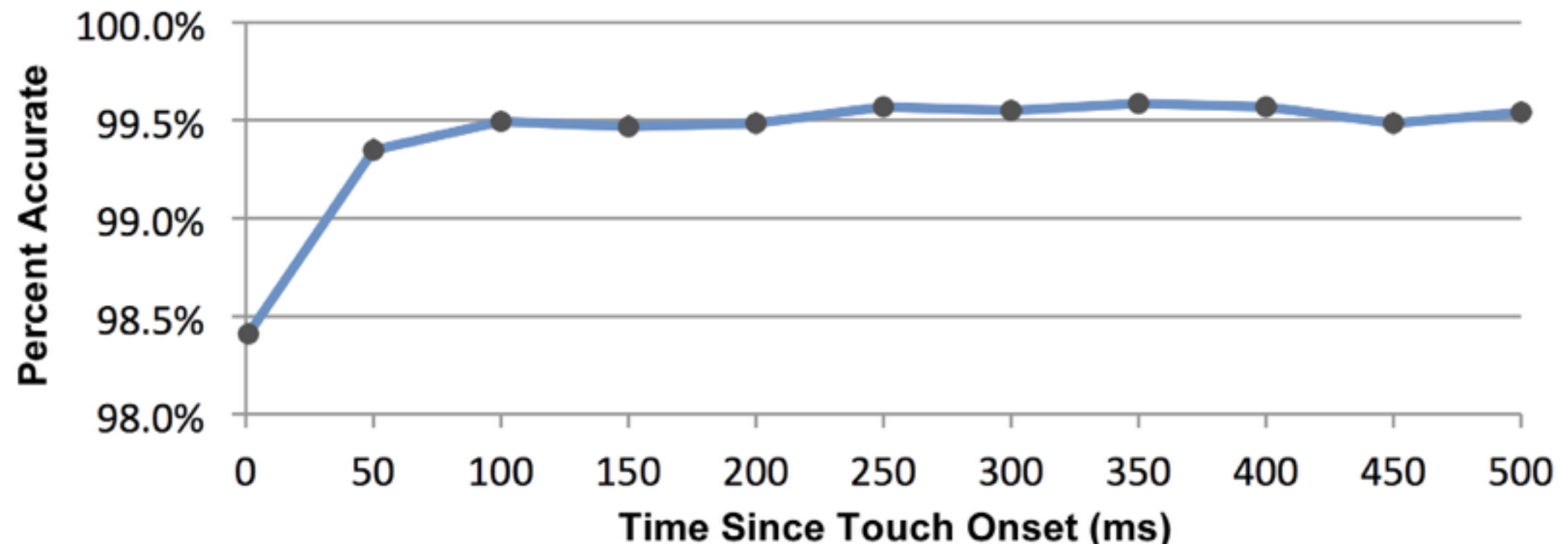
$[\mu, \sigma, \min, \max]$ velocity, acceleration



train: 11,000 instances from 3 people

test: 11,000 instances from 2 different people

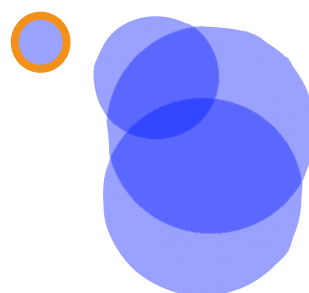
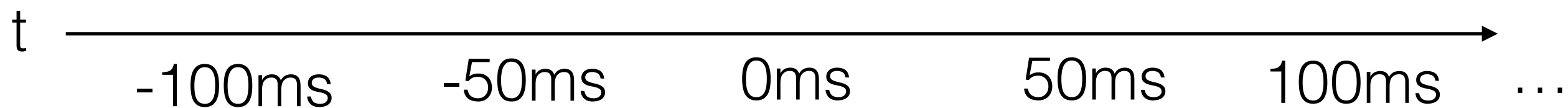
train and test data gathered in different locations and on different days

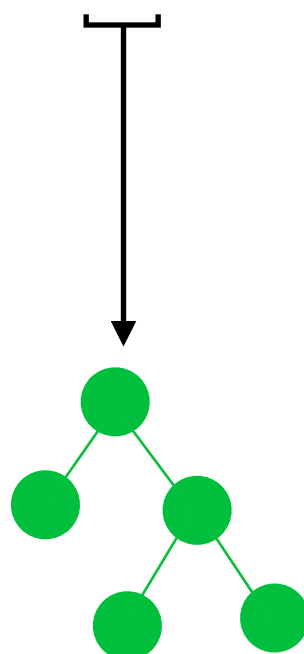
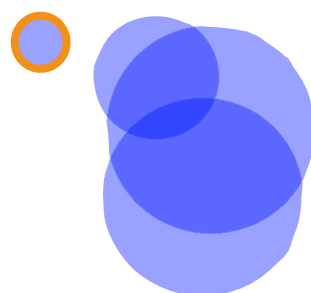
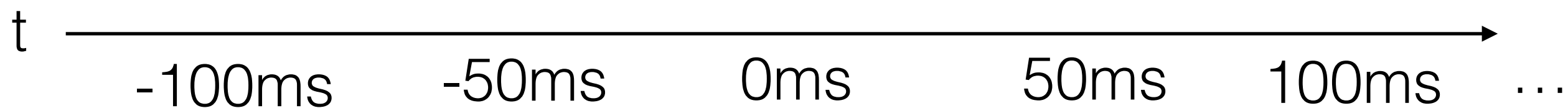


* leftmost point is at $t = 1\text{ms}$

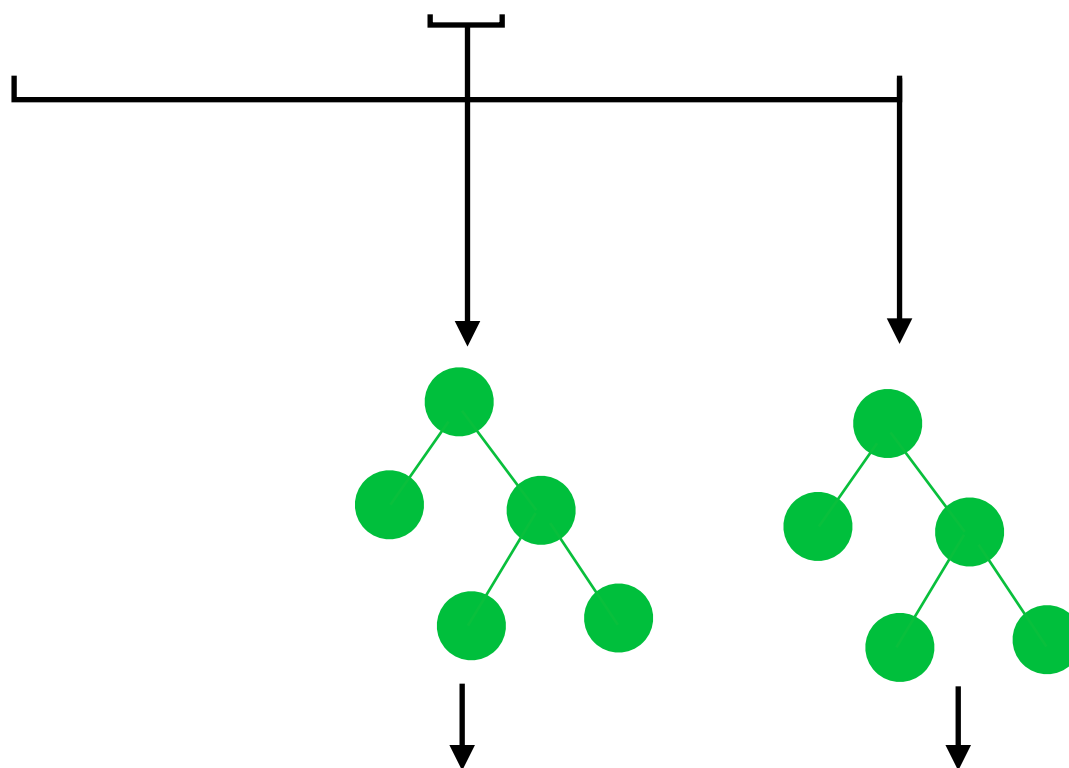
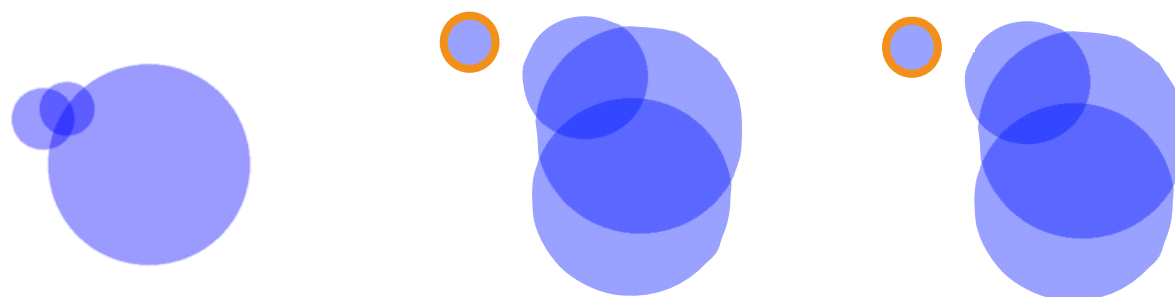
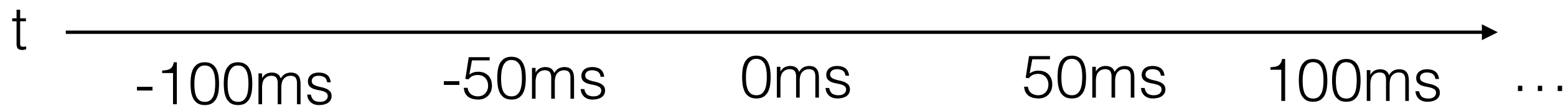
Window size of ~250ms would be ideal.

Want to provide immediate feedback to the user.



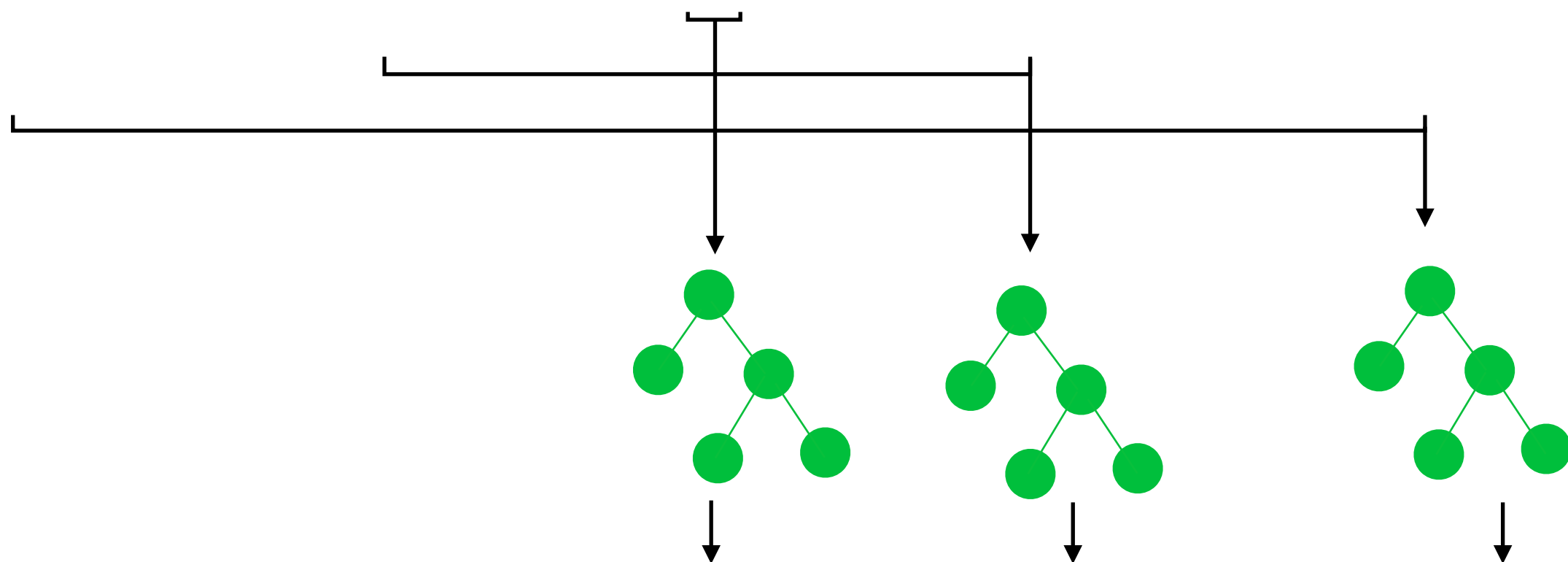
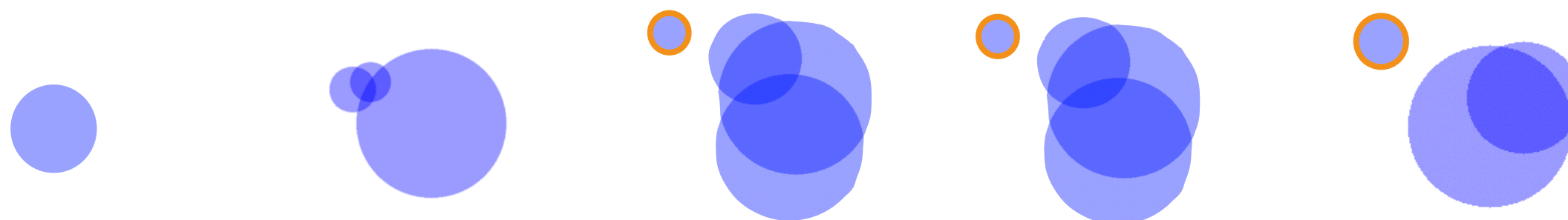
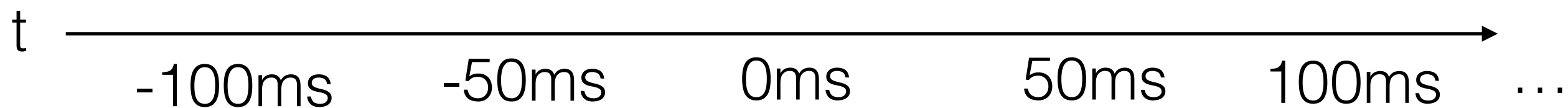


 = palm



 = palm

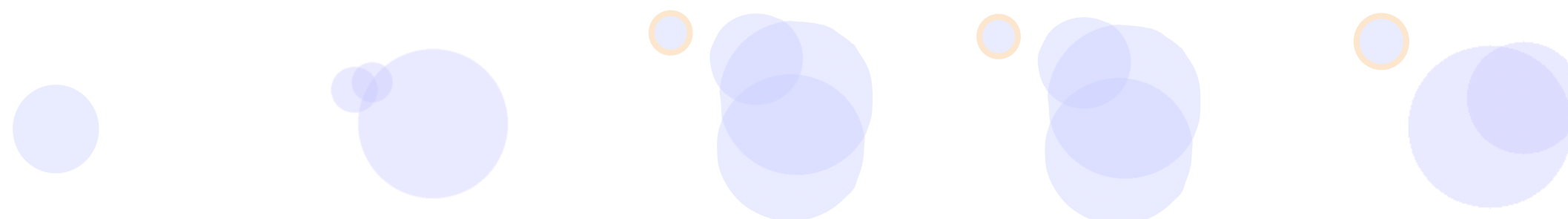
 = stylus



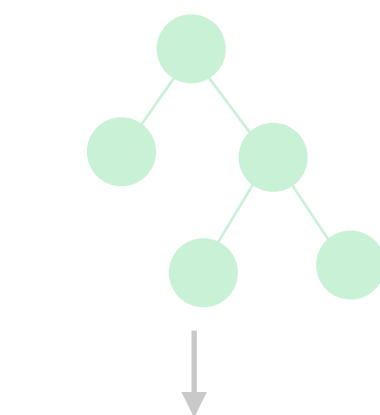
 = palm

 = stylus

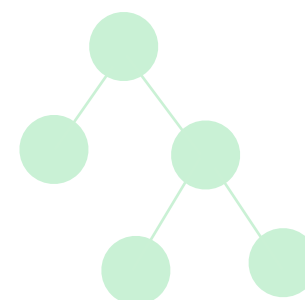
 = stylus



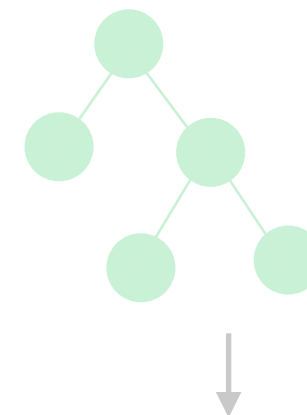
final classification ● = stylus



● = palm



● = stylus



● = stylus

Demo

Evaluation



Penultimate

vs.



Bamboo

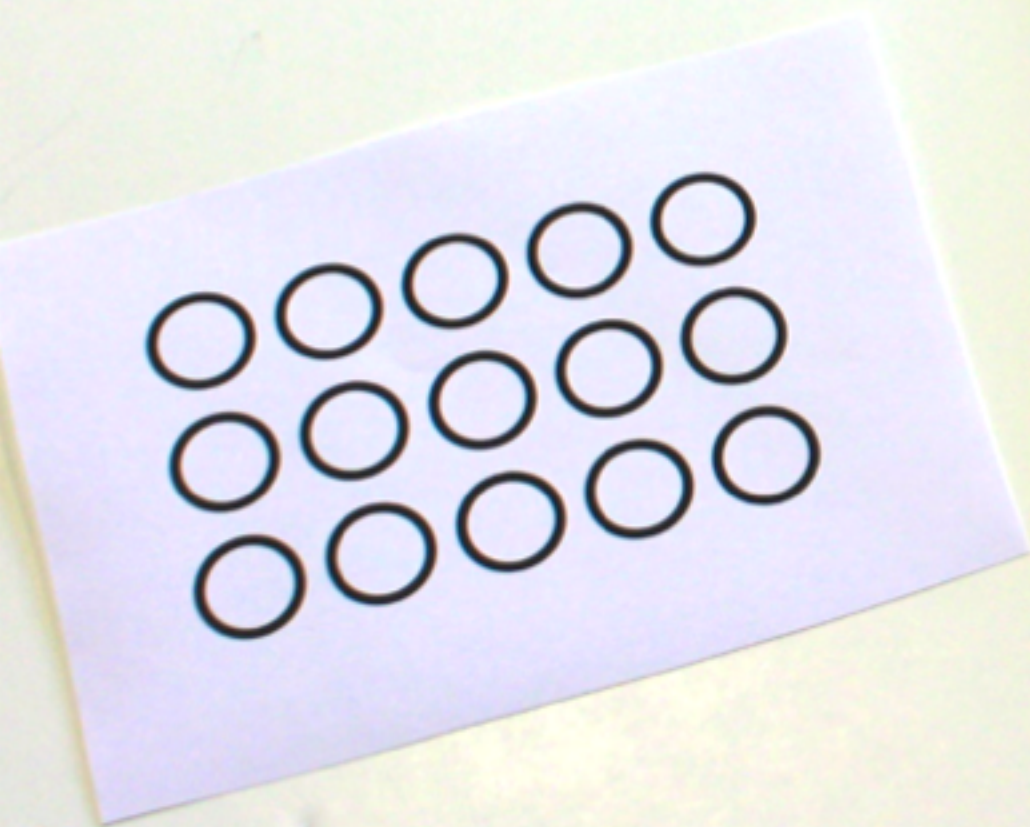
vs.



Our App

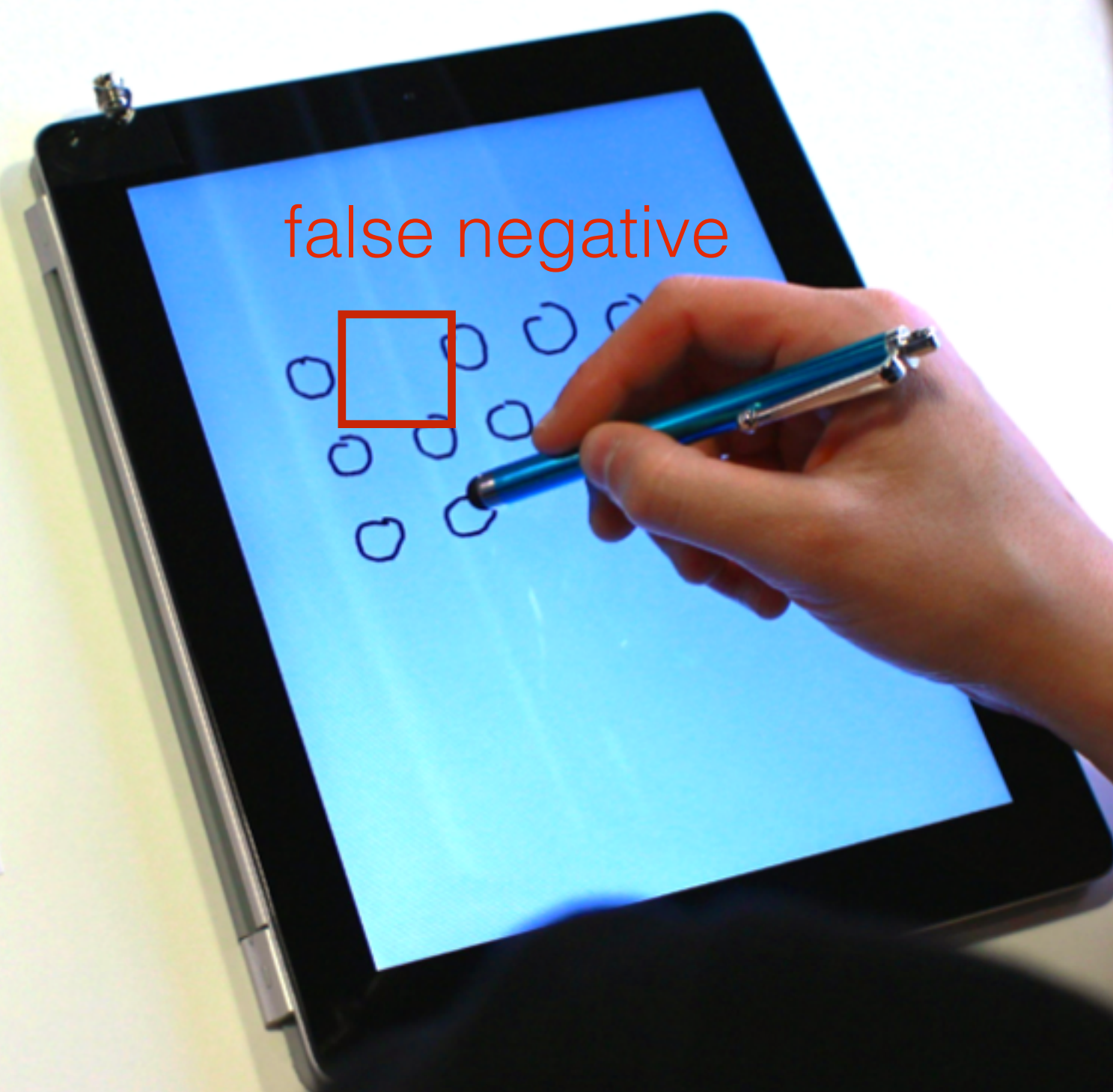
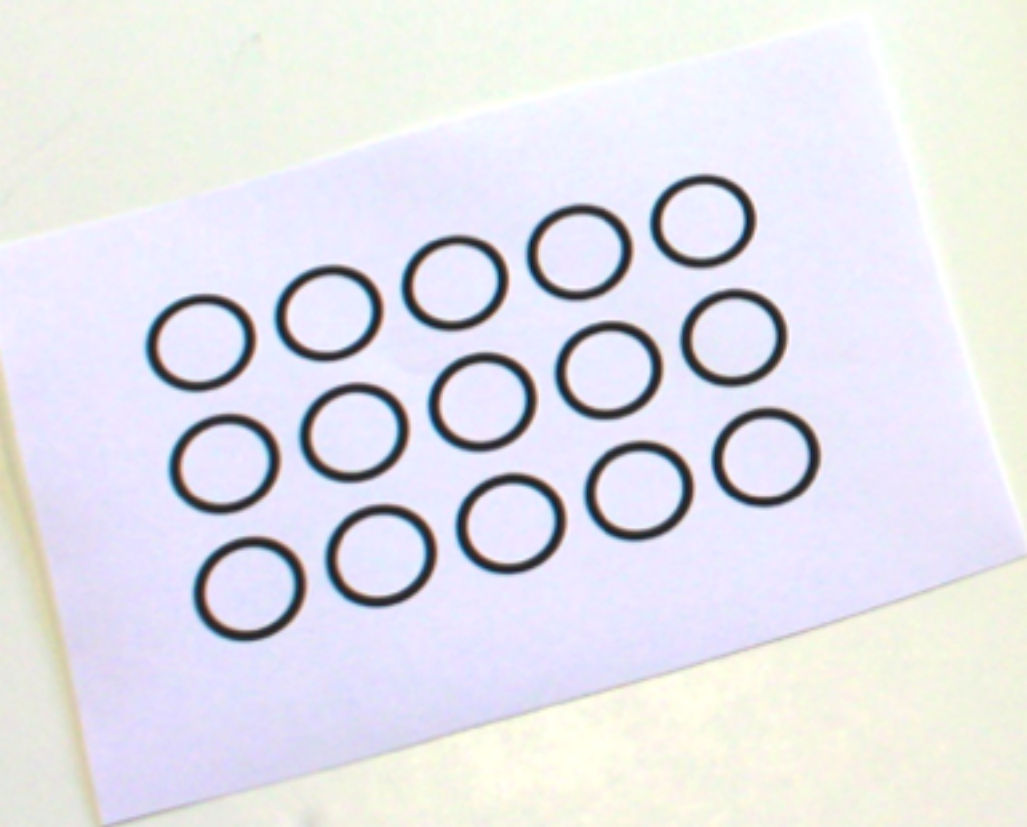
symbols:

S O • - IL

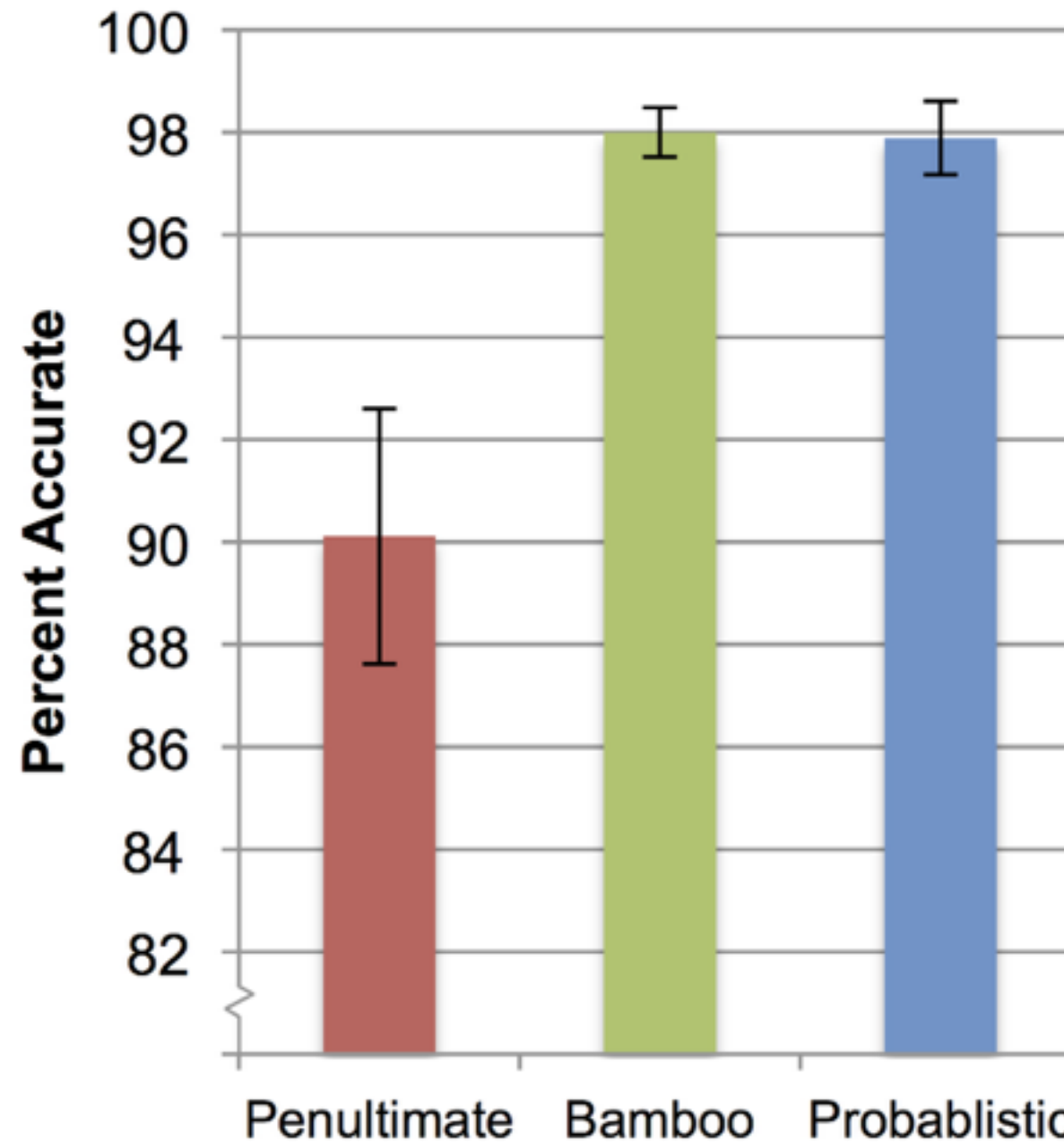


symbols:

S O • - IL



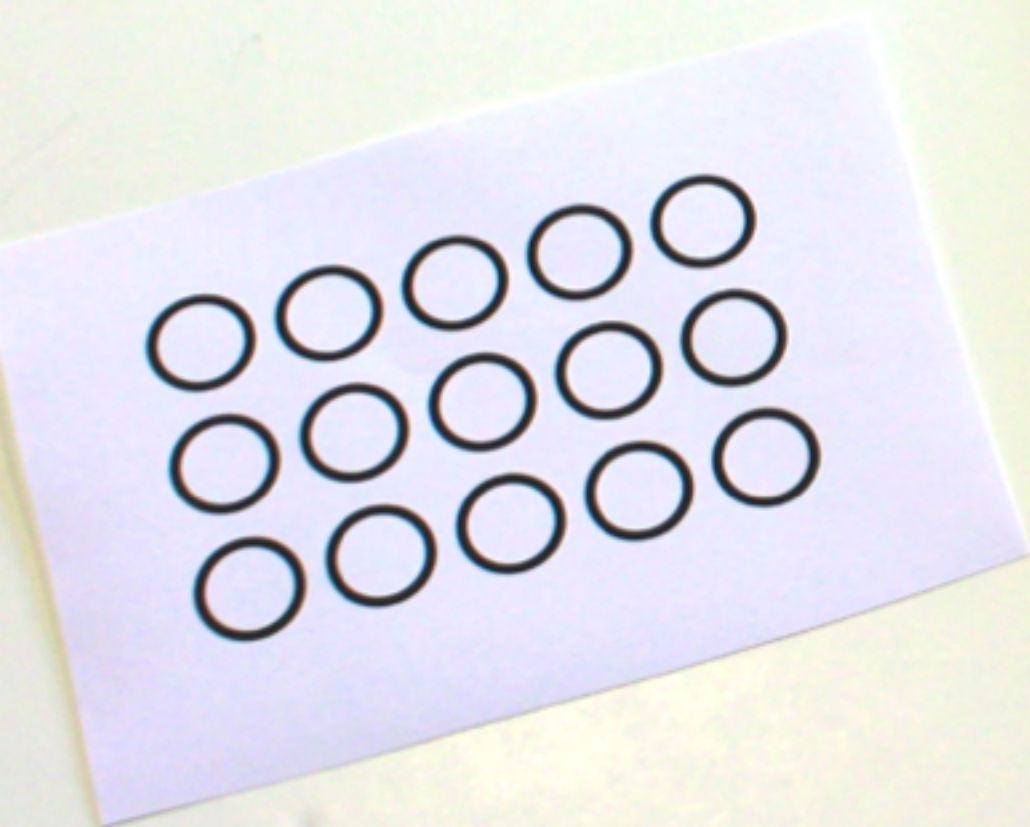
True Positives



% pen strokes classified as pen strokes
error bars = 95% confidence interval

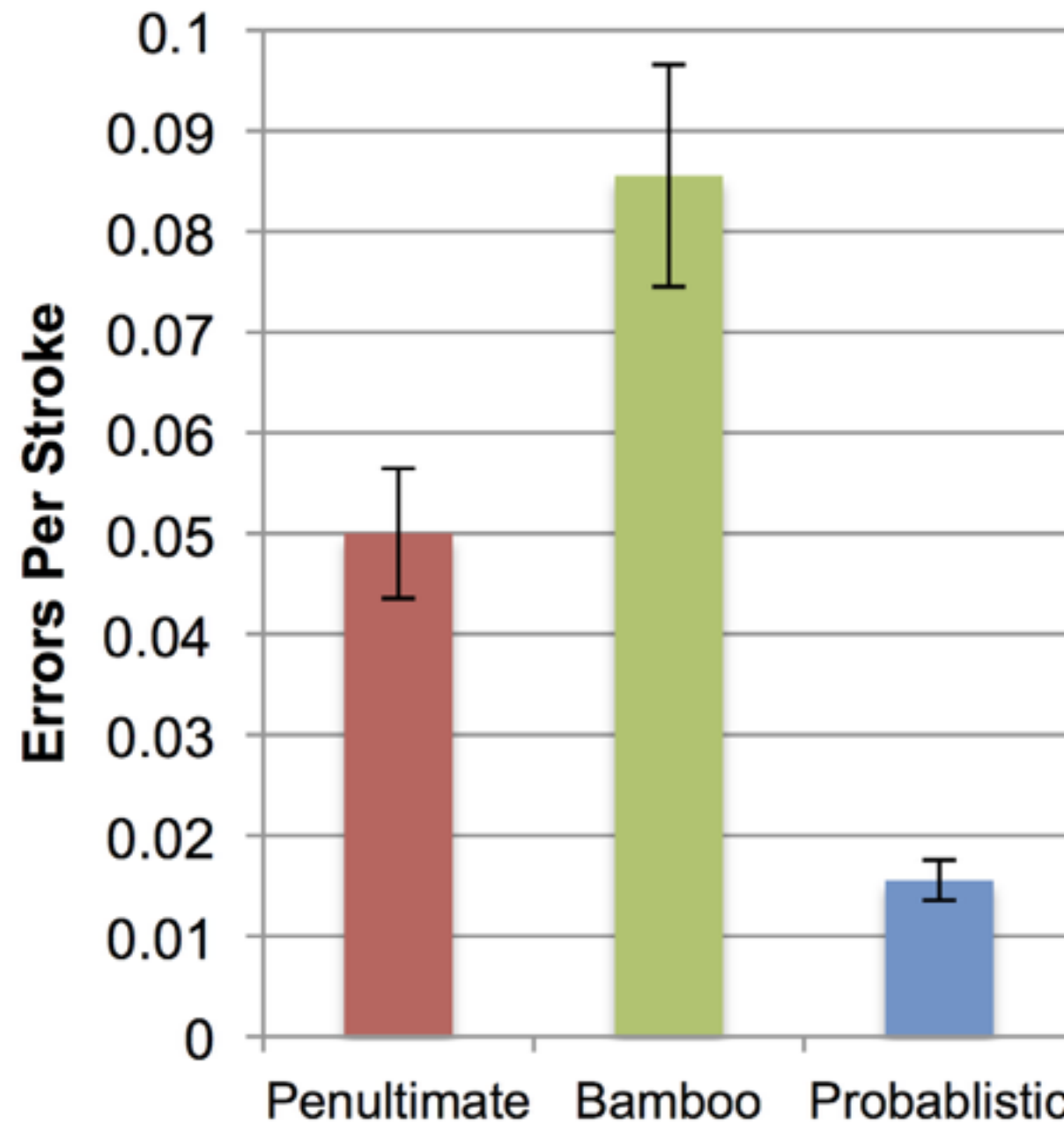
symbols:

S O • - IL



false positive

False Positives



of palm 'splotches' per pen stroke

*error bars = 95% confidence interval

Takeaways

Waiting to see how sensed input evolves before making a decision improves recognition accuracy.

Need a system that can show immediate feedback, but that can refine the interface as more information is presented.

Thank you!

julia@qeexo.com

Special thanks to Jim Baur for photography assistance

Also, thank you to our sponsors:



Why a decision tree?

Limitations

No multitouch gestures (yet)

Algorithm overly reliant on touch radius

Accuracy hit of 1% when not using radius features

Difficult to implement on platforms that do not expose touch radius