TARS
The Terascale All-sensing Research Studio

# User-Independent Detection of Swipe Pressure using a Thermal Camera for Natural Surface Interaction

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# User Interaction in Augmented Reality

- **Handheld controllers and touchscreens are currently state of the art**
- **Direct user interaction with natural surfaces reduces the need for commercial equipment**

http://fortune.com/2015/06/11/oculus-microsoft-partnership/


https://mashable.com/2017/08/04/sony-touch-handson/#DdfTiLvSuiqd

# Natural User Interfaces vs Touchscreens

**Limitations of surface instrumentation:**

- **expensive**
- **may ruin aesthetic appearance**
- **often impractical**
- **fixed location**

https://www.speechi.net/en/home/interactive-screens/speechitouch-84-giant-touch-screen-hd-and-uhd-interactive-screen/

https://www.alibaba.com/product-detail/Newest-Laser-touch-pico-projector-build_60390719367.html

# Our Work: Detecting Swipe Pressure

- Pressure is an intuitive gesture for many applications
- Differentiate between hard and soft swipes
- Test multiple materials
- No per-user configuration required

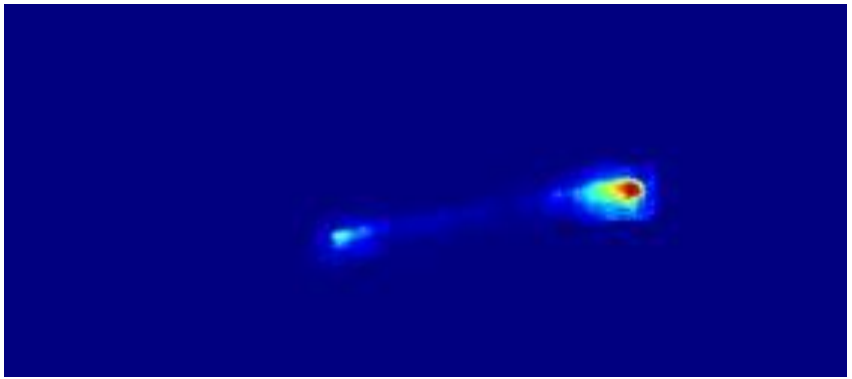
**SOFT**

**HARD**

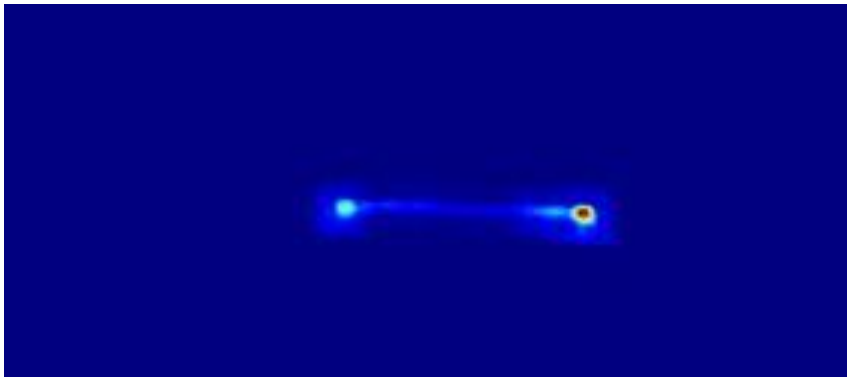
# RGB vs Thermal Cameras

**Greater pressure corresponds to increased frictional heat**

**SOFT**



**HARD**



# Related Work

- **Oka et. al.:** real-time tracking of multiple fingertips
- **Larson et. al., *HeatWave*:** gesture recognition
- **Iwai and Sato, *ThermoTablet*:** temperature-based interactions
- **Kurz, *ThermalTouch*:** identify and locate touched objects
- **Saba et. al., *DanteVision*:** train a per-user classifier

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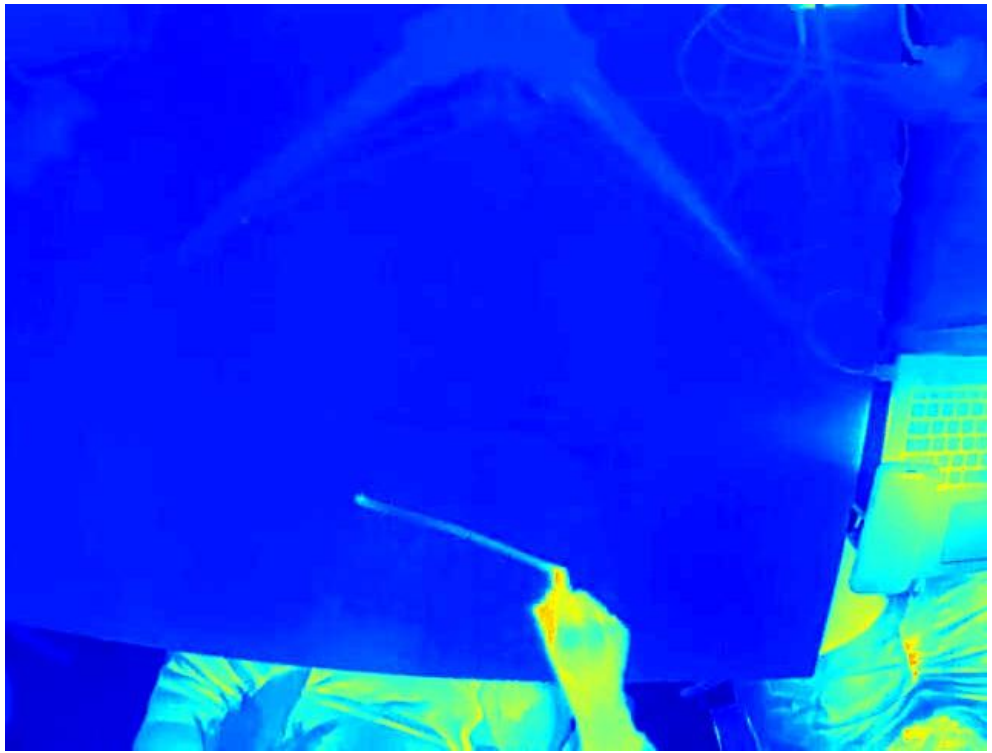
***A user-independent "out of the box" classifier for swipe pressure***

# Experimental Setup

- **FLIR Vue Pro Thermal Camera**
  - 640x512 resolution
  - captures 30 fps
- **Plywood and Paper**
  - anchored to desktop surface



https://www.drdrone.ca/products/flir-vue-pro-640-9hz-thermal-vision-camera

# Data Collection

- **Nine test subjects**
  - age range of 18 to 37 years
- **Collected 16 hard and 16 soft swipes for each material**
  - 5 second delay between soft swipes
  - 10 second delay between hard swipes
- **Allowed swipes of any length or direction**

# Examples

# Swipe Extraction

- Perform static background subtraction
- Cropped video to desired region
- Thresholded at fixed value
- Performed morphological filtering to remove hand from video

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- **Accumulate intensities over time into single image**
- **Represent swipe by translated and rotated quadratic function**
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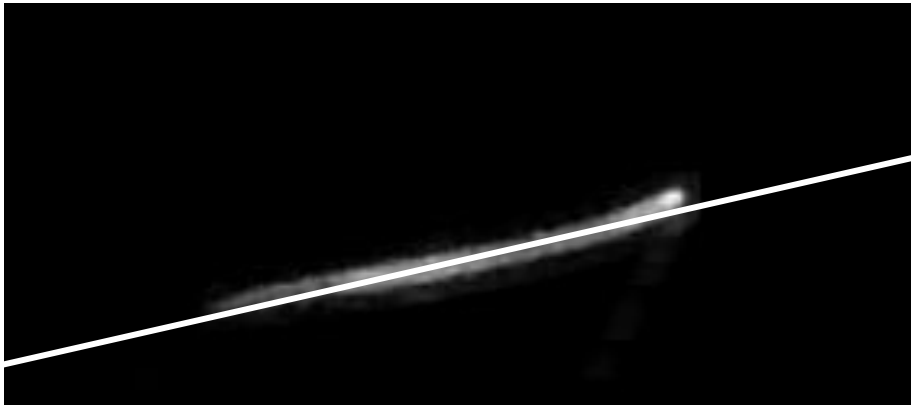

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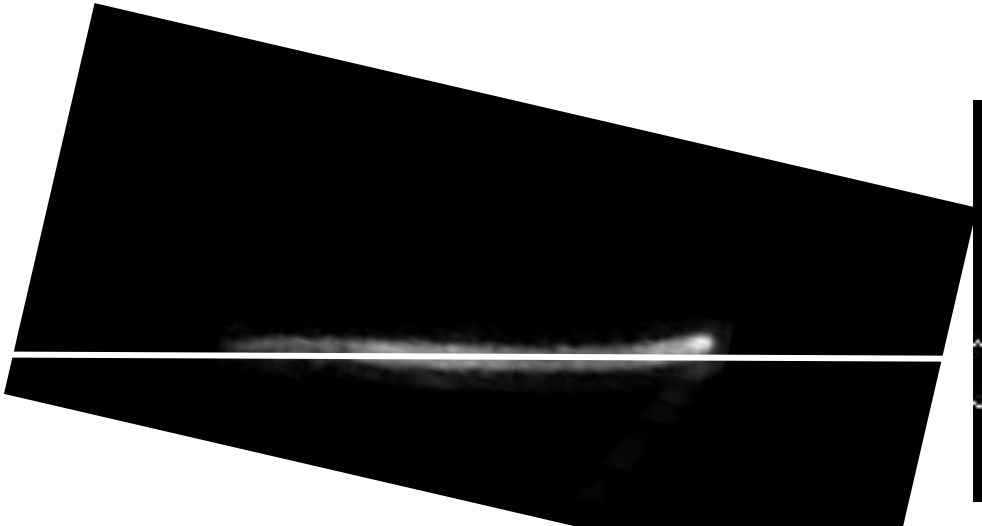

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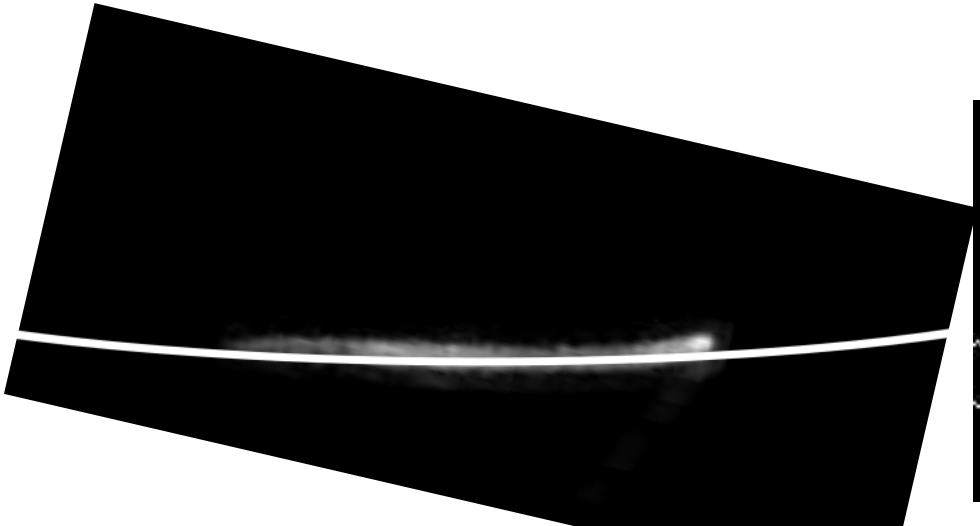

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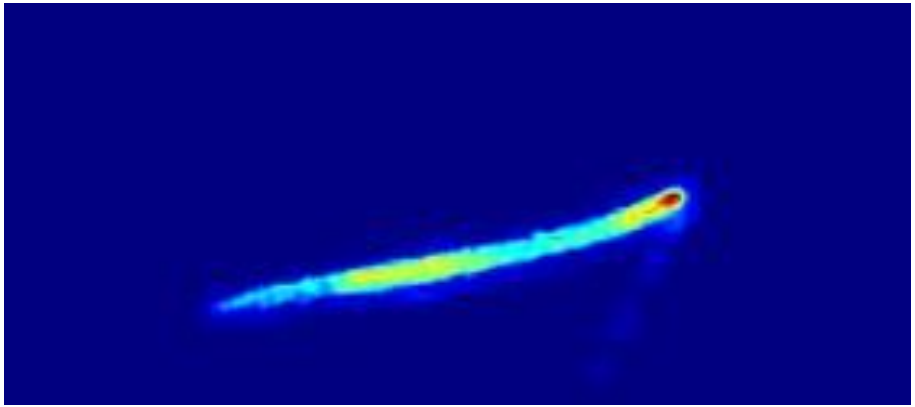
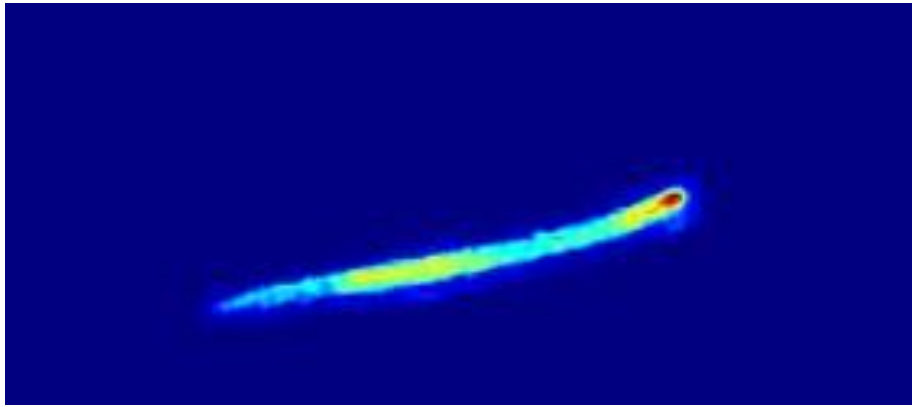
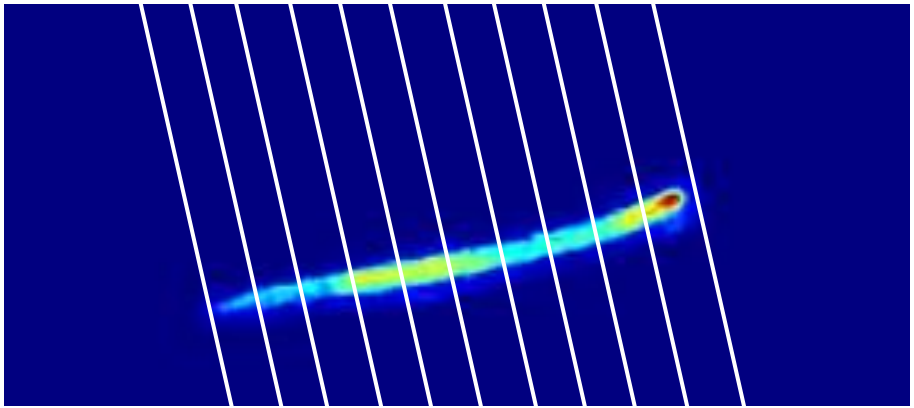


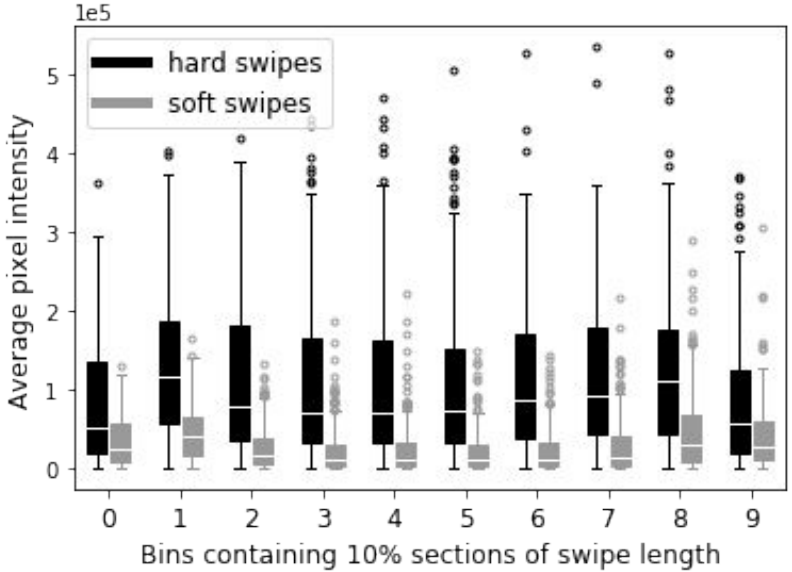


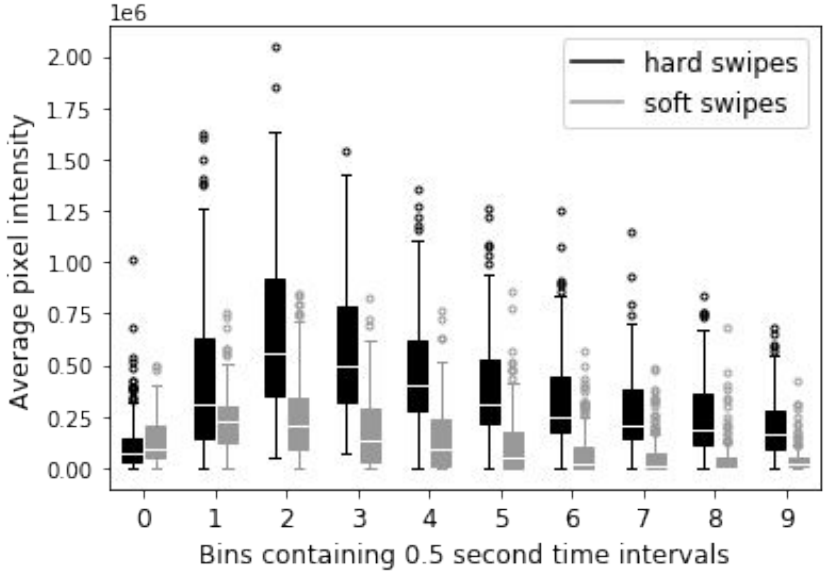
# Classification

- **Random Forest Classifier**
  - 500 trees
- **30 features used total**
  - 10 bins along swipe length, used avg and max pixel intensities within bin
  - 10 bins over time, used total pixel intensities

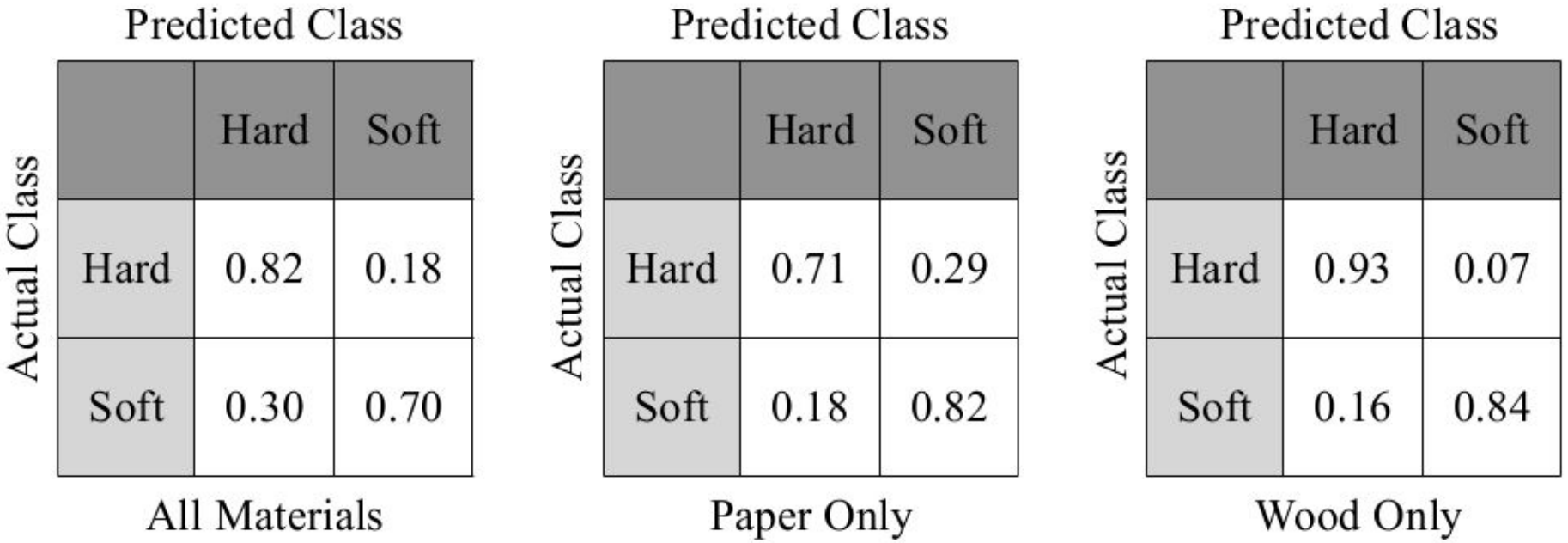


# Results


1e5
hard swipes
soft swipes
Average pixel intensity
0
1
2
3
4
5
0
1
2
3
4
5
6
7
8
9
Bins containing 10% sections of swipe length


1e6
hard swipes
soft swipes
Average pixel intensity
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00
0
1
2
3
4
5
6
7
8
9
Bins containing 0.5 second time intervals

# Results



Predicted Class

| Actual Class | Hard | Soft |
|---|---|---|
| Hard | 0.82 | 0.18 |
| Soft | 0.30 | 0.70 |

All Materials

Predicted Class

| Actual Class | Hard | Soft |
|---|---|---|
| Hard | 0.71 | 0.29 |
| Soft | 0.18 | 0.82 |

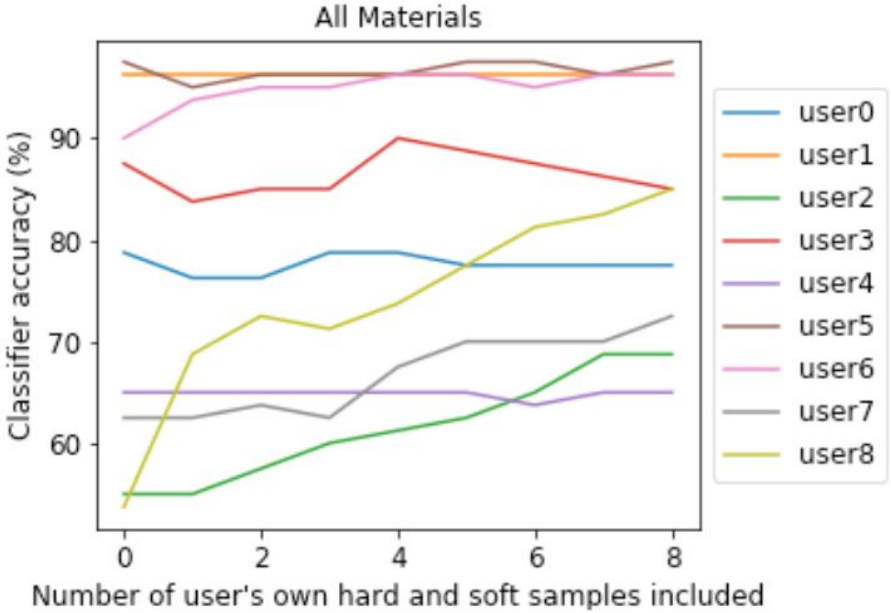
Paper Only

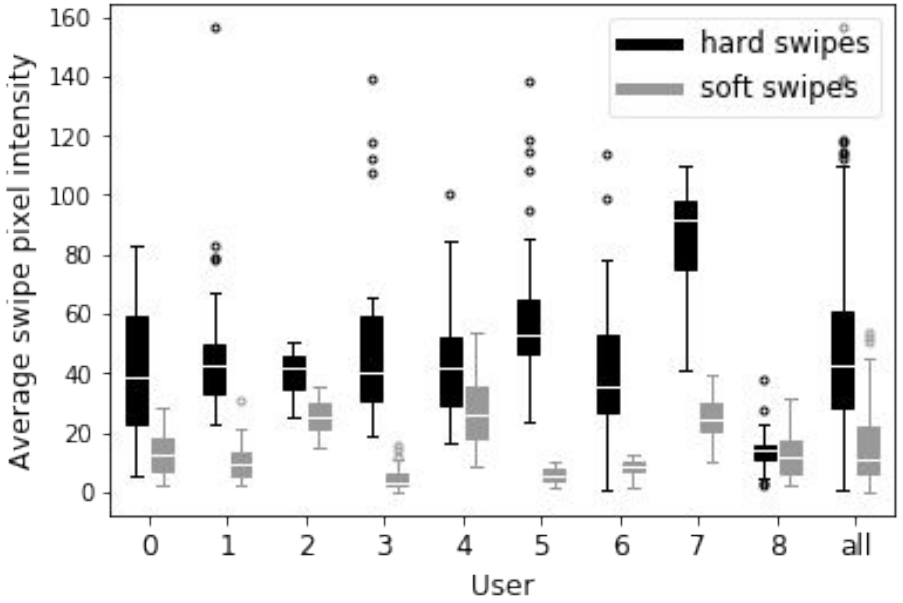
Predicted Class

| Actual Class | Hard | Soft |
|---|---|---|
| Hard | 0.93 | 0.07 |
| Soft | 0.16 | 0.84 |

Wood Only

# Adjusting the Classifier to a User



# Conclusions and Future Work

- **Thermal cameras can be used to effectively identify user gestures**
- **Calibration for each user is not required**
- **Classification rate can be improved over time**

- **Test additional common materials**
- **Identify more complex swiping patterns**
- **Deal with heat dissipation**