

University of Maryland

Center for Automation Research
University of Maryland
Rama Chellappa (PI)

Presented by:
Vlad I. Morariu (Co-PI)

Active Authentication PI Meeting

Oct 30, 2014

This research was developed with funding from the Defense Advanced Research Projects Agency (DARPA). The views, opinions, and/or findings contained in this article/presentation are those of the author(s)/presenter(s) and should not be interpreted as representing the official views or policies of the Department of Defense or the U.S. Government.

Visual Fingerprints

PI: Rama Chellappa

Co-PIs: Larry Davis (UMD)

Tom Yeh (UCB)

Vishal M. Patel (UMD)

Vlad I. Morariu (UMD)

RAs: Mohammed E Salem (UMD)

Henry Zhang (UMD)

Jacob Chen (UMD)

Yangmuzi Zhang (UMD)

Yan Chen (UCB)

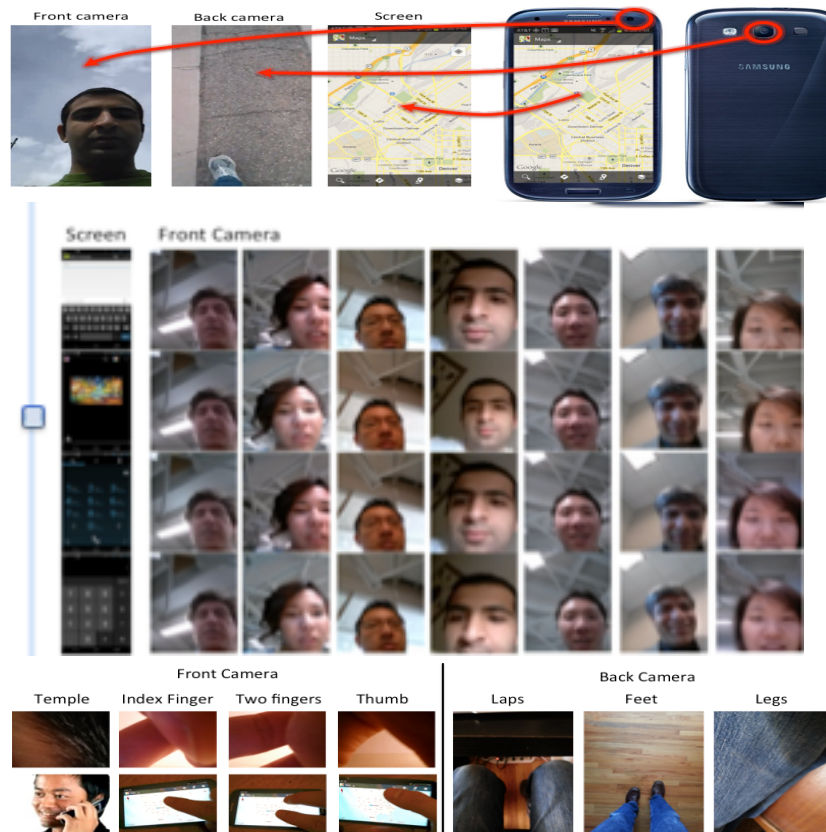
Esther Vasiete (UCB)

Ian Char (UCB)



Visual Fingerprints

Biometric: Use visual fingerprint which consists of three visual streams acquired by the front camera, the back camera, and the screen recorder to actively authenticate users on mobile devices.



Visual Fingerprints - Goals

- Multimodal data
 - Face
 - Touch gestures
 - Screen fingerprints (phase 1)
- Machine learning
 - Sparse coding
 - Dictionary learning
 - Anomaly detection
 - Domain adaptation
 - Multimodal fusion

UMD Data Collection

- iphone 5s
- 50 volunteers: 43 males, 7 females
 - Students, researchers, professors from ECE and CS departments of UMD
- 3 sessions
 - With different illumination conditions
 - Well lit room, dim lit room, and natural illumination
- 5 tasks per session
 - Enrollment, document test, popup test, scroll test, picture test
 - 0.5-2 minutes per task
- 750 videos and corresponding touch data

Enrollment + Four Tasks

1. Enrollment

2. Scroll test

- View a collection of images that are arrayed horizontally and vertically

3. Document test

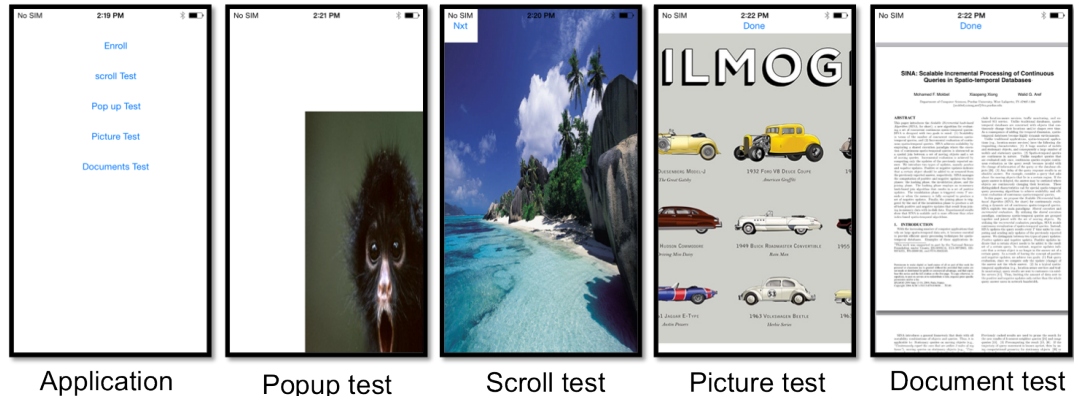
- Count the number figures, tables etc.

4. Popup test

- Drag and position an image in the center of the iPhone

5. Picture test

- Count the number of cars in a poster like image

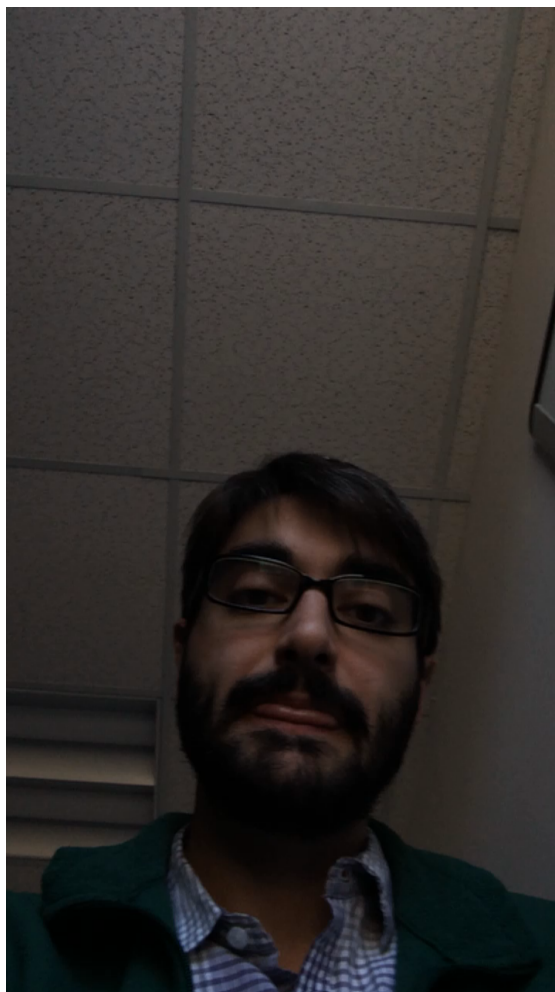


Sample UMD Data

Enrollment



Document Test



Scroll Test



UCB Data Collection

- Android Nexus4
- 50 volunteers
- Residence hall
- One session
 - 5 tasks + 1 enrollment task per session
 - 5 minutes per task
 - 30 minutes per session
- Screen, camera, and sensor recordings

UCB Data - Six Tasks

1. Typing

- Subject types a few sentences and a bullet point to do list

2. Reading from USA Today app

3. Scanning through Flipboard app

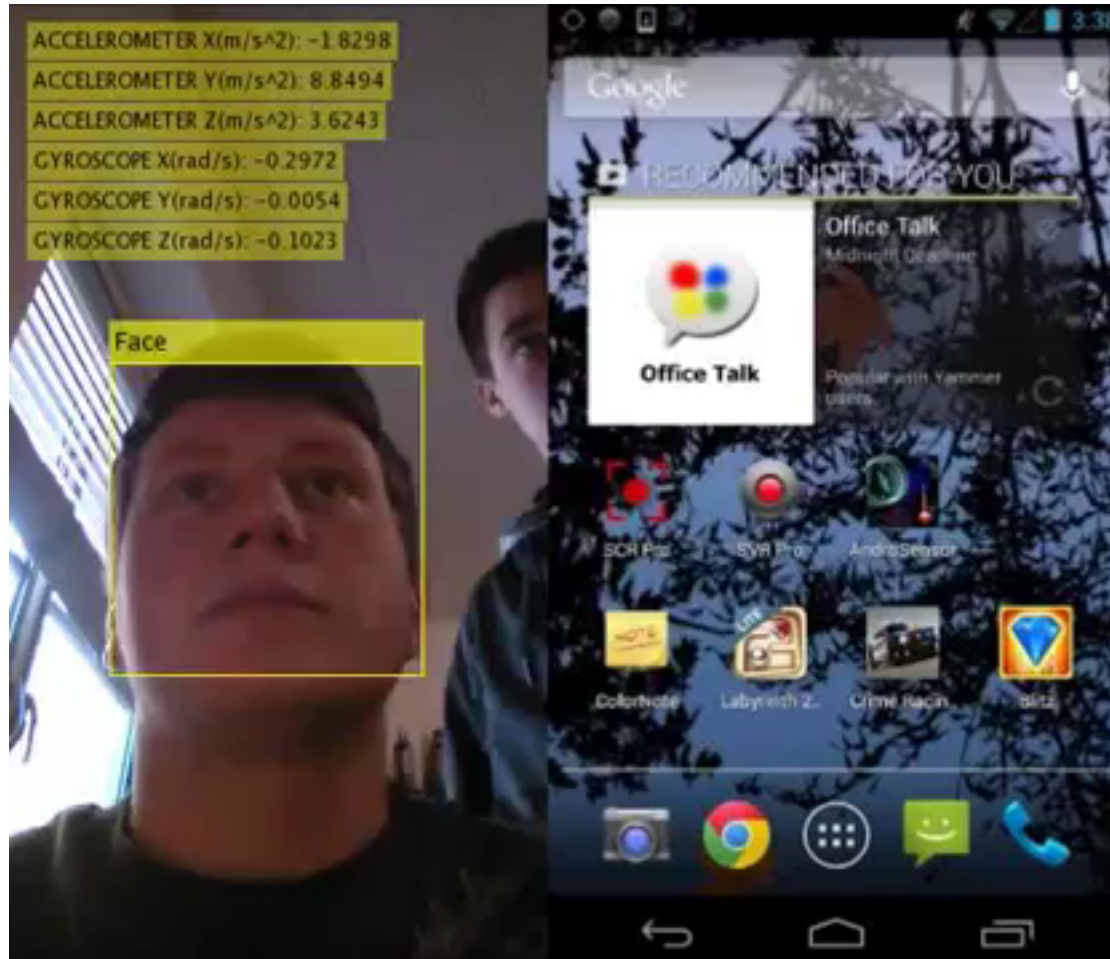
4. Play Labyrinth (ball balancing game)

5. Play Crime Racing City

6. Play Bejewelled

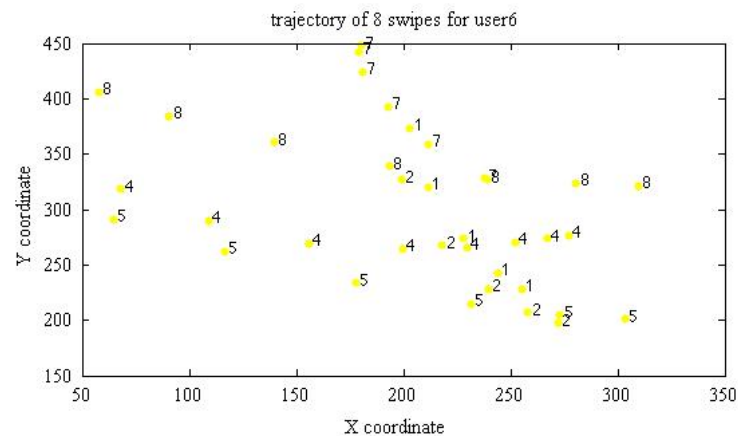
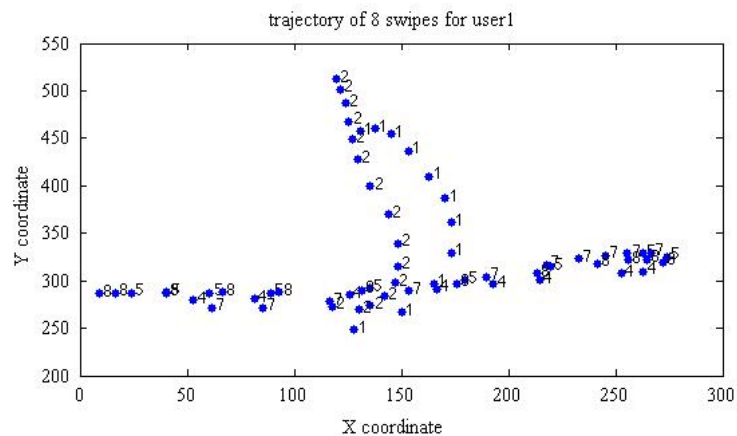
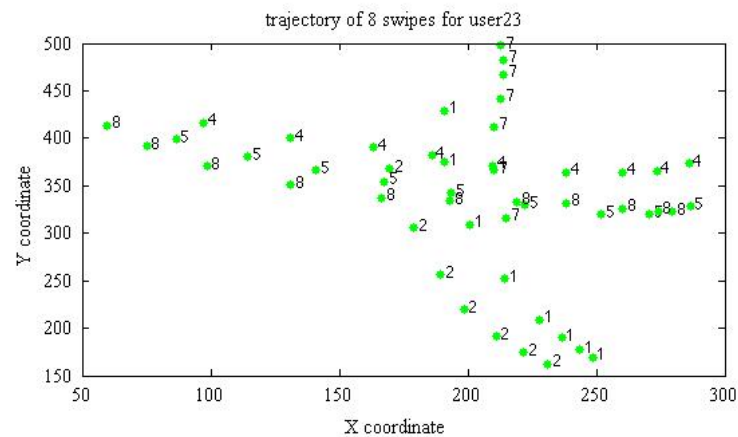
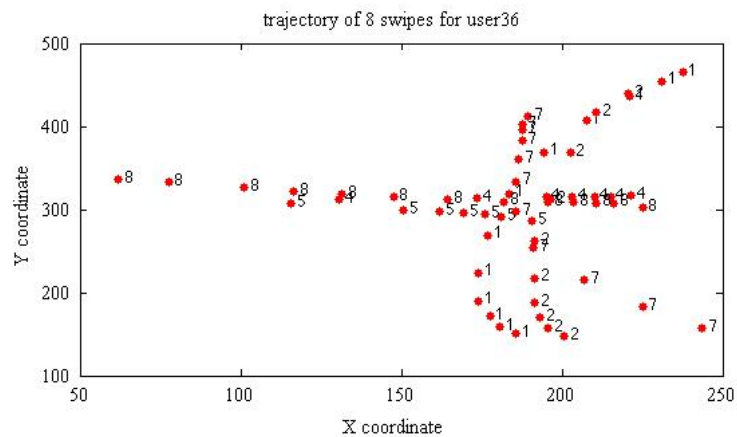
- This task was removed after the initial five subjects

Sample UCB Data: Camera + Screen + Sensor



UMD Touch Data

Touch Data



27 Dimensional Feature

- Inter-swipe time
- Swipe duration
- Start x
- Start y
- Stop x
- Stop y
- Direct end-to-end distance
- Mean resultant length
- Up/down/left/right flag
- Direction of end-to-end line
- Length of trajectory
- Average direction
- Average velocity
- Median acceleration at first 5 points
- Mid-swipe area covered
- Ratio end-to-end distance and length of trajectory
- 20%-perc. pairwise velocity
- 50%-perc. pairwise velocity
- 80%-perc. pairwise velocity
- 20%-perc. pairwise acc
- 50%-perc. pairwise acc
- 80%-perc. pairwise acc
- Median velocity at last 3 pts
- largest deviation from end-to-end line
- 20%-perc. dev. from end-to-end line
- 50%-perc. dev. from end-to-end line
- 80%-perc. dev. from end-to-end line

Average EER on Touch data

Swipes	KSRC	KDTGR	rbfSVM
1	29.86 $\pm$ 0.37	28.03 $\pm$ 0.22	17.41 $\pm$ 0.13
3	15.82 $\pm$ 0.30	12.92 $\pm$ 0.34	14.00 $\pm$ 0.27
5	9.71 $\pm$ 0.33	7.53 $\pm$ 0.31	8.56 $\pm$ 0.25
7	7.50 $\pm$ 0.32	5.59 $\pm$ 0.20	6.15 $\pm$ 0.27
9	5.85 $\pm$ 0.41	4.12 $\pm$ 0.22	4.75 $\pm$ 0.29
11	4.55 $\pm$ 0.32	2.91 $\pm$ 0.21	3.58 $\pm$ 0.26
13	3.40 $\pm$ 0.32	2.16 $\pm$ 0.14	2.66 $\pm$ 0.28
15	2.55 $\pm$ 0.40	1.43 $\pm$ 0.23	2.11 $\pm$ 0.27
17	1.98 $\pm$ 0.20	1.05 $\pm$ 0.20	1.43 $\pm$ 0.24
19	1.54 $\pm$ 0.25	0.77 $\pm$ 0.21	1.13 $\pm$ 0.22

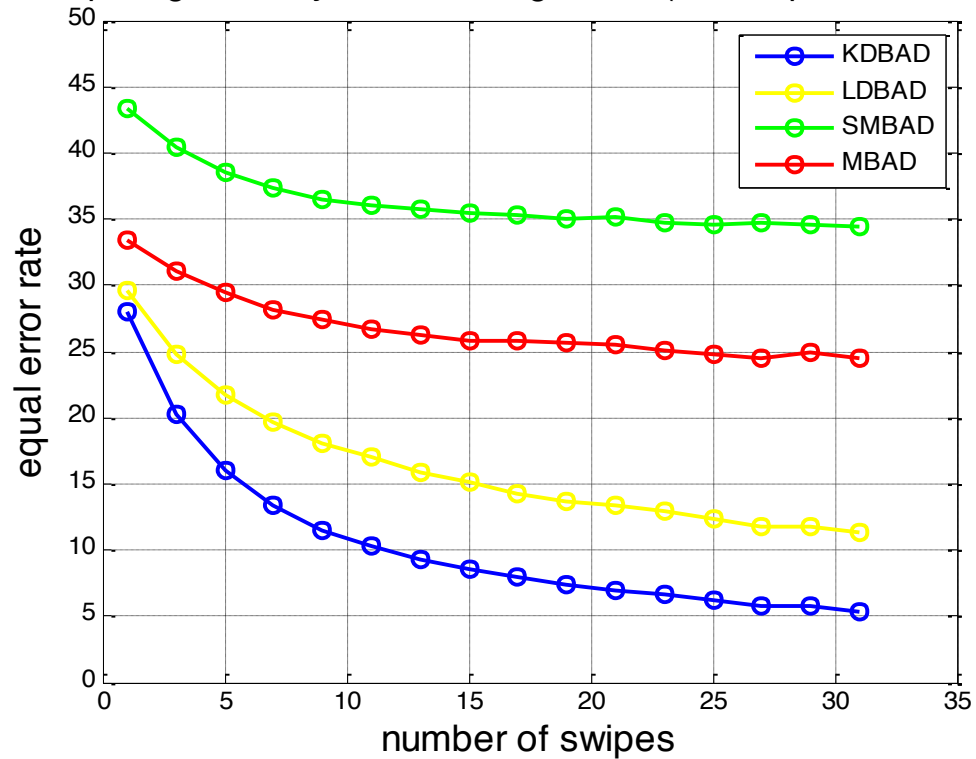
TABLE II: Average EER values (in %) for different classification methods on the new dataset.

Anomaly Detection

- Method
 - Select 90 samples for training
 - Use the remaining for anomaly detection
 - Randomly spilt data 20 times
 - Calculate the EER of 50 anomaly detectors
- Algorithms
 - Scaled Manhattan-based Anomaly Detector (SMBAD)
 - Mahalanobis-based Anomaly Detector (MBAD)
 - Linear Dictionary-based Anomaly Detector (LDBAD)
 - Kernel Dictionary-based Anomaly Detector (KDBAD)

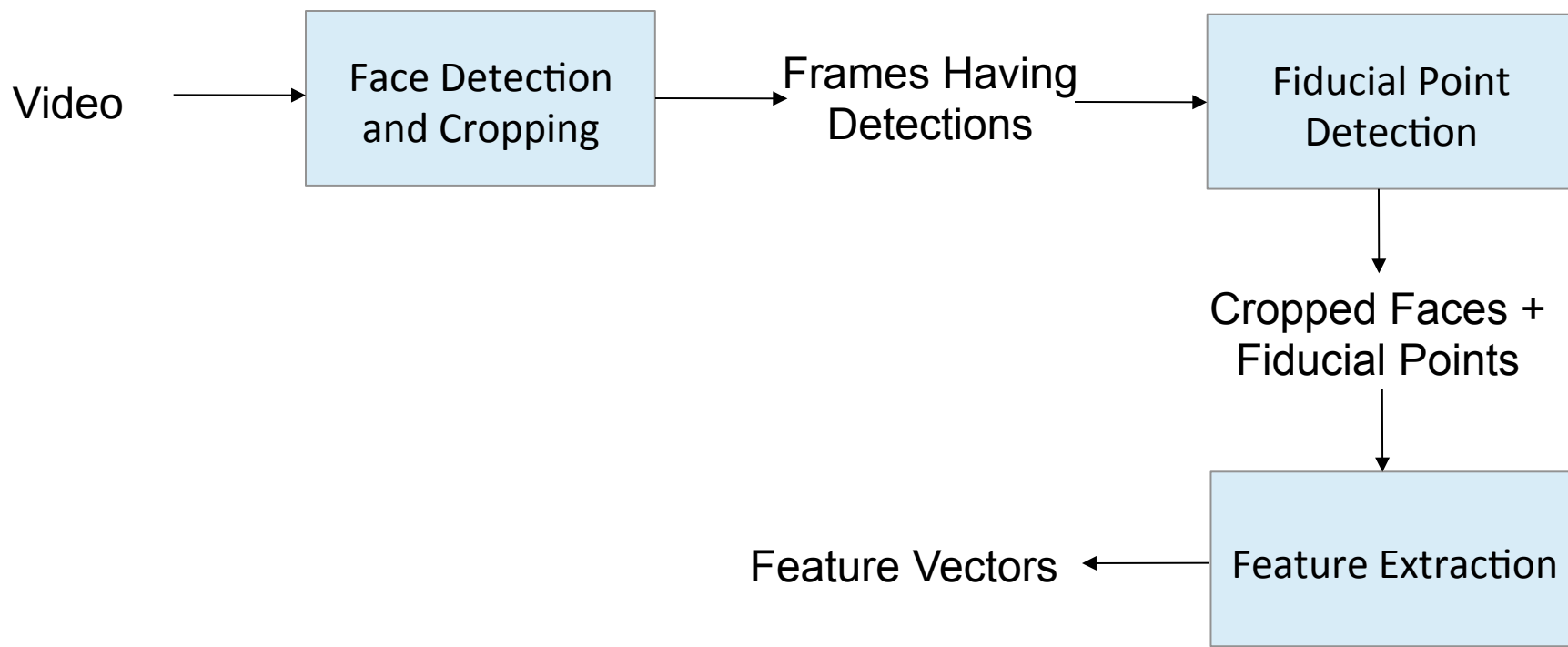
EER

Comparing Anomaly Detection Algorithms(90 samples for training)

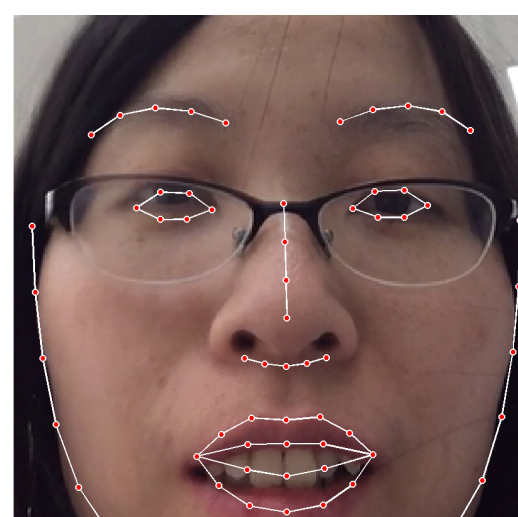
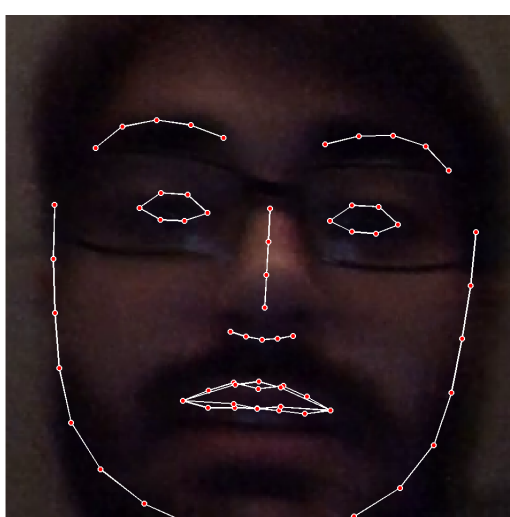
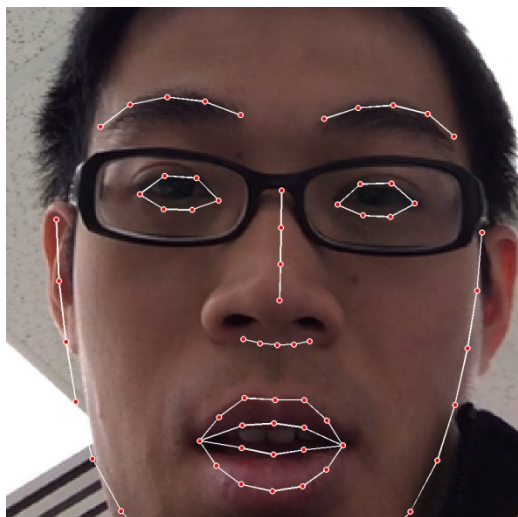
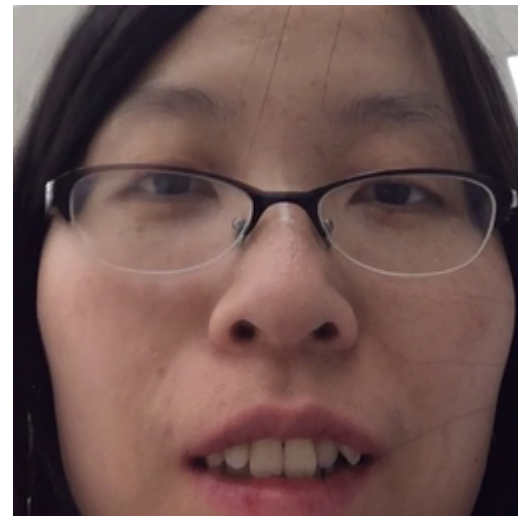


UMD Face Data

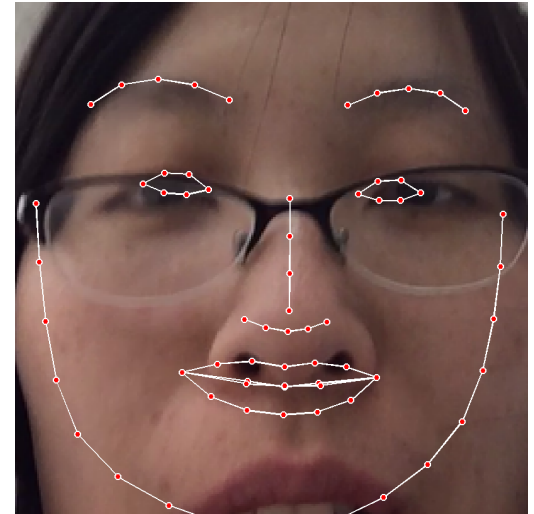
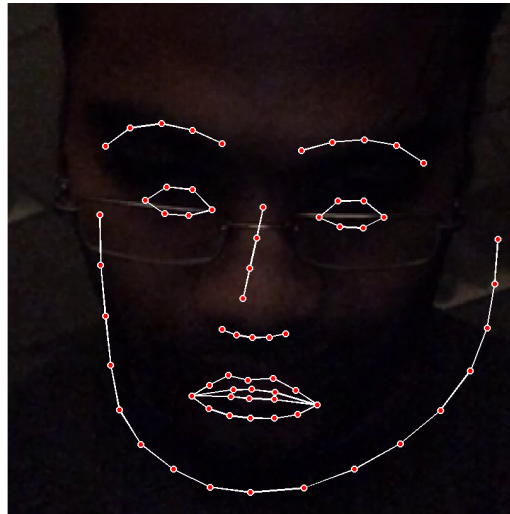
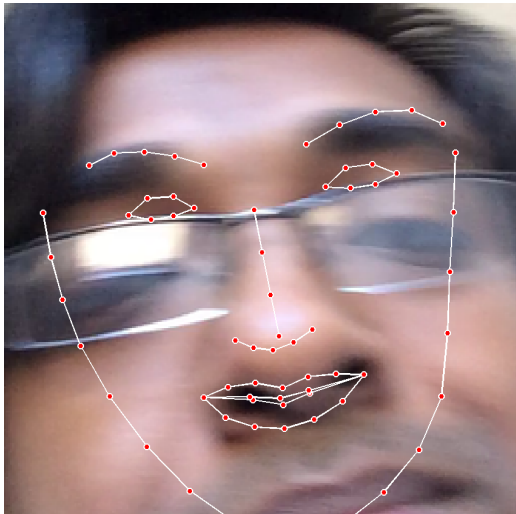
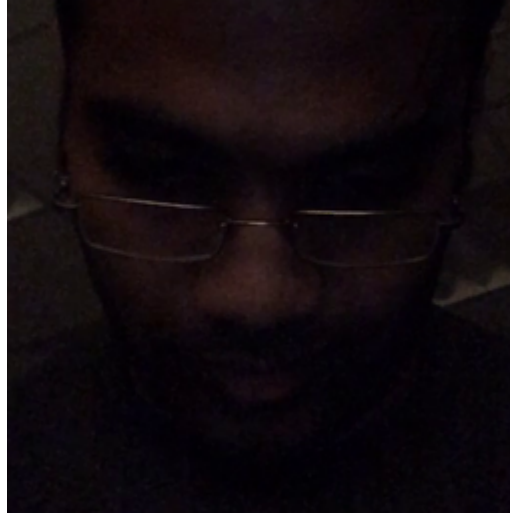
Preprocessing and Feature Extraction



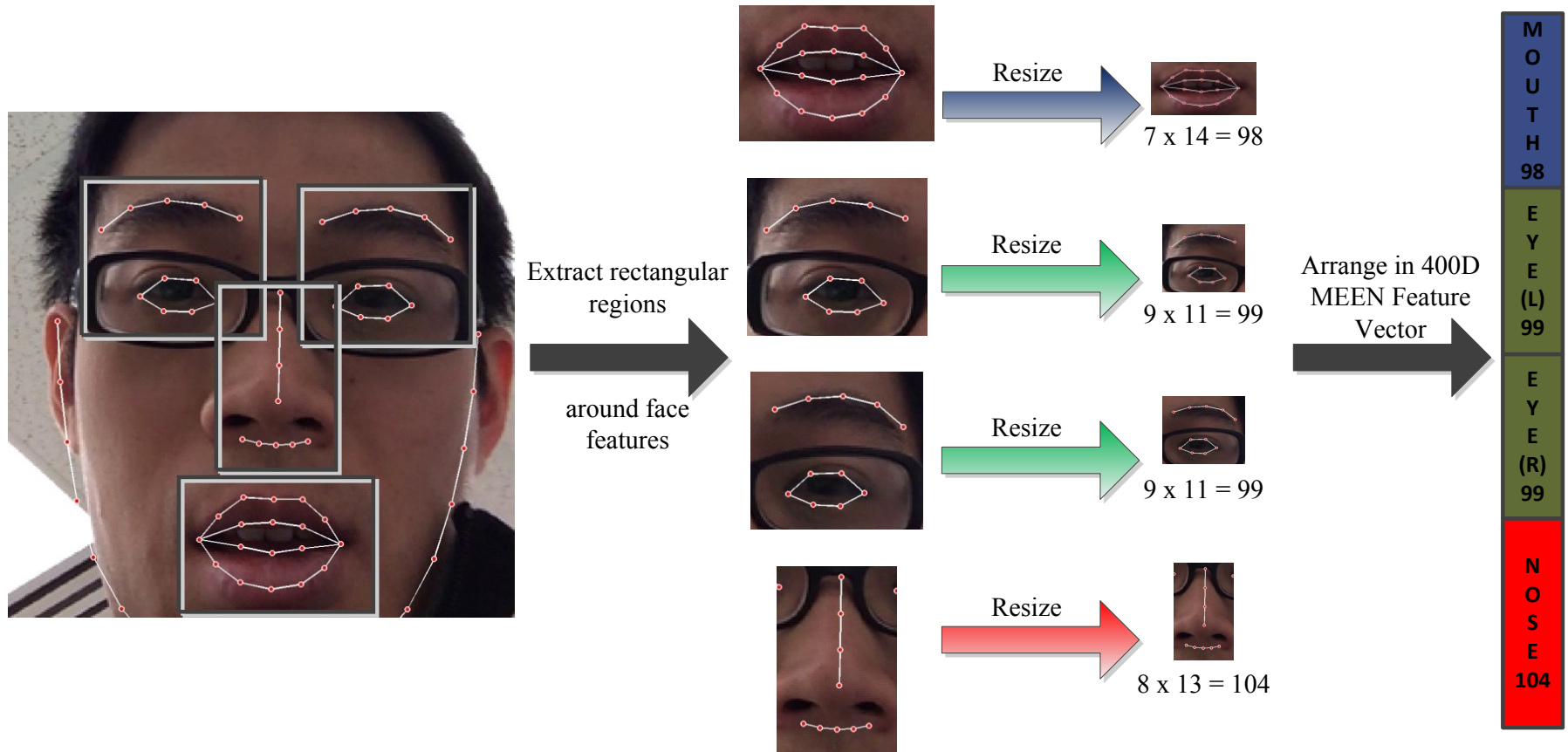
Detected Faces



Bad Detections



MEEN Feature



Mouth, left Eye, right Eye, and the Nose (MEEN)

Results

Table 1: Recognition rates under protocol 1: The different models are trained using one session’s enrollment videos and tested on video clips from another session. For each row, we show **in bold** the three highest recognition rates achieved for this experimental setting.

Enrollment Sessions	Testing Sessions	EF	FF	LMNN	SRC	AHISD	CHISD	SANP	DFRV	MSSRC
1	2	40.95	54.48	30.80	52.79	22.17	14.55	17.26	29.78	47.21
1	3	34.02	45.27	30.77	51.18	21.30	13.91	17.01	35.65	46.15
2	1	22.23	25.52	13.41	44.18	10.23	7.97	10.60	32.55	43.06
2	3	49.70	56.80	43.05	58.58	47.78	44.67	44.97	46.30	60.36
3	1	28.05	24.77	22.05	17.64	10.69	11.63	13.04	19.89	17.64
3	2	55.50	56.01	50.76	51.95	46.87	41.12	43.82	47.04	45.85

Table 2: Recognition rates under protocol 2: The different models are trained using the enrollment videos of two sessions and tested on video clips from the remaining session. For each row, we show **in bold** the three highest recognition rates achieved for this experimental setting.

Enrollment Sessions	Testing Sessions	EF	FF	LMNN	SRC	AHISD	CHISD	SANP	DFRV	MSSRC
{1, 2}	3	55.18	74.85	48.37	72.93	51.18	47.04	48.08	52.81	72.19
{2, 3}	1	30.11	54.69	25.33	24.20	14.35	16.51	16.79	39.21	22.14
{1, 3}	2	63.96	71.91	56.18	72.93	50.08	43.15	46.70	50.25	69.71

Results

Table 3: Recognition rates when enrollment videos and non-enrollment test video clips come from the same session. The recognition rates for such setting are relatively good compared to those of protocol 1 and protocol 2. For each row, we show **in bold** the three highest recognition rates achieved for this experimental setting.

Enrollment Sessions	Testing Sessions	EF	FF	LMNN	SRC	AHISD	CHISD	SANP	DFRV	MSSRC
1	1	91.84	93.53	94.65	93.25	94.00	95.50	94.84	91.56	93.25
2	2	79.70	84.77	84.94	84.94	86.46	85.45	85.11	83.59	85.45
3	3	82.25	86.98	83.58	80.47	85.06	82.54	83.14	76.78	73.52
{1, 2}	1	92.31	93.34	94.18	92.96	93.90	95.31	94.47	92.03	93.06
{1, 2}	2	81.73	83.76	83.76	85.11	85.96	85.11	84.77	83.93	85.79
{2, 3}	2	81.90	84.09	82.57	79.86	85.45	84.43	83.59	82.57	68.02
{2, 3}	3	84.17	91.72	85.21	82.40	88.46	84.76	85.50	81.66	73.22
{1, 3}	1	93.25	93.25	93.71	92.78	94.09	96.06	95.03	92.50	92.68
{1, 3}	3	83.14	87.43	83.88	85.36	84.62	82.40	83.58	78.25	83.88

Ongoing and Future Research

- Multi-modal fusion of both touch and face data
- Latency experiments
- Domain adaptation experiments
- Hardware implementation

Thanks!!