# Image and Video Person Identification in an Operational Environment

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- Project Start Date: **January 2016**
- Anticipated End Date: **December 2017**
- Project personnel:
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# Problem Statement

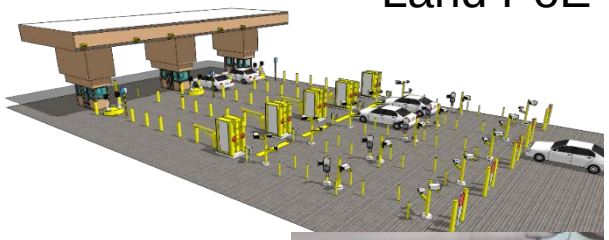
- **Identifying** individuals against both **known** and **unknown perpetrators** in the presence of unconstrained pose and arbitrary illumination conditions

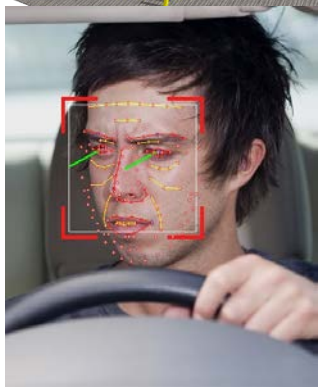
# Biometric Identity: Applications

Air PoE

Game Cameras

Land PoE






BTI Institute

Clockwise from top: sportsmansguide.com, TX DPS, Rutgers, nViso SA, Universal, cbp.gov (2)

# Beneficiary / End User Profile: Jobs

- DHS strategy officials: Analysts
- Enforcement Systems Division: Dispatchers

# Beneficiary / End User Profile: Desired Gains

- A method that will **accurately** identify individuals in **real-time** to enable the dispatchers to alert the agents dispatched in the field

# Beneficiary / End User Profile: Pain Points

- The methods currently available have **limitations** for matching images where a person's face is **partially visible** due to **pose** or **illumination**

# Products & Services

- The product is a **software prototype** for matching a facial image to a gallery of facial images with variety of poses and illuminations. The functionalities for the prototype software include:
  1. computing a biometric template (derived by the UH software) from an image
  2. ability to ingest a set of images to create a gallery
  3. matching biometric templates from a probe image to a gallery of templates

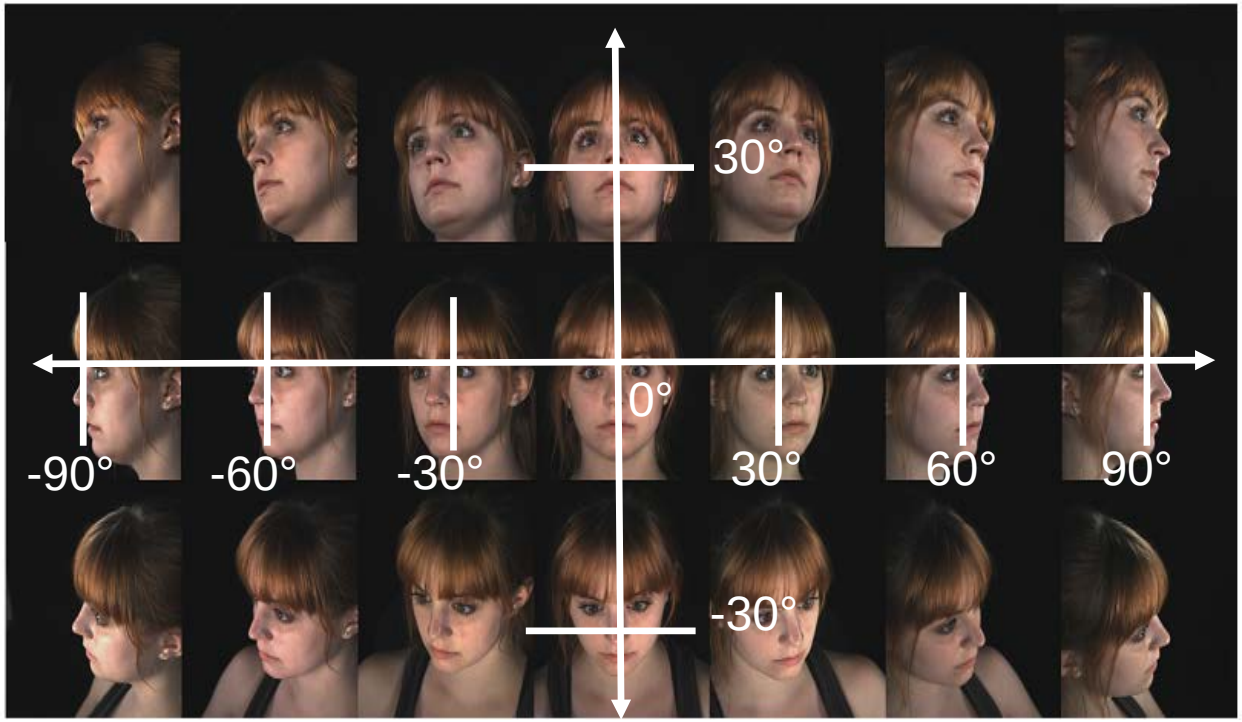
# Gains Created

- This product aims to enable the US BP dispatchers to accurately match images in existing databases by providing a beyond-state-of-the-art method for identification

# Pains Alleviated

- Enhancement of the overall situational awareness of the Border Patrol units
- USBP officer increased safety
- Effort and time savings
- Anticipation of future actions by modelling routes and habits of repeat offenders

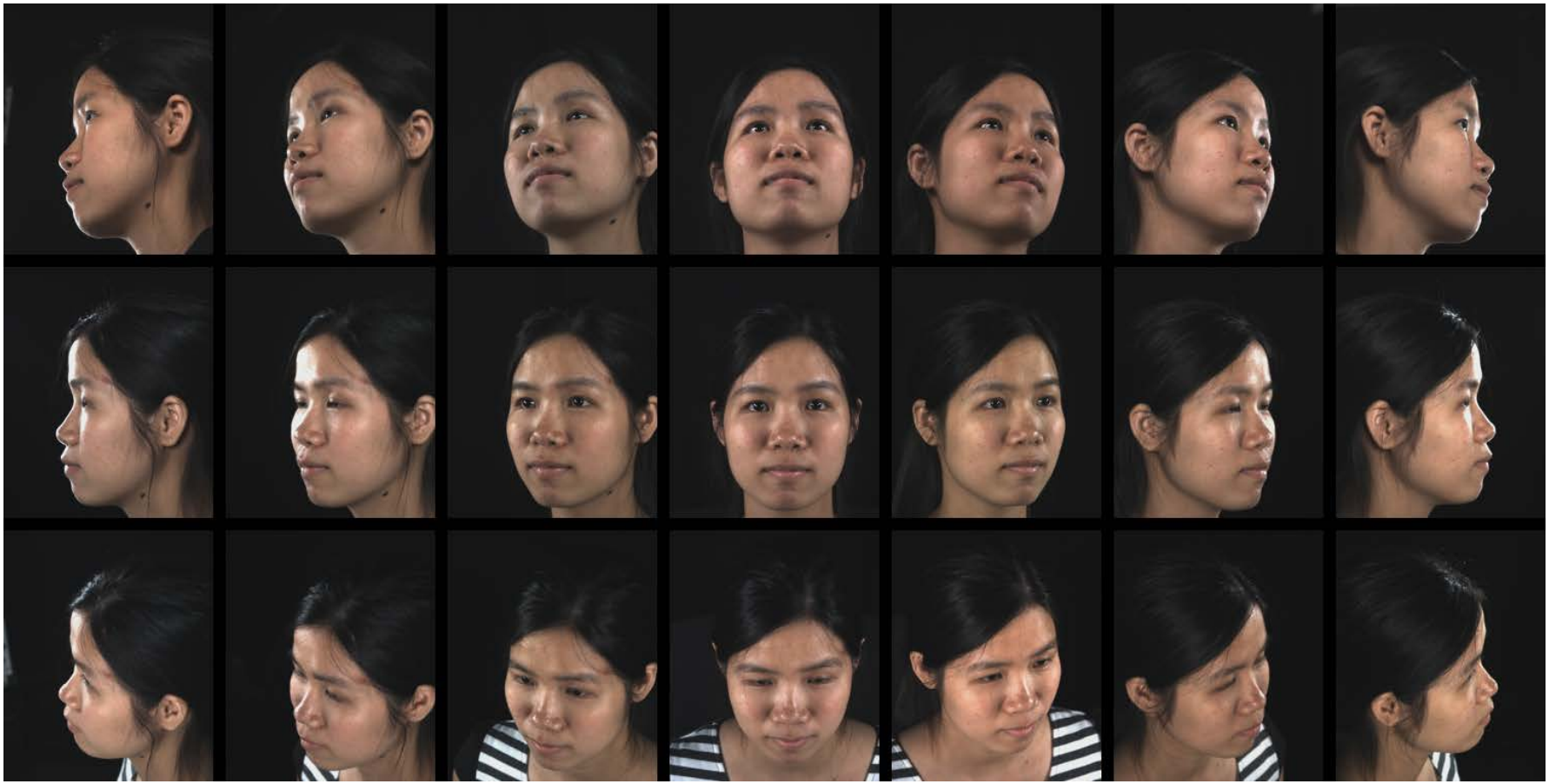
# UHDB31 – Multi-View Facial Database




[1] Ha Le and Ioannis A. Kakadiaris, UHDB31: A Dataset for Better Understanding Face Recognition across Pose and Illumination Variation. In Proc. IEEE International Conference on Computer Vision Workshops. Venice, Italy. October 22-29 2017

# 21 Camera System

# 21 Pod Acquisition: 2D



# 21 Pod Acquisition: 2D

# UHDB31: Specifications

**Purpose**: Facilitates different experimental configurations, including 3D-3D, 3D-2D and 2D-2D, with pose and illumination variability

**Origin**: Acquired using a 21-pod system

**Data**: Both 2D images and 3D facial scans

**Number of subjects**: 77

**Resolutions**: Five different resolutions per image

**Pose variations**: 21 distinct facial poses

**Lighting conditions**: Three indoor lighting conditions

**Number of 3D facial scans**: 77 (one per subject) 3D facial scans

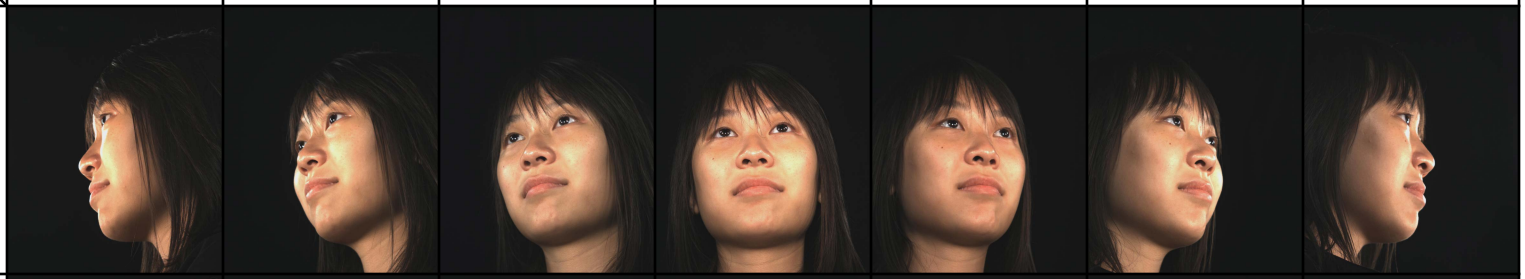
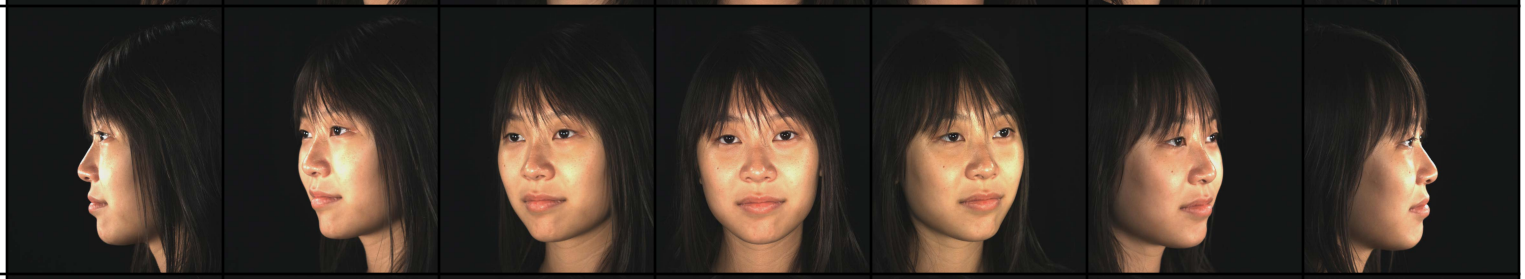
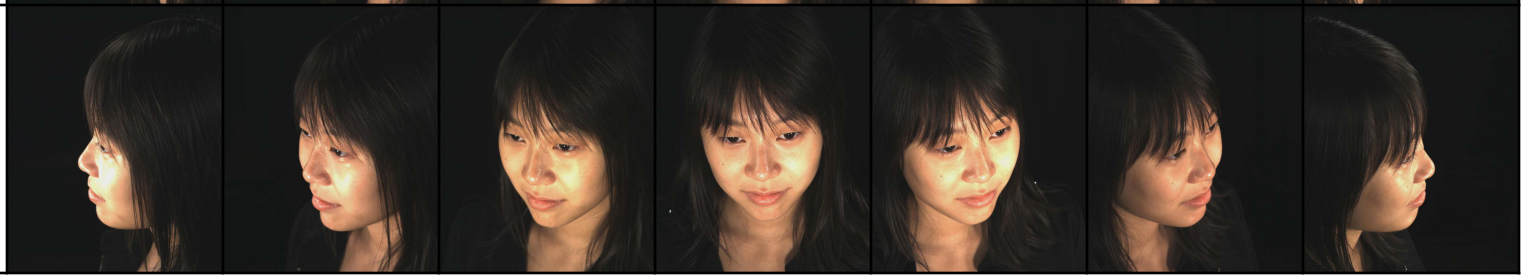
**Number of 2D images**: 24,255 images

# UHDB31: Resolutions

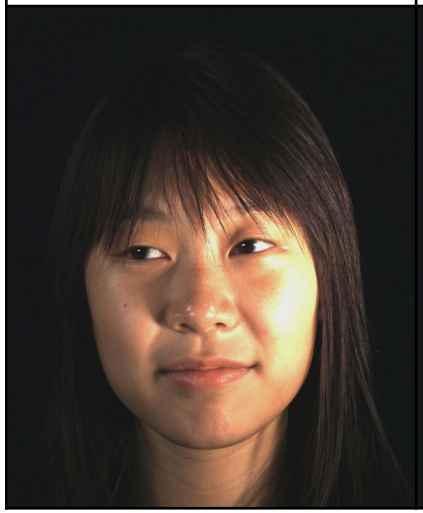
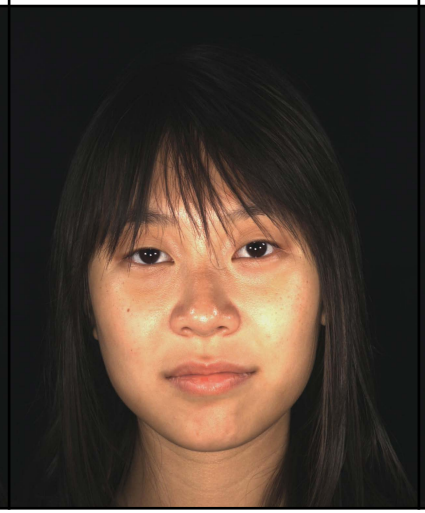
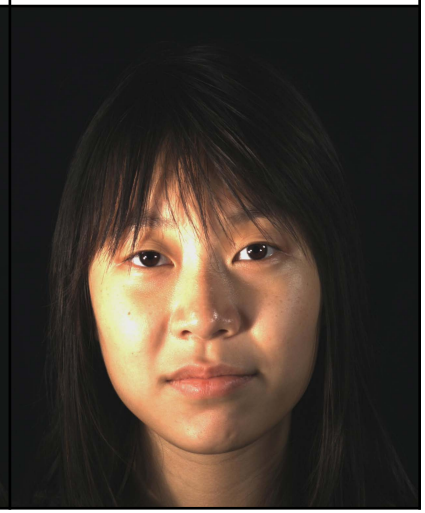
| Name | Image Size | Face ROI | IOD |
|---|---|---|---|
| UHDB31.R2048 | 2048x2448 | 1070x1070 | 536 |
| UHDB31.R1024 | 1024x1224 | 535x535 | 268 |
| UHDB31.R0512 | 512x612 | 267x267 | 134 |
| UHDB31.R0256 * | 256x306 | 134x134 | 67 |
| UHDB31.R0128 * | 128x153 | 64x67 | 34 |

The last two cohorts marked with * are used to evaluate the UH-URxD face recognition pipeline

# UHDB31: Pose Variations

| Pitch \ Yaw | -90° | -60° | -30° | 0° | 30° | 60° | 90° |
|---|---|---|---|---|---|---|---|
| -30° |  | | | | | | |
| 0° |  | | | | | | |
| 30° |  | | | | | | |

# UHDB31: Lighting Conditions

| I01 | I03 | I05 |
| --- | --- | --- |
|  |  |  |

# UH-URxD performance on UHDB31.R0256.I03


This table illustrates the rank one rates of UH-URxD

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | | |
| | | | | | | |
| | | | | | | |

# UH-URxD performance on UHDB31.R0256.I03


This table illustrates the rank one rates of UH-URxD

| | | | | | | |
|---|---|---|---|---|---|---|
| 0.78 | | | | | | |
| | | | | | | |
| | | | | | | |

# UH-URxD performance on UHDB31.R0256.I03


This table illustrates the rank one rates of UH-URxD

| | | | | | | |
|---|---|---|---|---|---|---|
| 0.78 | 1 | | | | | |
| | | | | | | |
| | | | | | | |

# UH-URxD performance on UHDB31.R0256.I03


This table illustrates the rank one rates of UH-URxD

| | | | | | | |
|---|---|---|---|---|---|---|
| 0.78 | 1 | 0.99 | 1 | 1 | 0.99 | 0.71 |
| 0.99 | 1 | 1 | | 1 | 1 | 0.96 |
| 0.65 | 1 | 1 | 1 | 1 | 0.99 | 0.84 |

# UH-URxD performance on UHDB31.R0256.I03


This table illustrates the rank one rates of UH-URxD compared with VGG-Face [1] and COTS

| | | | | | | |
|---|---|---|---|---|---|---|
| **0.78**, 0.31, 0.03 | **1**, 0.84, 0.40 | **0.99**, **0.99**, 0.79 | **1**, 0.97, 0.88 | **1**, 0.99, 0.79 | **0.99**, 0.87, 0.44 | **0.71**, 0.43, 0.10 |
| **0.99**, 0.62, 0.05 | **1**, 0.95, 0.53 | **1**, **1**, 0.94 | | **1**, **1**, 0.91 | **1**, **1**, 0.68 | **0.96**, 0.77, 0.10 |
| **0.65**, 0.33, 0.01 | **1**, 0.79, 0.13 | **1**, 0.95, 0.68 | **1**, 0.97, 0.91 | **1**, 0.97, 0.81 | **0.99**, 0.82, 0.17 | **0.84**, 0.34, 0.08 |

[1] O. M. Parkhi, A. Vedaldi, A. Zisserman, Deep face recognition, in: Proc. British Machine Vision Conference, Swansea, UK, September 7-10, 2015, pp. 1–12

# UH-URxD performance on UHDB31.R0256.I01


This table illustrates the rank one rates of UH-URxD compared with VGG-Face [1] and COTS

| | | | | | | |
|---|---|---|---|---|---|---|
| **0.60**, 0.34, 0.01 | **0.92**, 0.75, 0.09 | **0.97**, 0.92, 0.60 | **0.99**, 0.94, 0.74 | **0.95**, 0.91, 0.43 | **0.77**, 0.64, 0.07 | **0.31**, 0.22, 0.03 |
| **0.92**, 0.46, 0.07 | **0.99**, 0.84, 0.22 | **0.99**, 0.97, 0.82 | | **1**, **1**, 0.71 | **1**, 0.86, 0.21 | **0.57**, 0.31, 0.04 |
| **0.52**, 0.20, 0.00 | **0.95**, 0.51, 0.03 | **0.99**, 0.83, 0.34 | **1**, 0.92, 0.79 | **1**, 0.88, 0.22 | **0.83**, 0.55, 0.01 | **0.18**, 0.09, 0.01 |

[1] O. M. Parkhi, A. Vedaldi, A. Zisserman, Deep face recognition, in: Proc. British Machine Vision Conference, Swansea, UK, September 7-10, 2015, pp. 1–12

# UH-URxD performance on UHDB31.R0256.I05


This table illustrates the rank one rates of UH-URxD compared with VGG-Face [1] and COTS

| | | | | | | |
|---|---|---|---|---|---|---|
| **0.21**, 0.13, 0.03 | **0.71**, 0.51, 0.03 | **0.97**, 0.87, 0.34 | **1**, 0.91, 0.83 | **1**, 0.95, 0.74 | **0.99**, 0.77, 0.38 | **0.66**, 0.48, 0.05 |
| **0.58**, 0.26, 0.01 | **0.97**, 0.78, 0.12 | **0.99**, 0.96, 0.68 | | **1**, 0.99, 0.94 | **1**, 0.91, 0.43 | **0.91**, 0.64, 0.07 |
| **0.18**, 0.17, 0.01 | **0.82**, 0.48, 0.04 | **0.94**, 0.77, 0.12 | **0.99**, 0.91, 0.73 | **1**, 0.88, 0.64 | **0.99**, 0.69, 0.10 | **0.56**, 0.29, 0.05 |

[1] O. M. Parkhi, A. Vedaldi, A. Zisserman, Deep face recognition, in: Proc. British Machine Vision Conference, Swansea, UK, September 7-10, 2015, pp. 1–12

# UH-URxD performance on UHDB31.R0128.I03


This table illustrates the rank one rates of UH-URxD compared with VGG-Face [1] and COTS [2]

| | | | | | | |
|---|---|---|---|---|---|---|
| **0.82**, 0.33, 0.05 | **0.99**, 0.78, 0.40 | **1**, 0.99, 0.74 | **1**, 0.99, 0.88 | 0.99, **1**, 0.74 | **0.99**, 0.87, 0.42 | **0.75**, 0.40, 0.08 |
| **0.96**, 0.62, 0.10 | **1**, 0.96, 0.47 | **1**, **1**, 0.91 | | **1**, **1**, 0.90 | **1**, **1,** 0.64 | **0.96**, 0.71, 0.10 |
| **0.70**, 0.30, 0.03 | **0.97**, 0.78, 0.10 | **1**, 0.94, 0.66 | **1**, 0.97, 0.91 | **1**, 0.97, 0.82 | **0.96**, 0.81, 0.18 | **0.78**, 0.27, 0.07 |

[1] O. M. Parkhi, A. Vedaldi, A. Zisserman, Deep face recognition, in: Proc. British Machine Vision Conference, Swansea, UK, September 7-10, 2015, pp. 1–12

# UH-URxD performance on UHDB31.R0128.I01


This table illustrates the rank one rates of UH-URxD compared with VGG-Face [1] and COTS

| | | | | | | |
|---|---|---|---|---|---|---|
| **0.45**, 0.40, 0.04 | **0.95**, 0.74, 0.10 | **0.99**, 0.92, 0.60 | **1**, 0.97, 0.71 | **0.97**, 0.88, 0.39 | **0.71**, 0.53, 0.08 | **0.23**, 0.18, 0.00 |
| **0.83**, 0.49, 0.07 | **0.99**, 0.81, 0.20 | **1**, 0.96, 0.77 | | **1**, 0.99, 0.73 | **1**, 0.82, 0.18 | **0.52**, 0.26, 0.03 |
| **0.35**, 0.21, 0.01 | **0.83**, 0.53, 0.04 | **0.99**, 0.87, 0.30 | **1**, 0.90, 0.74 | **0.97**, 0.84, 0.16 | **0.64**, 0.40, 0.03 | **0.18**, 0.10, 0.07 |

[1] O. M. Parkhi, A. Vedaldi, A. Zisserman, Deep face recognition, in: Proc. British Machine Vision Conference, Swansea, UK,

# UH-URxD performance on UHDB31.R0128.I05


This table illustrates the rank one rates of UH-URxD compared with VGG-Face [1] and COTS

| | | | | | | |
|---|---|---|---|---|---|---|
| **0.16**, 0.13, 0.03 | **0.69**, 0.49, 0.03 | **0.99**, 0.82, 0.35 | **1**, 0.91, 0.82 | **0.97**, 0.90, 0.75 | **0.96**, 0.79, 0.30 | **0.66**, 0.47, 0.05 |
| **0.48**, 0.23, 0.01 | **0.92**, 0.73, 0.08 | **0.99**, 0.96, 0.74 | | **1**, 0.74, 0.91 | **1**, 0.94, 0.42 | **0.88**, 0.53, 0.08 |
| 0.12, **0.13**, 0.05 | **0.55**, 0.39, 0.05 | **0.88**, 0.69, 0.17 | **0.99**, 0.90, 0.71 | **1**, 0.88, 0.58 | **0.92**, 0.64, 0.09 | **0.48**, 0.20, 0.01 |

[1] O. M. Parkhi, A. Vedaldi, A. Zisserman, Deep face recognition, in: Proc. British Machine Vision Conference, Swansea, UK, /

# Key accomplishments

| | | Face identification improvement rates (Percentage above SotA) | | | |
|---|---|---|---|---|---|
| **Conditions** | | **Rank-1** | | **Rank-5** | |
| **pose** | **illumination** | **VGG-Face** | **COTS** | **VGG-Face** | **COTS** |
| Large pose variation | Uniform illumination | 26.6 | **61.0** | 14.4 | **64.7** |
| | Non-uniform illumination | 28.3 | **60.9** | 18.8 | **63.4** |

# Transition Pathways

- Testing of the prototype software on US BP data

# Transition Engagement

- US BP dispatchers utilization of the prototype software to match individuals
- Accuracy rates measured on the US BP data

# Transition Challenges (if applicable)

- Testing with real data

# Conclusions

- Face identification accuracy well beyond the projected performance improvement and well beyond the state of the art
- Gain: USBP enabled to assess potential threats by identifying persons of interest before they come in contact with the agents

# Acknowledgement


- This material is based upon work supported by the U.S. Department of Homeland Security under Grant Award Number 2015-ST-061-BSH001. This grant is awarded to the Borders, Trade, and Immigration (BTI) Institute: A DHS Center of Excellence led by the University of Houston, and includes support for the project “Image and Video Person Identification in an Operational Environment” awarded to the University of Houston. The views and conclusions contained in this document are those of the authors and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the U.S. Department of Homeland Security