Biometrics 2
Face recognition

PV181 Laboratory of security and applied cryptography
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CROCS
Centre for Research on Cryptography and Security

Lecture structure

Seminar 1

1. Introduction
2. Fingerprints
3. Hands-on:
   - Generate fingerprints
   - Fake fingerprints
4. Homework:
   - Fake fingerprints

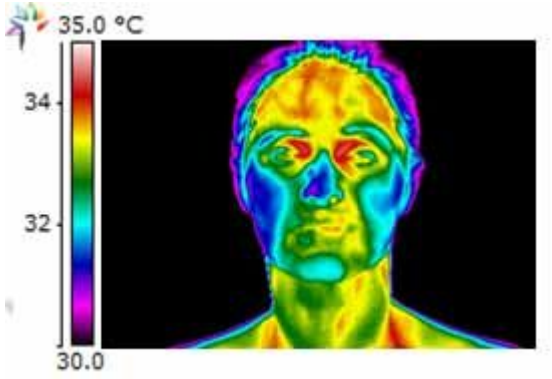
Seminar 2

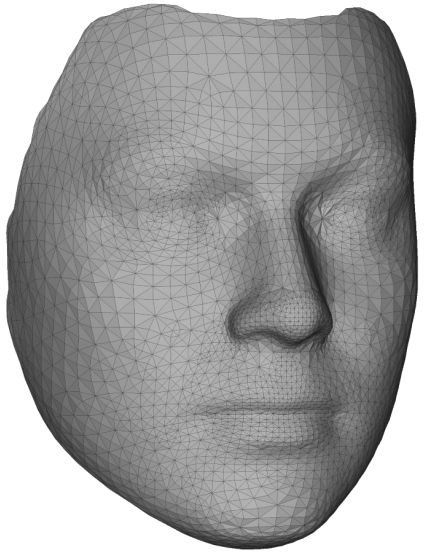
1. Face recognition
2. Hands-on:
   - Face matching
   - Fake fingerprints validation
3. Homework:
   - Age estimation

Real-life example

Face recognition – Input

- Single picture
- Video sequence
- 3D image
- Facial thermograms





Face recognition

- Statistical
  - Eigenface, PCA, LDA in Open BR
- Neural networks
  - Microsoft: Face API
  - Facebook: DeepFace
  - VK: FindFace *(“best results” in MegaFace comp.)*
  - Google: FaceNet

Open source frameworks

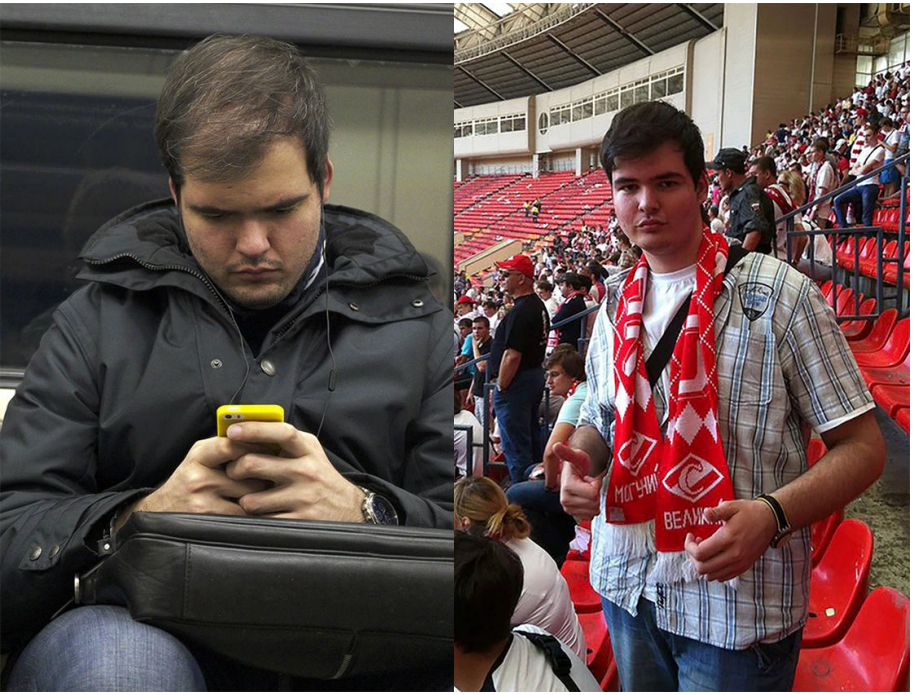
Project	Modern	Active	Deployable
CSU [17]	Yes	No	No
OpenCV [4]	No	Yes	Yes
OpenBR	Yes	Yes	Yes

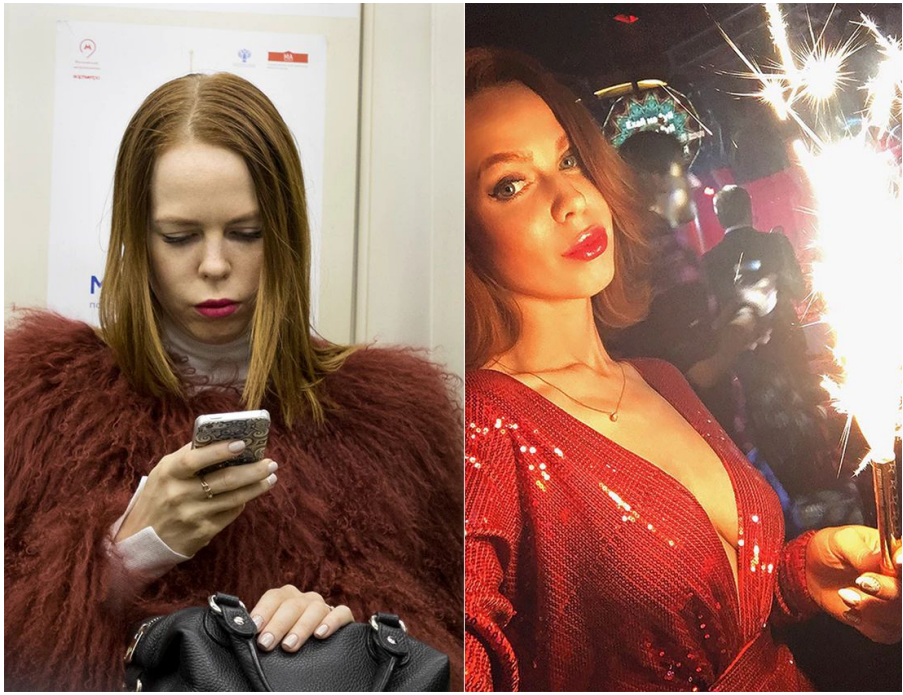
Table 1: Existing open source face recognition software. A project is considered *modern* if it incorporates peer-reviewed methods published in the last five years, *active* if it has source code changes made within the last six months, and *deployable* if it exposes a public API.

J. Klontz, B. Klare, S. Klum, A. Jain, M. Burge. "Open Source Biometric Recognition", Proceedings of the IEEE Conference on Biometrics: Theory, Applications and Systems (BTAS), 2013.

FindFace – example

Subway photo (left), social network photo (right)

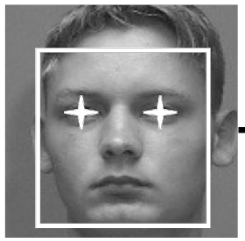




Challenges in face recognition

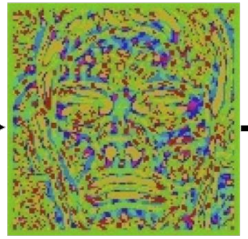
- Illumination
- Pose
- Environment
  - Noisy background
- Aging
- Feature occlusion
  - Hats, glasses, hair, ...
- Image quality
  - colour, resolution, ...

OpenBR: Face recognition overview

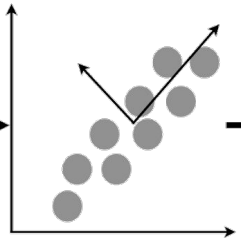


Detection +
Eyes
Face
Keypoints
Landmarks

Normalization +
Color Conversion
Enhancement
Filtering
Registration



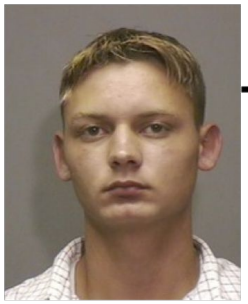
Representation +
Binary Patterns
Keypoint Descriptors
Orientation Histograms
Wavelets



Extraction :
Clustering
Normalization
Subspace Learning
Quantization

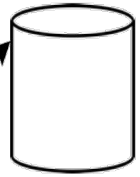
Matching
Classifiers
Density Estimation
Distance Metrics
Regressors

Data
CUFS
CUFSF
FERET
MEDS
FRGC
HFB
LFW
PCSO

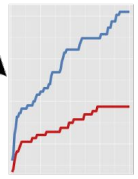


OpenBR

Design
Plugin Framework
Algorithm Description
Model Training



Gallery Management
Clustering & Fusion
Parallelization
Persistent Storage



Evaluation
CMC & ROC
Error Rates
Score Distributions

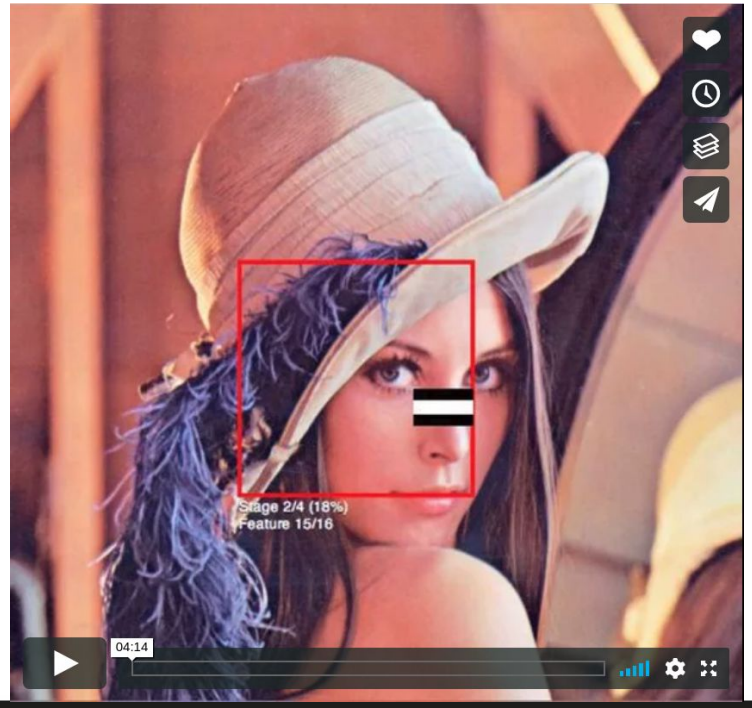
Photo © 2016 openbiometrics.org

Step 1 – Face detection

- Knowledge-based methods.
  - Ruled-based methods that encode our knowledge of human faces.
- Template matching methods.
  - These algorithms compare input images with stored patterns of faces or features.
- Appearance-based methods.
  - A template matching method whose pattern database is learnt from a set of training images.

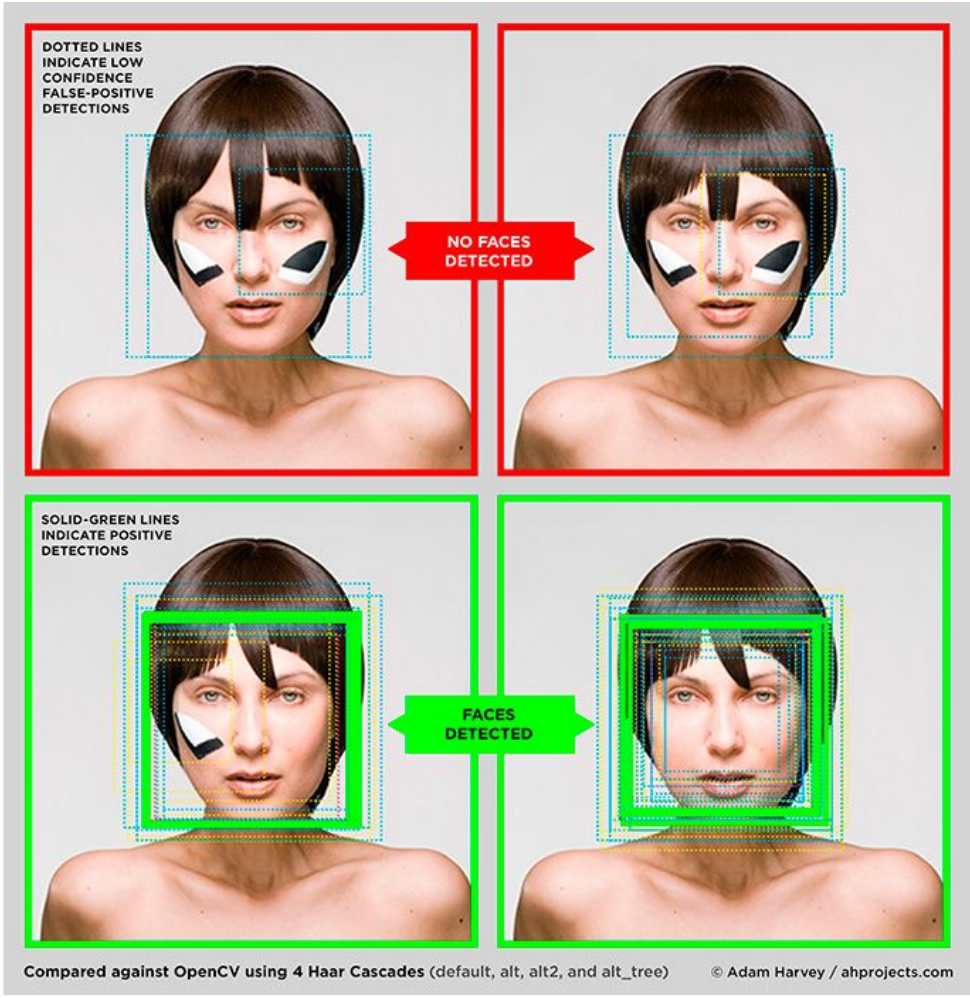
OpenBR face recognition – visualization

- Haar-cascade Detection
- Machine learning based approach where a cascade function is trained from a lot of positive and negative images.
- See video:
  OpenCV Face Detection: Visualized
  https://vimeo.com/12774628



CV Dazzle: Anti face-detection

Photo © 2010-2016 Adam Harvey, CV Dazzle



CV Dazzle: Anti face-detection

Photo © 2010-2016 Adam Harvey, CV Dazzle

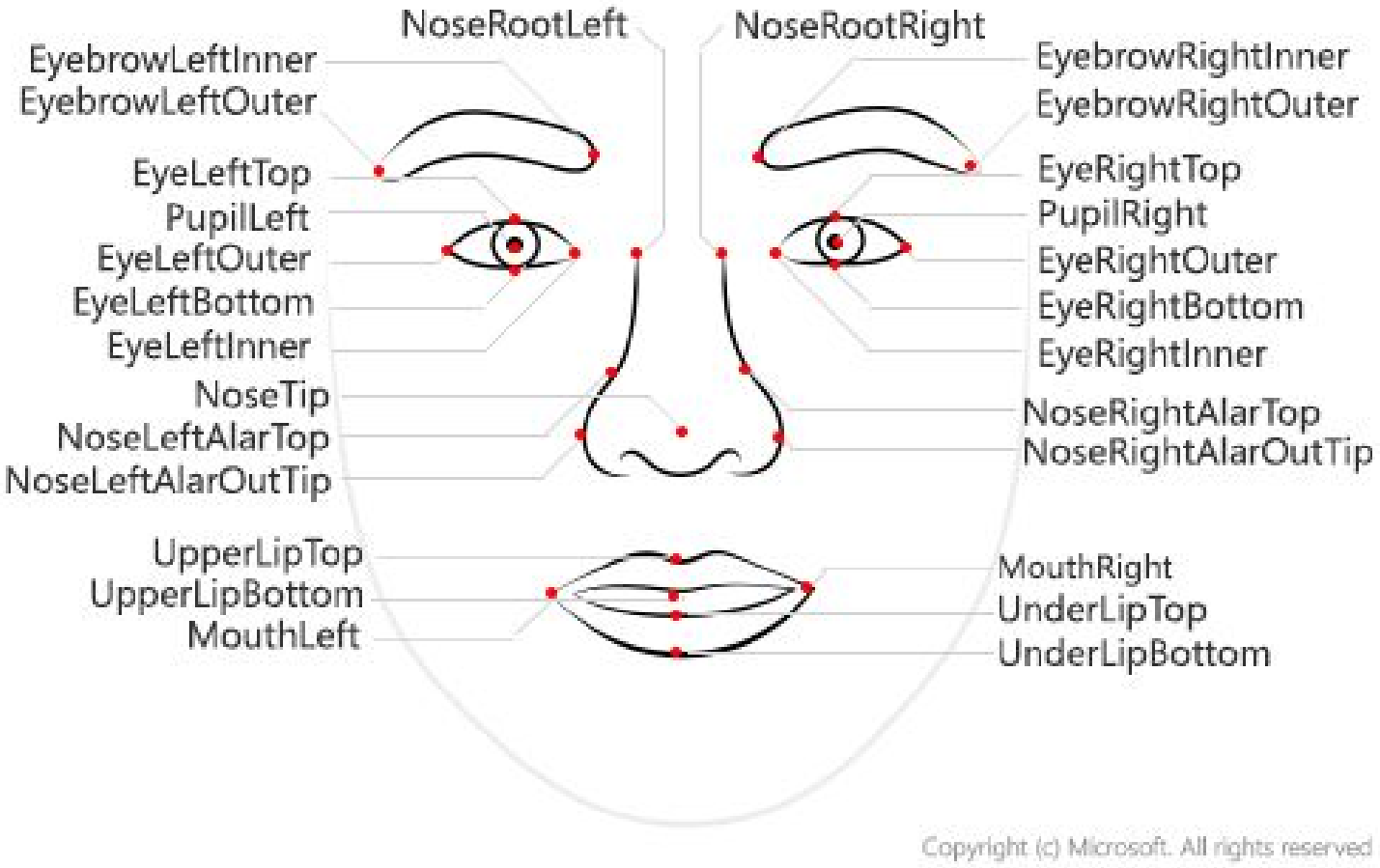
Step 2 – Normalization and Representation

- Picture preprocessing
- OpenBR approach (Eigenface):
  - Detects eyes in detected faces
  - Normalize the face with respect to rotation and scale using the eye locations
  - Converts the image to floating point format
  - Embeds the image in a PCA subspace trained on face images

Step 3 – Extraction

- Extracting relevant information from image
- Face color? Position of eyes, mouth, nose? Between eyes ratio? Width-length ratio?
- Information must be valuable to the later step of identifying the subject
- “Reducing dimension”

Microsoft: Face API



Step 4 – Matching

- Template matching
  - Patterns are represented by samples, models, pixels, curves, textures. The recognition function is usually a correlation or distance measure.
- Statistical approach
  - Patterns are represented as features. The recognition function is a discriminant function.
- Neural networks
  - The representation may vary. There is a network function in some point.

Step 5 – Output

- Confidence:
  - Euclidian distance as match measure
  - Interval 0 (=bad match) to 1 (=perfect match)
  - Cca >0.6 to detect similarity
- Similarity value for comparing two templates
  - The higher value the more likely the same
  - Computed as -log(distance+1) where distance is the sum of the Euclidean distances between two face images
  - Smaller distances (Euclidean) indicate higher similarity

Automatic passport control

Biometric passports

- “Smart card”, contain NFC chip
- Two security levels:
  - BAC: Reading your photo+personal information (Try Android app Passport reader)
  - EAC: Reading your biometrics
    - Fingerprint, Face and Iris support.

Face impersonation

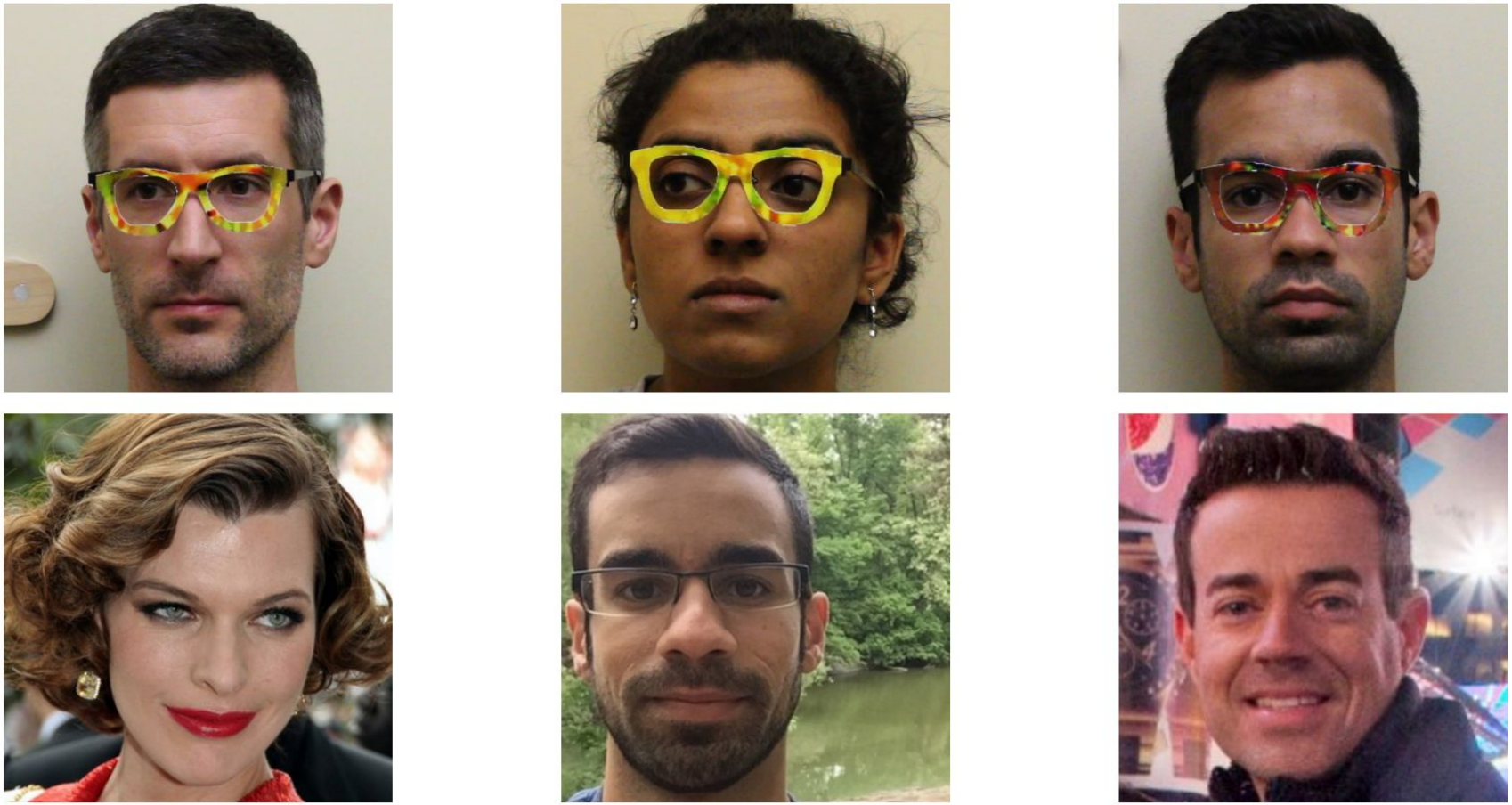


Photo © 2016 Carnegie Mellon University, *Accessorize to a Crime: Real and Stealthy Attacks on State-of-the-Art Face Recognition*

Face impersonation

- Fooling deep-neural-networks-based face recognition systems (e.g. Face++)
  - Over 90% success rate
  - The principle is more general
- *"physically realizable and inconspicuous"*

Sharif, Mahmood, et al. "Accessorize to a crime: Real and stealthy attacks on state-of-the-art face recognition." Proceedings of the 2016 ACM SIGSAC Conference on Computer and Communications Security. ACM, 2016.

Detecting sexual orientation from faces

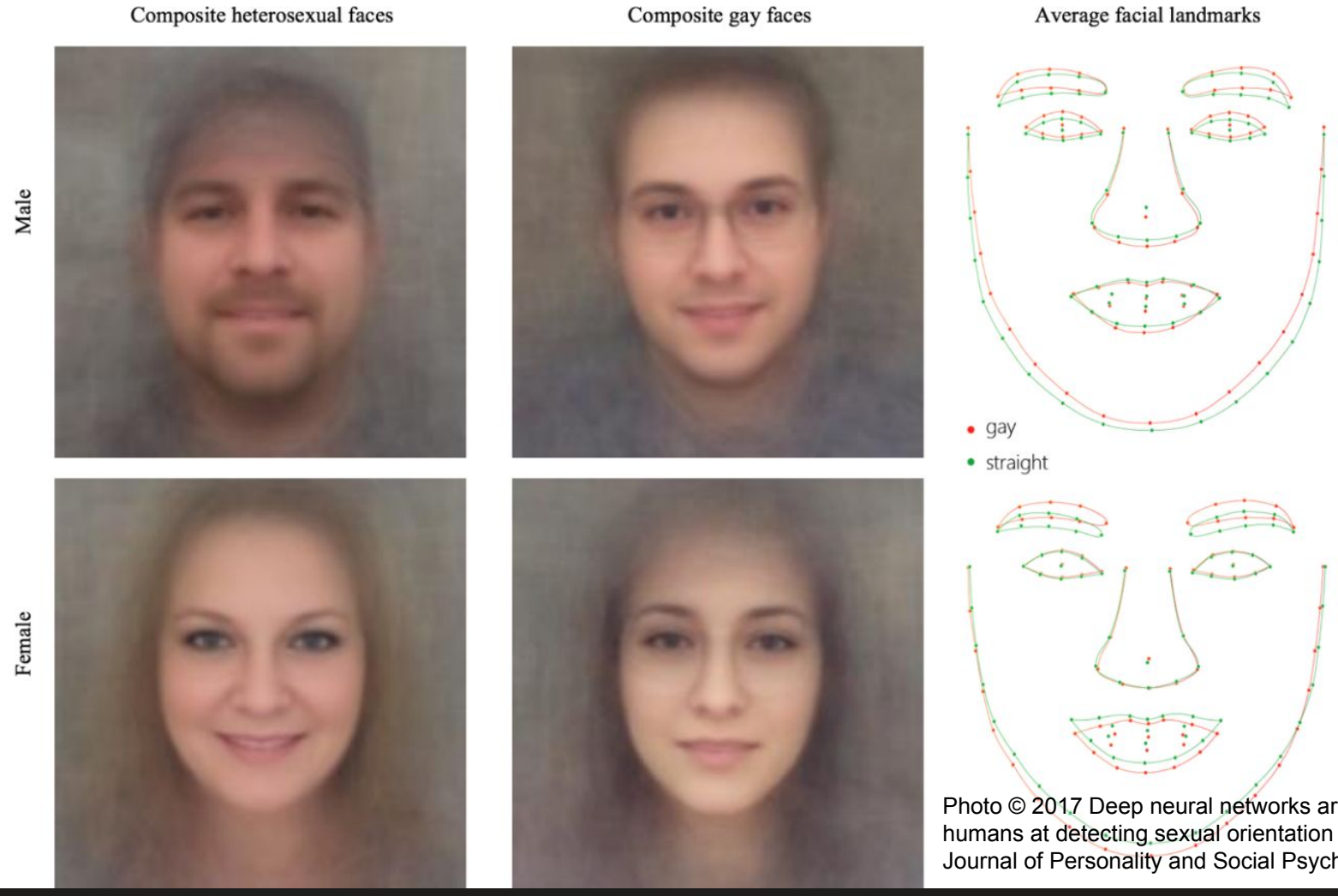


Photo © 2017 Deep neural networks are more accurate than humans at detecting sexual orientation from facial images. Journal of Personality and Social Psychology

Detecting sexual orientation from faces

- Classifying sexual orientation (straight vs. gay) on men/women photos
  - Human success: 61% / 54%
  - Neural networks: 81% / 71%
  - Neural networks (5 images): 91% / 83%
- May be a privacy issue!

Wang, Y., & Kosinski, M. (in press). Deep neural networks are more accurate than humans at detecting sexual orientation from facial images. Journal of Personality and Social Psychology.

Testing sets (databases)

- Many databases:
  http://www.face-rec.org/databases/
- Covering:
  - Aging
  - Ilumination
  - Pose
  - Expresion

Fun with biometrics

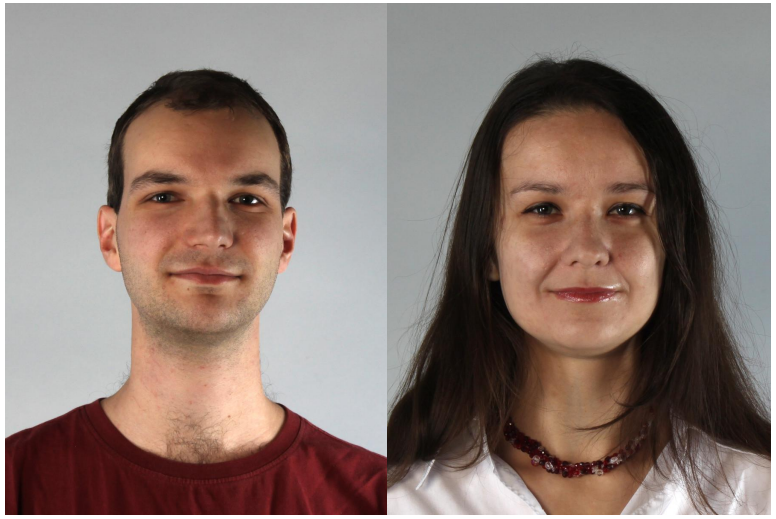
- Attractivenes measurement
  - https://www.howhot.io/
- InterSoB task
  - https://how-old.net/
  - Try to appear as old as possible

Photo © 2016 Dominika Krejčí, InterSoB

Seminar task

Exploring face matching in OpenBR

Seminar task



- Inspect what influences face recognition in OpenBR
  - http://openbiometrics.org/
- Use faces of the teachers to experiment
  - Compare images to “photoshopped versions” to determine what changes matter most
  - Be creative and playful!

Seminar task (tips)

- What can influence identification/age estimation?
  - Distance between eyes/mouth/nose/…
  - Light/colour differences (think CV Dazzle)
  - Wrinkles, hair style, general “smoothness”
  - “Transplanting” eyes/parts of other faces
- What is necessary to avoid face detection?
  - Deleting/covering an eye/mouth/…
  - Multiple eyes/mouths/...
  - Colour changes, wrong distance ratios

Seminar task (examples)

OpenBR invocation (prepared VM)

- Face recognition/comparison

```
br -algorithm FaceRecognition -compare me.jpg you.jpg
```

Approximately: similarity < 2 is different people, similarity > 3 is the same person

- Age estimation

```
br -algorithm AgeEstimation -enroll me.jpg meta.csv
cat meta.csv
```

- Gender estimation

```
br -algorithm GenderEstimation -enroll me.jpg meta.csv
cat meta.csv
```

- Documentation

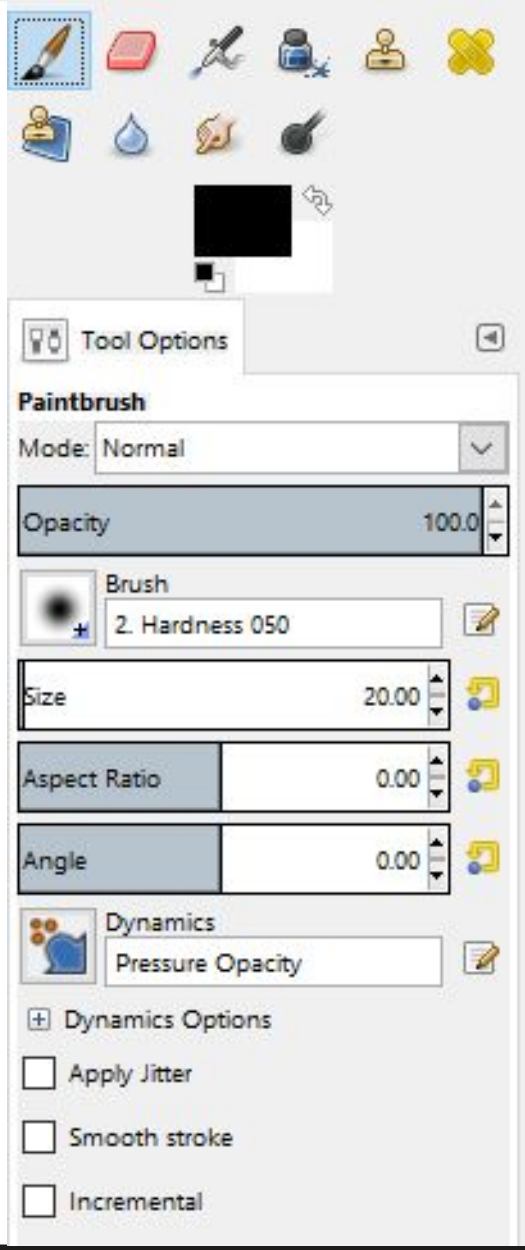
http://openbiometrics.org/docs/tutorials/#face-recognition

Prepared VM (details)

- .ova file at O:\pv181\pv181-biometrics1
- Import PV181-biometrics1.ova to VirtualBox
  - Import appliance (don't create a new machine)
- Boot the system
  - Ubuntu 16.04, login: 'vagrant', password: 'vagrant'
  - Images available in Documents
  - Everything necessary is already installed
  - You are sudo, in case you want to add something
- It's build with Vagrant
  - Vagrantfile available in study materials, if interested

GIMP basics

- Paintbrush tool
  - Shape, opacity, size
  - Mode (normal, darken, saturation, ...)
- Clone tool
  - Select source with Ctrl
- Smudge tool
- Others as you see fit...
- You may want single-window mode
  - Windows > Single-Window Mode

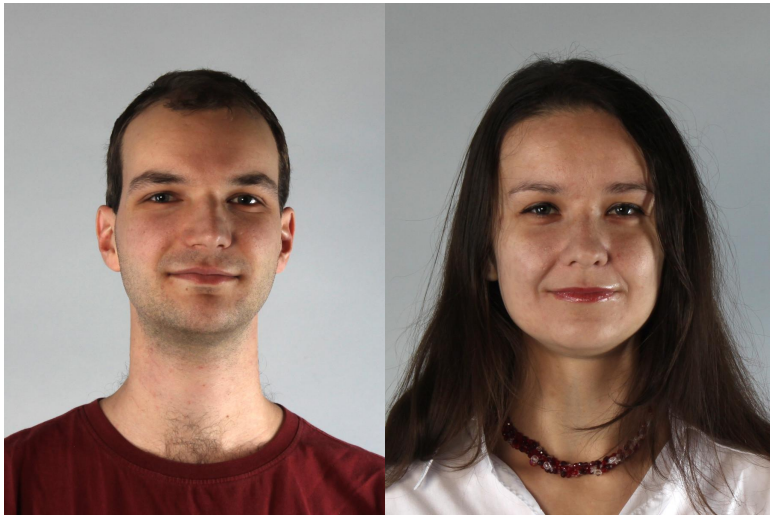


Homework

Exploring automatic age estimation

Homework: Overview

- Investigate what influences age estimation
  - In https://how-old.net/ (neural-networks based)
  - Adjust our pictures again
- Submit to homework vault **a single ZIP file** with
  - Report (PDF),
    see next slide
  - Used adjusted images
- Due date: 6. 12. 2017



Homework: Report

- Write a summarizing report
  - Your hypotheses and how you tested them
  - Test at least 5 distinct features
- Concentrate on:
  - Having a formulated hypotheses for each feature (e.g. smoother skin decreases estimated age)
  - Having several images supporting/falsifying your idea
- Avoid:
  - Many changes in the face at once
  - Radical changes (deleting half the face)
  - Overgeneralization