Computational pipeline for face analysis

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Outline

1. Applications of face analysis
2. Why is face analysis (relatively) easy?
3. Face analysis pipeline
4. What are we doing?
5. Future applications

Applications of face analysis

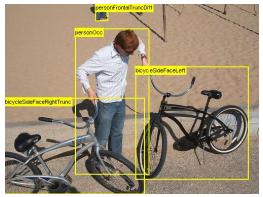
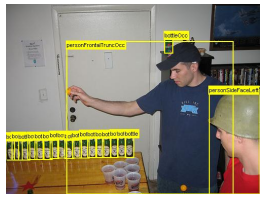
- Face recognition
- Gender estimation
- Ethnicity estimation
- Age estimation
- “Spacial” face similarity
  - Kin estimation
  - High/Low resolution face estimation
- Facial expressions

Why is face analysis (relatively) easy?

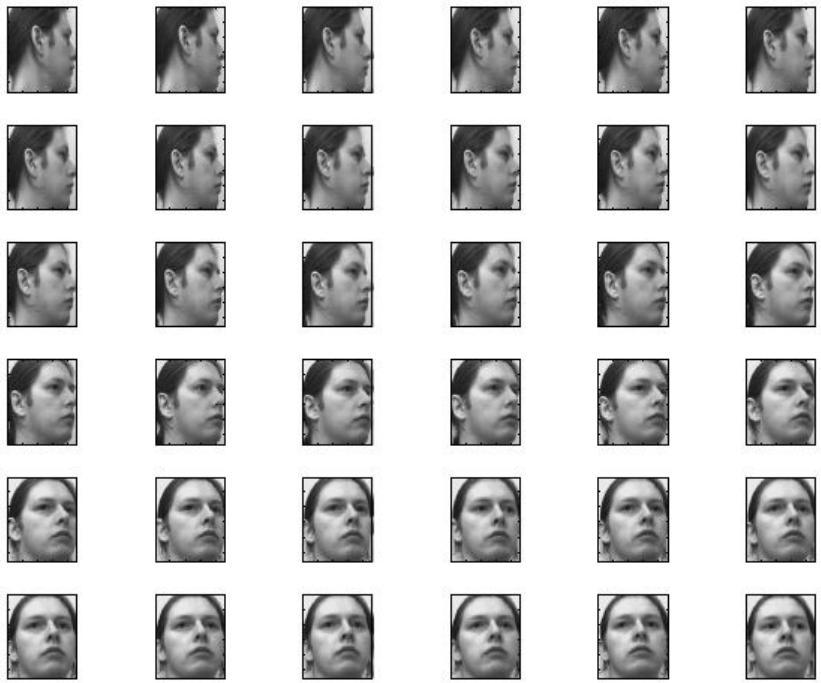
The most difficult attribute of visual recognition is the visual variability
Best detection results VOC 2007:

- Girshick et al. 2014: mAP of 53.3%
- Oxford VGG 16-layer network mAP of 66.0%

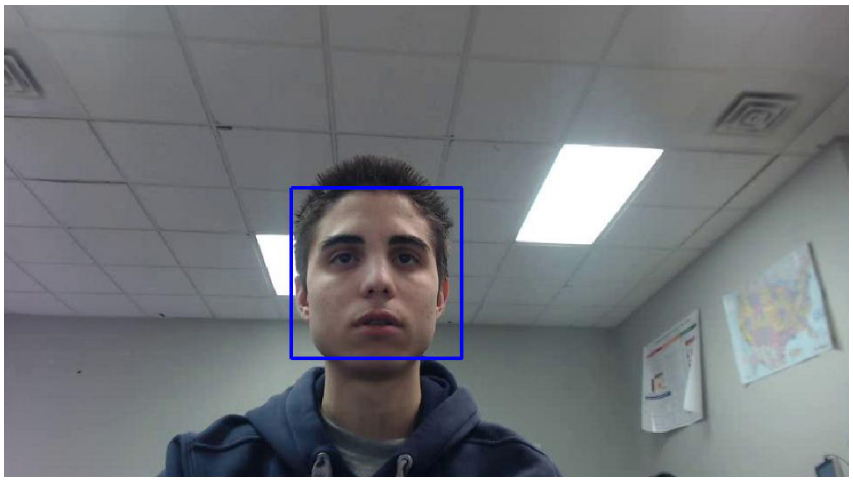


The variability of faces is mostly geometrical and parametric



Face detection



Classical work of Viola–Jones 2001:

- Fast and accurate
- Available in OpenCV and Matlab
- Can be improved using extra features
- Coarse estimate - “one size fits all”

Face alignment

”Supervised Descent Method and its Applications to Face Alignment”, Xiong and De la Torre, 2013
Very fast and accurate:

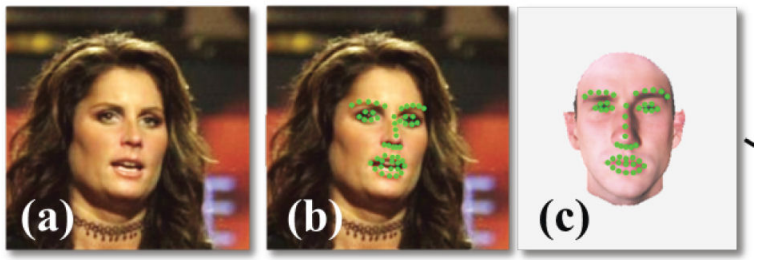
1. Compute (SIFT/Hog/LBP) descriptors at 49 points: $\mathbf{x}$
2. Regression: $\Delta = \mathbf{A} \cdot \mathbf{x}$

- The regression matrix is learnt.
- Runs at 60 FPS
- Extensions: regression tree and binary features
  - “Face Alignment at 3000 FPS via Regressing Local Binary Features”, Ren et al., 2014
  - “One Millisecond Face Alignment with an Ensemble of Regression Trees”,Kazemi et al., 2014

Our research: improve the convergence range
Show video

Pose estimation and 3D alignment

- Each point has a “name”
- Classical pose estimation: Perspective-n-Point problem (PnP)
  Posit



- Given the pose, the face image is rendered on the 3D model
- The 3D model can be rotated
- Missing parts added using symmetry
- Can be used for analysis

Face features

- Dense LBP, HOG, SIFT
- Face specific features: Weber Local Descriptor (WLD)
- Deep learning
  - Representation learning - requires a large training set
  - Task specific refinement

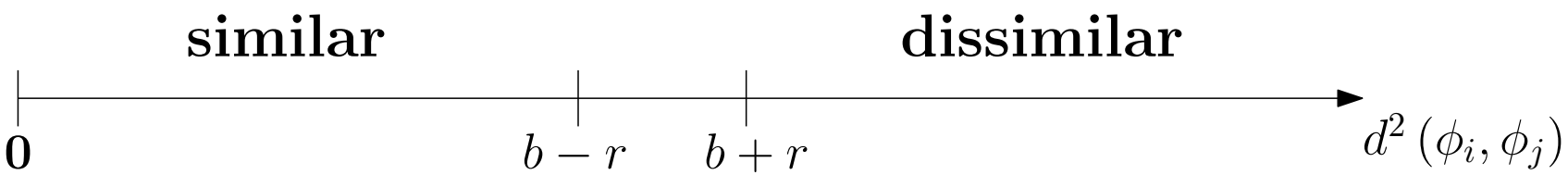
Distance learning I

Fisher Vector Faces in the Wild, Simonyan et al. 2013

- Can be applied directly
- The last layer in a deep network

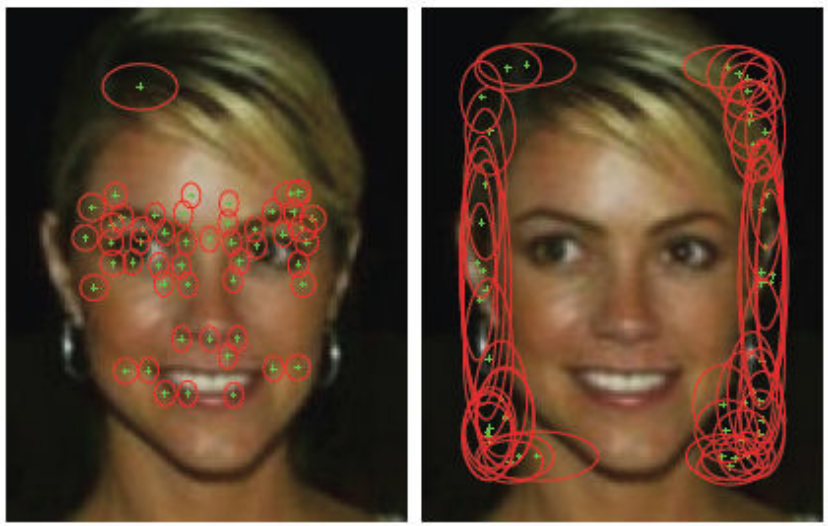
Learn a linear projection using margin maximization

$$d^2_{\mathbf{W}}\left(\boldsymbol{\phi}_i, \boldsymbol{\phi}_j\right) = \left\|\mathbf{W}\boldsymbol{\phi}_i - \mathbf{W}\boldsymbol{\phi}_j\right\|_2^2$$



Distance learning II

Activations for recognition (from *Fisher Vector Faces in the Wild*)

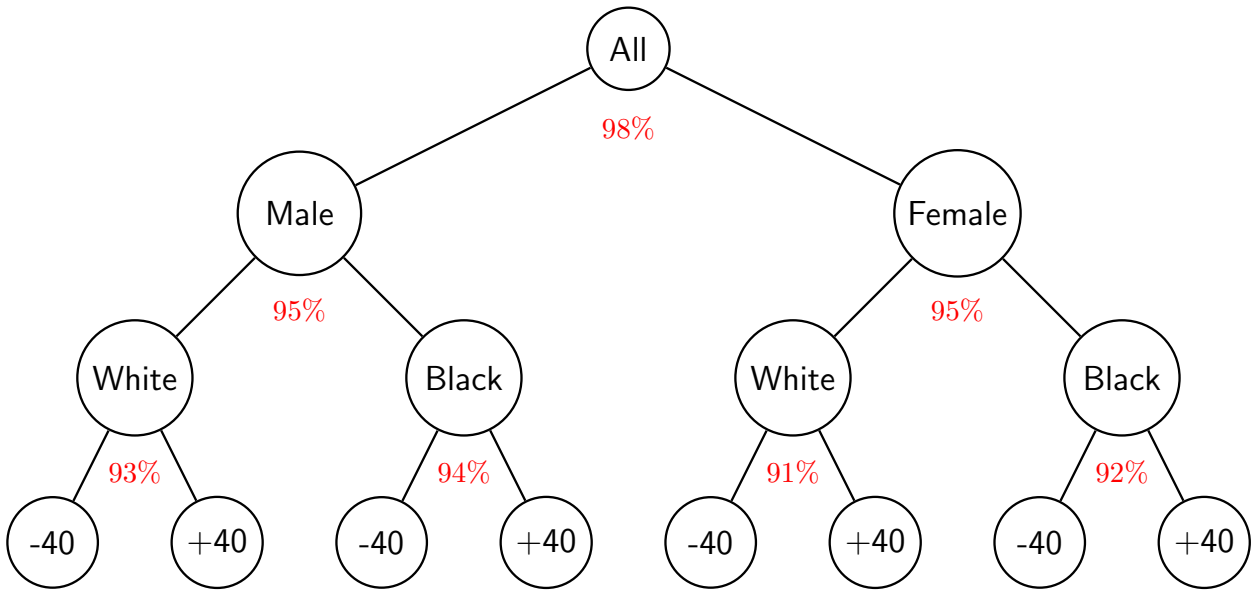


Application	**Same**	**Not same**	**Learning**	**Accuracy**
Verification	$name_i = name_j$	$name_i \neq name_j$	overfit	99%
Age estimation	$\lvert age_i - age_j \rvert \leq T$	$\lvert age_i - age_j \rvert > T$	generalization	3 years
Gender	$gender_i = gender_j$	$gender_i \neq gender_j$	generalization	98%
Ethnicity	$ethnicity_i = ethnicity_j$	$ethnicity_i \neq ethnicity_j$	generalization	98%

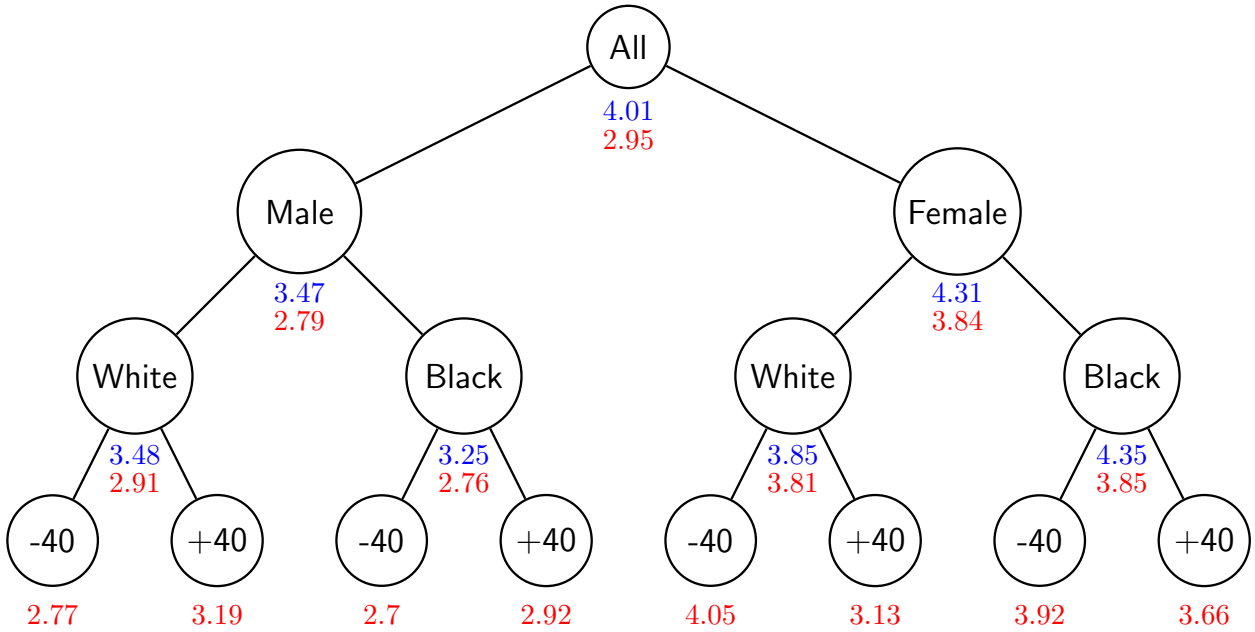
Face hierarchies I

- It is difficult to learn a classifier/regressor on a heterogeneous dataset
- Common solution - split data to folders and learn a set of classifiers/regressors
- Faces have a natural hierarchy based on: gender, ethnicity, age

Example of age estimation (Mor,Keller2014)



Face hierarchies II



Algorithm	MAE
KNN	6.26
PLS	4.56
KPLS (Guo 2011)	4.18

“Spacial” face similarity: non-identical twins I

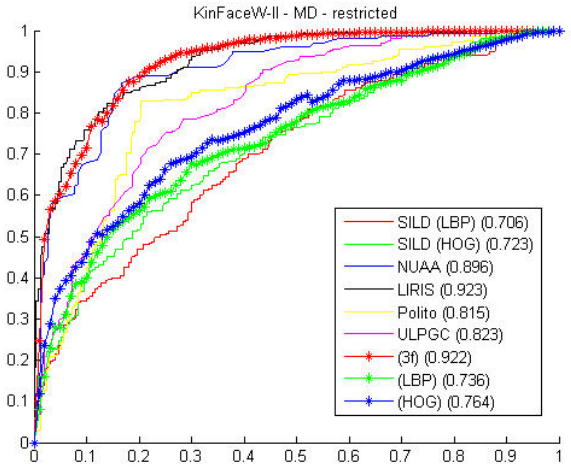
So far we considered

$$d^2_{\mathbf{W}}\left(\boldsymbol{\phi}_i, \boldsymbol{\phi}_j\right) = \left\|\mathbf{W}\boldsymbol{\phi}_i - \mathbf{W}\boldsymbol{\phi}_j\right\|_2^2$$

But, there are other problems

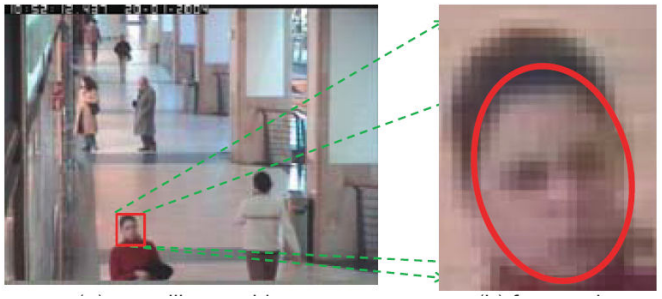
$$d^2_{\mathbf{W}}\left(\boldsymbol{\phi}_i, \boldsymbol{\phi}_j\right) = \left\|\mathbf{W}_o\boldsymbol{\phi}_i^o - \mathbf{W}_y\boldsymbol{\phi}_y^y\right\|$$

“Spacial” face similarity: non-identical twins II



Mahpod,Keller2015,FG2015

Similar problem



Yuen,Zou2012

But, we can use **multiple** low-resolution images

Future

- New technology - many potential applications
- Preprocessing infrastructure is important:alignment, frontalizations, features, etc.
- Some face analysis requires multiple images
- Temporal analysis: RNN, HMM
- Psychological analysis (“poker face”)