A BAG OF FACIAL SOFT BIOMETRICS FOR PERSON RECOGNITION

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OUTLINE

- What are Soft Biometrics?
- Person recognition a la Bertillon using soft biometrics
- A bag of facial Soft Biometrics (BoFSB)
  - General Setting
  - Novel questions regarding the BoFSB
  - Extraction of BoFSB
  - Reliability of a BoFSB for person recognition

WHAT ARE SOFT BIOMETRICS?

- Soft biometrics are weak biometric identifiers
  - Are not as permanent and distinctive as classical biometrics, but have several advantages, such as:
    - Can be sensed from a distance,
    - can be applied to unknown individuals,
    - do not require enrolment,
    - human compliant,
    - non intrusive, etc.
- Examples: eye or hair color, presence of glasses or beard
- Applications
  - **Person recognition**
  - Pruning the search for face recognition

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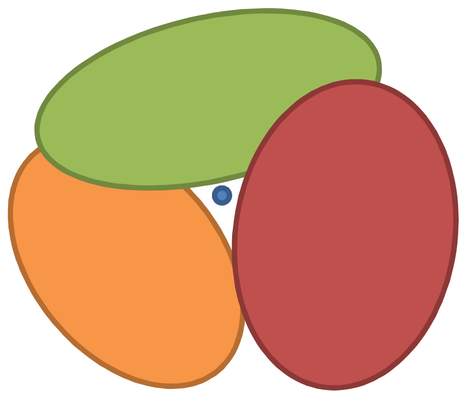
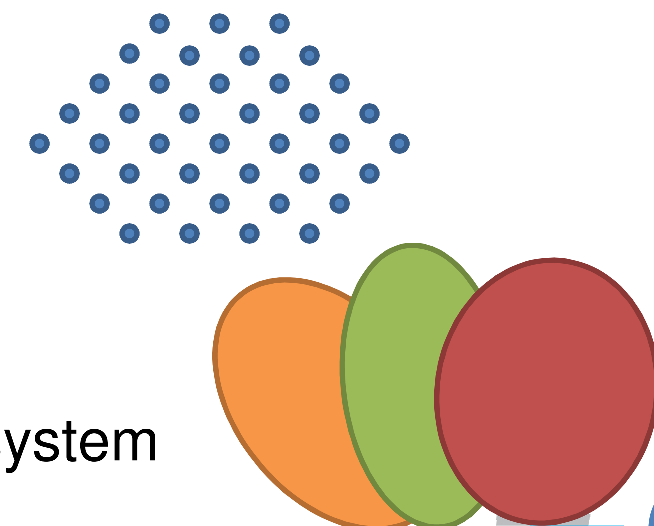
Person Recognition using soft biometrics
Primary idea: Bertillon, 19TH century



Subjects in an authentication group



- Size of authentication group

- λ...Number of *soft biometric traits*
- μ_i...*trait-instances*
- Number of overall categories the system is endowed with: $\rho = \prod_{i=1}^{\lambda} \mu_i$

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General Setting

- All over categories:
  - General:

$$\rho = \prod_{i=1}^{\lambda} \mu_i$$

  - Symmetric case:

$$\rho = \mu^{\lambda}$$

λ \ μ	2	3	4	5	6	7
2	4	9	16	25	36	49
3	8	27	64	125	216	343
4	16	81	256	625	1296	2401
5	32	243	1024	3125	7776	16807
6	64	729	4096	15625	46656	117649
7	128	2187	16384	78125	27993 6	823543

  - The all over categories number increases polynomially with the number of traits instances (e.g. color categories) and exponentially with the number of soft biometric traits (e.g. glasses, moustache, facial shapes,…)

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A Bag of Facial Soft Biometrics

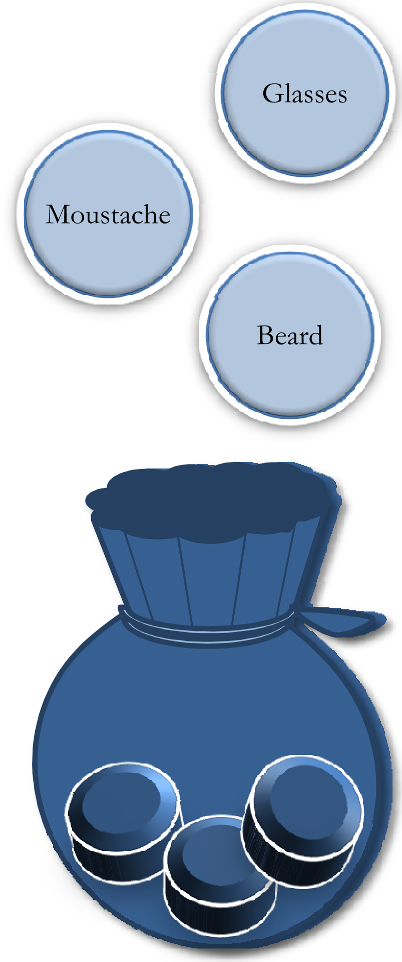
- Our bag of facial soft biometrics BoFSB includes the following six traits:
  - Hair color
  - Eye color
  - Skin color
  - Beard
  - Moustache
  - Glasses

European Project ACTIBIO

Unobtrusive authentication using ACTIvity related and soft BIOmetrics

www.actibio.eu

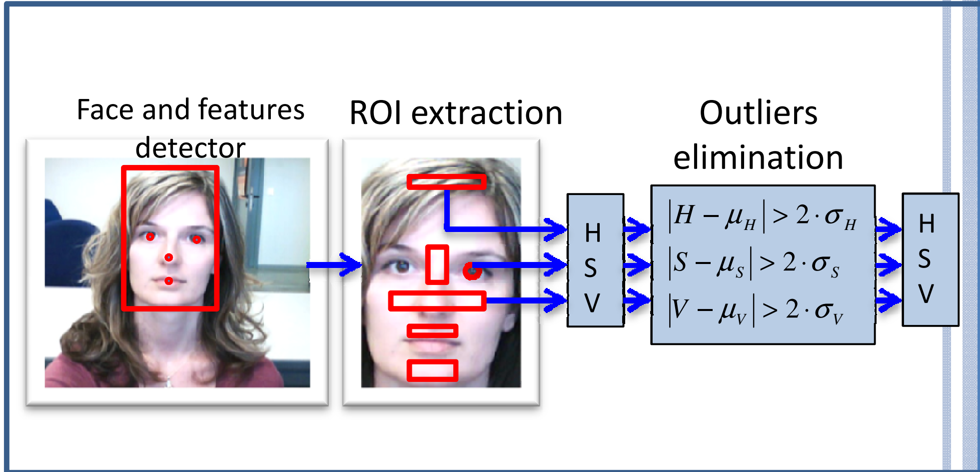
ACTIBIO



EXTRACTION

Viola & Jones Face and features detector

- Glasses: line detection between the eyes
- Color face soft biometrics: ROI finding and GMM color classification
- Beard and moustache: comparison of color of ROI's color with skin and hair color



Soft biometric trait	Algorithm	Traits instances
Skin color	Derived from [1]	3
Hair color	Derived from [2]	5
Eye color	Own developed	4
Beard	Own developed	2
Moustache	Own developed	2
Eye glasses	Derived from [3]	2

[1] P. Kakumanua, S. Makrogiannisa, and N. Bourbakis, "A survey of skin-color modeling and detection methods", *Pattern Recognition*, vol. 40, issue 3, March 2007.

[2] M. Zhao, D. Sun, and H. He, "Hair-color Modeling and Head Detection," in *Proc. WCICA*, 2008, pp.7773-7776.

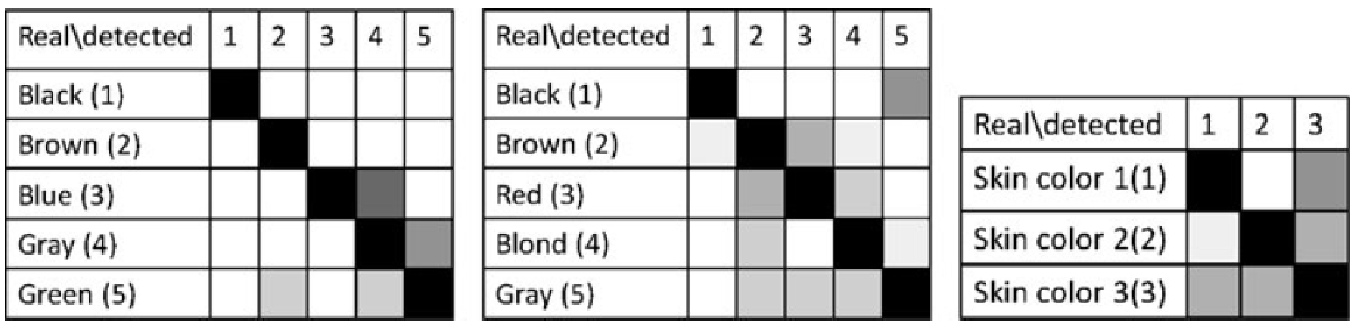
[3] X. Jiang, M. Binkert, B. Achermann, and H. Bunke, "Towards Detection of Glasses in Facial Images," *Pattern Analysis & Applications,* Springer London, vol. 3, pp. 9-18, 2000.

Results on FERET with the BoFSB

- Facial color soft biometrics

	Eye color	Skin color	Hair color
True positive rate	72.6%	79.2%	70.08%

  - Confusion matrices: Eye, Hair and Skin color:



- Facial binary soft biometrics

SB trait	Detection rate	FPR	FNR
Glasses	87.17%	7.17%	5.66%
Beard	80.7%	8.1%	11.2%
Moustache	72.8%	12.7%	14.5%

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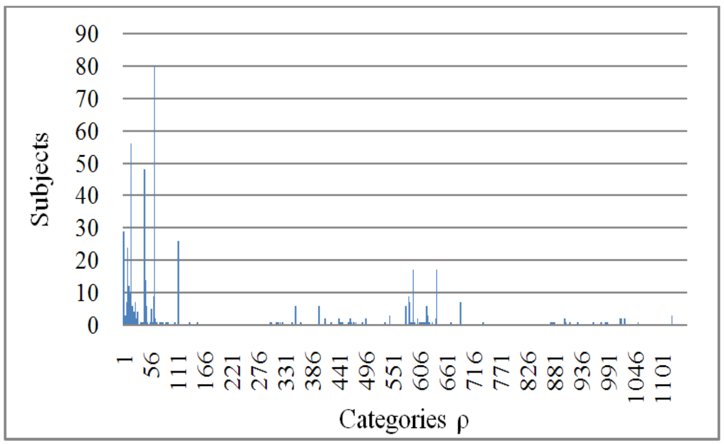
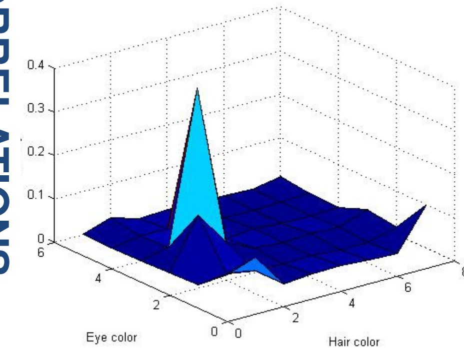
Correlations of FSB in the Feret Database

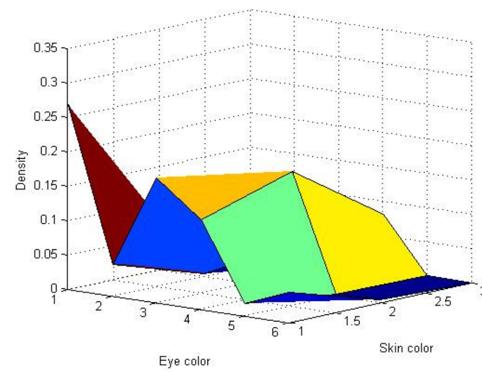
Pearson's correlation coefficients:

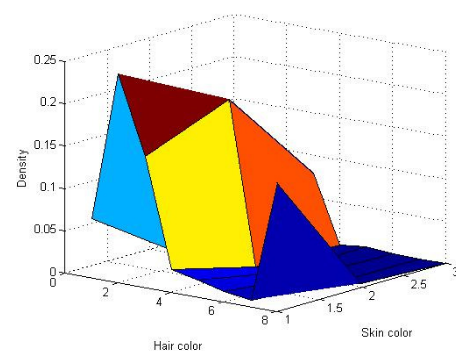
- r (eye, hair) = -0.1964
- r (eye, skin) = 0.3770
- r (hair, skin) = -0.1375
- r (moustache, beard) = 0.6359

Non – uniform distribution of categories









A BAG OF FACIAL SOFT BIOMETRICS FOR PERSON RECOGNITION

- Collision (=any two subjects belong to the same category) probability of subjects in a group of N:

  - p[N]… probability for collision within a group of N subjects

  - q[N]…probability of a specific person to collide with one of the N-1 subjects

BIRTHDAY PARADOX

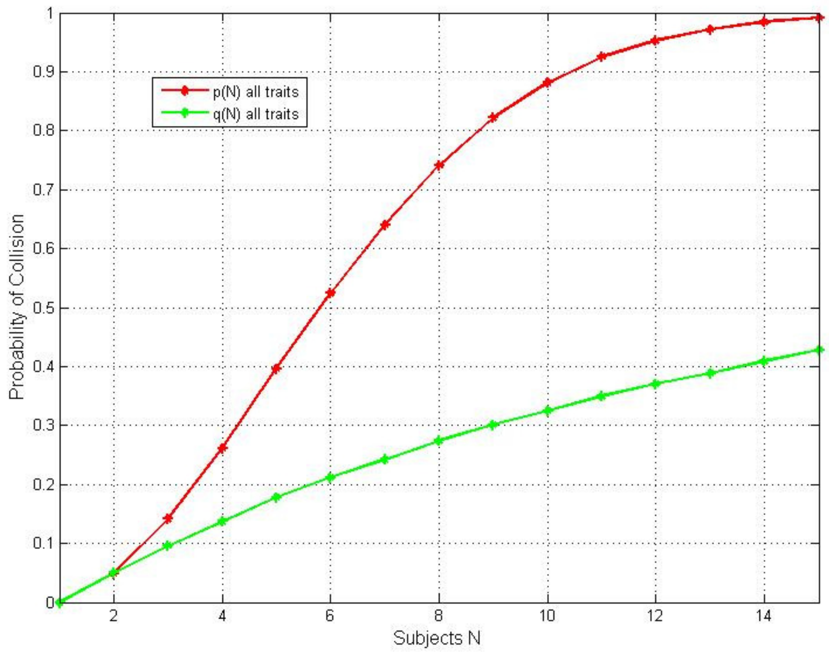
Birthday paradox:

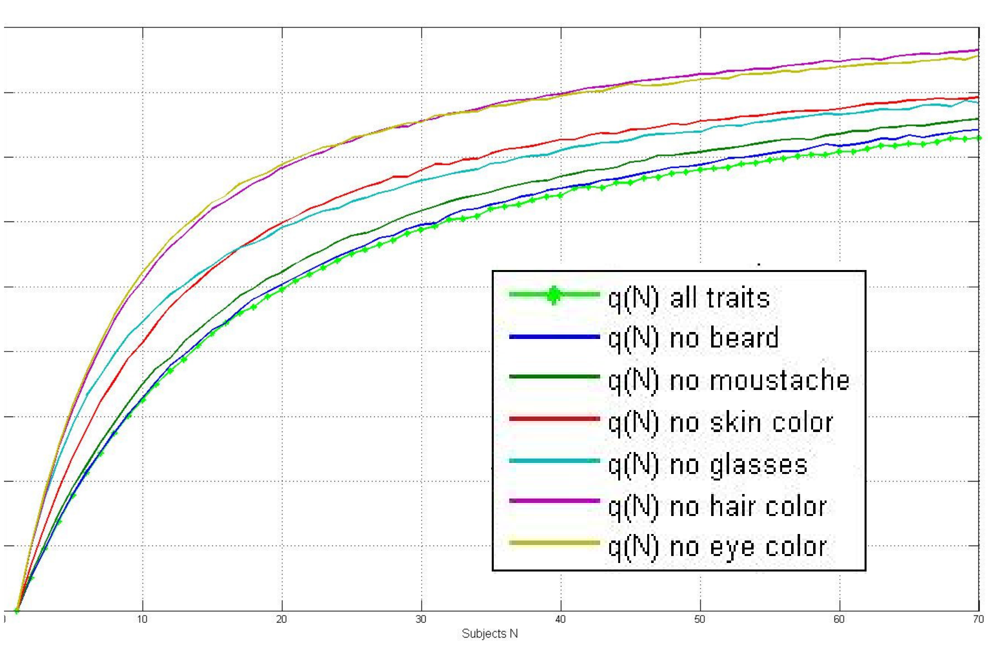
- p[N]… probability for collision within a group of N subjects
  - Uniform case: $$p(N;\rho) = 1 - \left(1-\frac{1}{\rho}\right)\left(1-\frac{2}{\rho}\right)\dots\left(1-\frac{N-1}{\rho}\right) = 1 - \frac{\rho!}{\rho^n(\rho-N)!}$$
  - Non uniform case: $$p(N;\rho) = 1 - \sum_{\alpha\neq\beta\neq\cdots\neq\omega} \mathrm{P}(\varphi_\alpha)\mathrm{P}(\varphi_\beta)\dots\mathrm{P}(\varphi_\omega)$$
- q[N]…probability of a specific person to collide with one or more of the N-1 subjects $$\mathrm{q(N)} = 1 - \left(\frac{\rho-1}{\rho}\right)^{\mathrm{N}}$$

A. DasGupta, "The matching, birthday and the strong birthday problem: A contemporary review" *Journal of Statistical Planning and Inference*, vol. 130 (1-2), pp. 377-389, March 2005.

S. E. Ahmed and R. J. Mcintosh, "An asymptotic approximation for the birthday problem," *Crux Mathematicorum*, vol. 26, pp. 151-155, Apr. 2000.

P(N) AND Q(N) FOR THE BAG OF FACIAL SOFT BIOMETRICS





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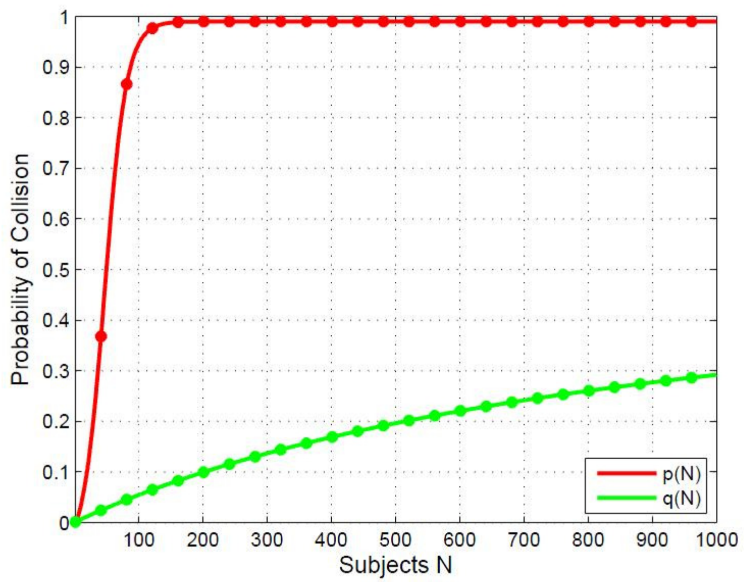
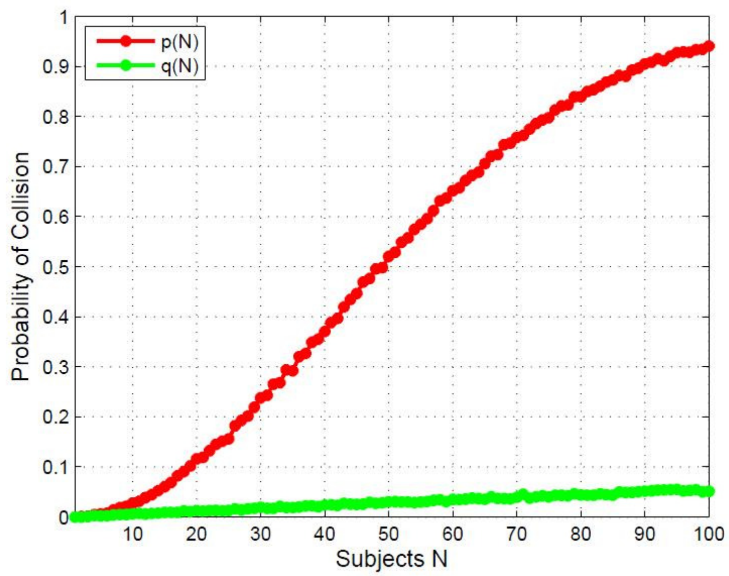
FULL BODY SOFT BIOMETRICS

- Creation of a virtual database containing face and body features. Body features were weight and color of clothes.





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RELIABILITY AND SCALING LAWS

- Effective categories
- Interference / Collision
- Reliability / Probability of error for the interference limited scenario
- Asymptotic bounds on interference

$$P(\text{err}|\text{v}) = 1 - \frac{F}{N}$$

	ϕ_1	ϕ_2	ϕ_3	F	$P(\text{err}|\mathbf{v})$
$\mathbf{v}_1$	10	1	1	3	3/4
$\mathbf{v}_2$	4	4	4	3	3/4
$\mathbf{v}_3$	10	2	0	2	5/6

- Annotation: v…N-tuple of subjects
  F…effective categories
  φ…specific category

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SUMMARY

- A. Dantcheva, C. Velardo, A. D'angelo, J.-L. Dugelay, “Bag of soft biometrics for person identification : New trends and challenges,” Mutimedia Tools and Applications, Springer, October 2010.
- A. Dantcheva, J.-L. Dugelay, P. Elia, “Person recognition using a bag of soft biometrics (BoFSB),” in Proc. of MMSP 2010.
- A. Dantcheva, J.-L. Dugelay, P. Elia, “Soft biometrics systems: Reliability and asymptotic bounds,” in Proc. of BTAS 2010.
- M. Ouaret, A. Dantcheva, R. Min, L. Daniel, J.-L. Dugelay, “BioFACE, a biometric face demonstrator,” in Proc. of ACM MM 2010.
- A. Dantcheva, N. Erdogmus, J.-L. Dugelay, “On the reliability of eye color as a soft biometric trait,” to appear in Proc. of WACV 2011.

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THANK YOU FOR YOUR ATTENTION