Bridging Gaps: An Application of Feature Warping to Online Signature Verification

Andreas Nautsch, Christian Rathgeb and Christoph Busch

Hochschule Darmstadt, CASED, da/sec Security Research Group

ICCST'14, Rome, 14.10.2014

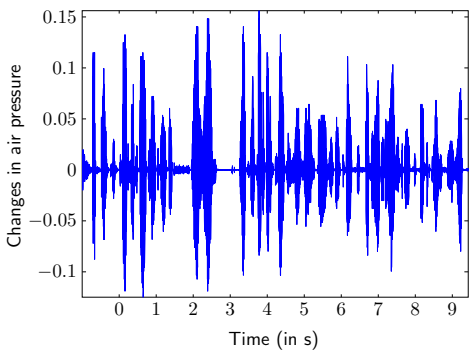
Outline

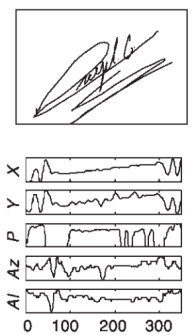
- Motivation: Processing Similarities to Speaker Recognition
- Feature Warping
- Experimental Evaluation
- Conclusion & Future Perspectives

Processing Similarities

Continuous-time source signals

- Source recognition: speaker or author
- Signals: voice, stylus coordinates, angles, pressure
- Examples: NIST SRE'12 ⇔ MCYT online signatures





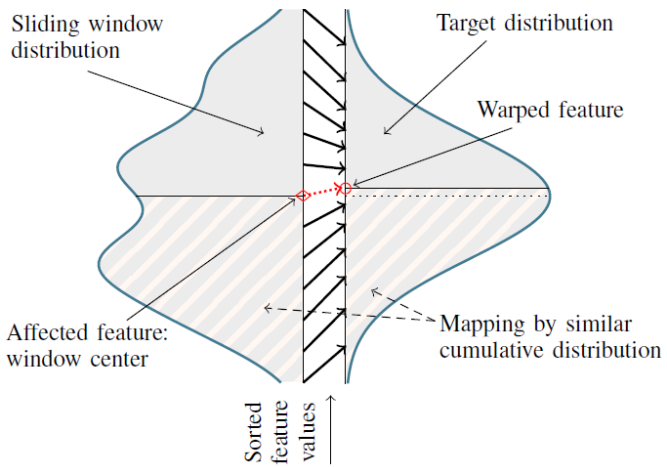
- Intra-class variance: *even if* all environmental conditions are similar, a re-captured sample would be different

Left: from A. Nautsch: *Speaker Recognition using i-Vectors*, M.Sc. thesis, Hochschule Darmstadt, 2014.
Right: from J. Ortega-Garcia et al.: *MCYT baseline corpus: a bimodal biometric database*, IEE Proceedings – Vision, Image and Signal Processing, 2003.

Feature Warping

Reducing intra-class variance

- Gaussian-distributed features
- Normalizing Features by mapping them into a standard Gaussian space



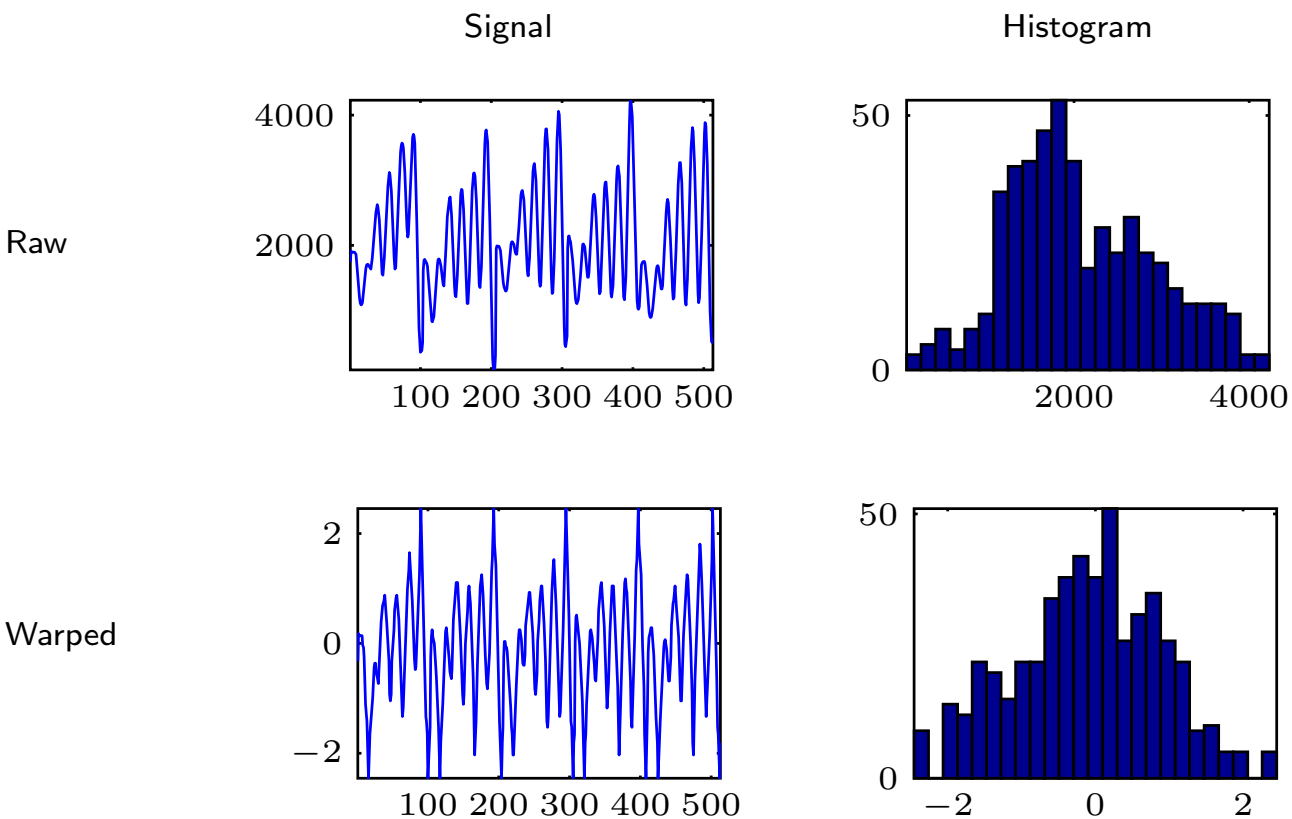
$$\frac{N_{\text{window}} - R_{\text{ank}} + \frac{1}{2}}{N_{\text{window}}} = \int_{-\infty}^{w_{\text{arped}}} \mathcal{N}(0,1)$$

Further reading: J. Pelecanos and S. Sridharan: *Feature Warping for Robust Speaker Verification*, ISCA 2001: A Speaker Odyssey — The Speaker and Language Recognition Workshop, 2001.

Feature Warping

Effects on MCYT online signature database

- Example on x-coordinate signal of subject *0000*
- Concatenation of first 5 genuine samples



Experimental Evaluation

Database & set-up

- MCYT online signature database
  - 330 subjects
  - 10 enrolment samples
  - 15 genuine samples $\Rightarrow$ 4935 random forgeries/subject
  - 5×5 skilled-forgery samples $\Rightarrow$ 25 samples/subject
- Gaussian Mixture Models & Universal Background Model

  GMM – UBM comparison
- 18 extracted features

1.	x coordinate	7.	pen-top x velocity	13.	curvature acceleration
2.	x velocity	8.	pen-top x acceleration	14.	azimuth
3.	x acceleration	9.	inst. displ. vel.	15.	pen-top y coordinates
4.	curvature velocity	10.	y coordinate	16.	pen-top y velocity
5.	altitude	11.	y velocity	17.	pen-top y acceleration
6.	pen-top x coord.	12.	y acceleration	18.	pen-top inst. displ. vel.

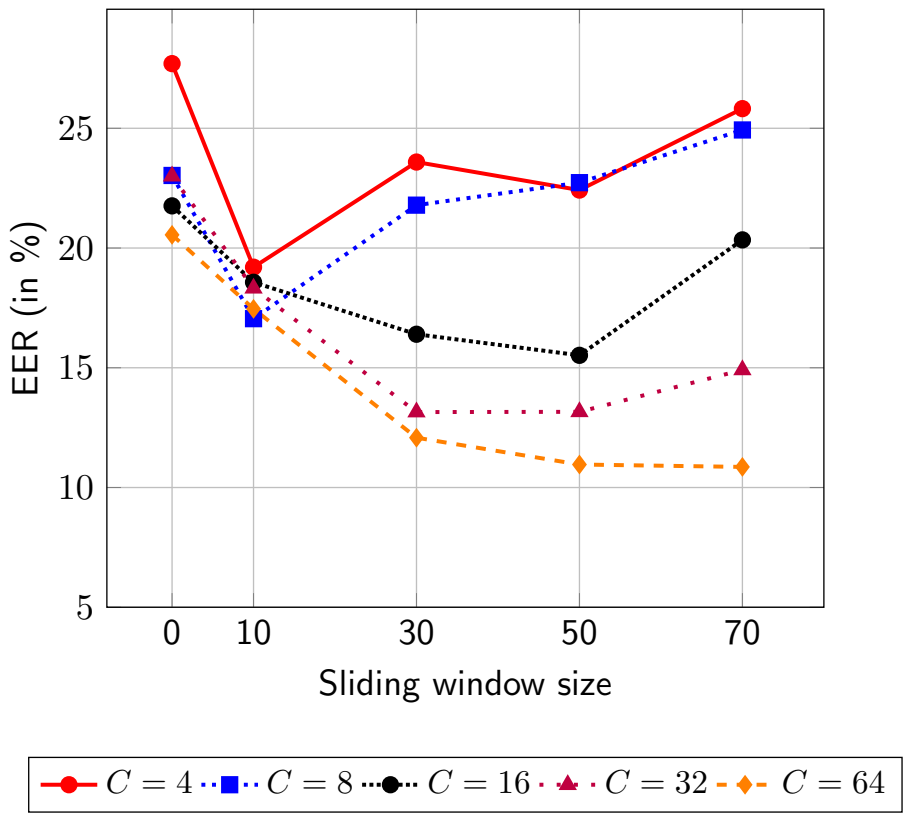
Evaluation metrics

- Biometric performance accoding to ISO/IEC IS 19795-1
  - False Match Rate (FMR): *falsely positive matched impostors*
  - False Non-Match Rate (FNMR): *falsely non-matched genuines*
  - Equal-Error-Rate (EER): *error rate of FMR = FNMR*
- Forensic evidence
  - Empirical Cross-Entropy (ECE)
    - Given prior odds of impostor attacks, Bayesian thresholds can be denoted
    - Score-level cross-entropy measures the evidence obtained from a recognition system's Likelihood Ratio (LR) scores
  - Focus on well-calibrated systems

Experimental Evaluation

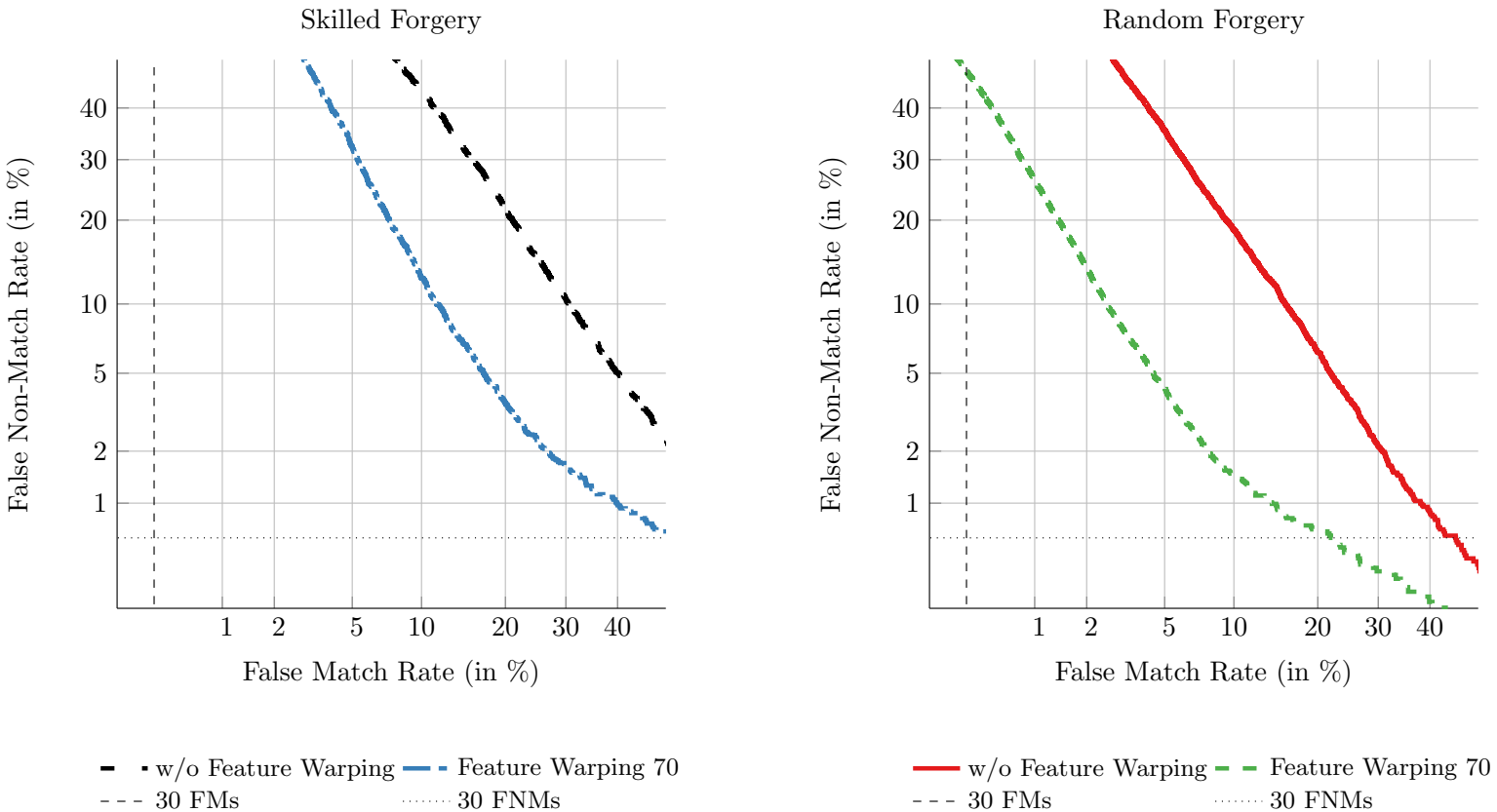
Effect of the size of a sliding window

- Examining EERs depending on amount of UBM components (C)



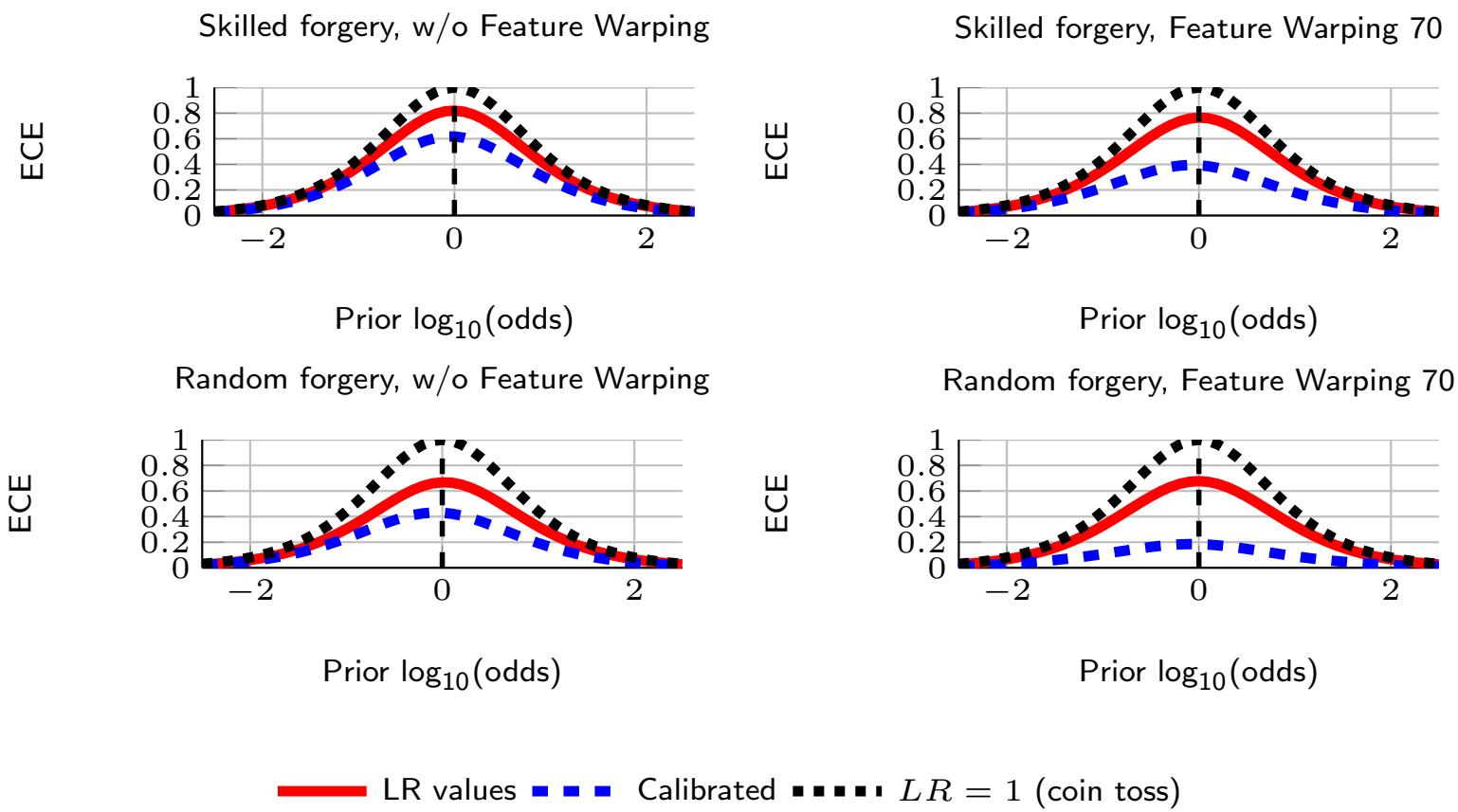
Experimental Evaluation

Biometric performance



Experimental Evaluation

Score cross-entropy



Further reading: D. Ramos and J. Gonzalez-Rodriguez: *Cross-entropy Analysis of the Information in Forensic Speaker Recognition*, IEEE Odyssey, 2008.

Conclusion & future perspectives

- Successful proof-of-concept
- Feature Warping reduces intra-class variations effectively for GMM-based comparisons
- Limits
  - Evaluation on only 18 features
  - Not evaluated on state-of-the-art systems (yet)
  - Pressure features were not in the feature set
  - Instead of pressure features: *pen-top* features
- Impact analysis on state-of-the-art features & comparators
- Further transmodality experiments e.g., identity-vector features (i-vectors) & Probabilistic Linear Discriminant Analysis comparison (PLDA)

Thank you.

Any Questions?