Entropy-Based ECG Biometric Identification

João M. Carvalho, Susana Brás, Armando J. Pinho

IEETA/DETI, University of Aveiro, 3810–193 Aveiro, Portugal

Introduction

- There is a trend in biometrics to use the ECG signal for personal identification;
- Compression models have shown to be suitable for that application;
- We propose a compression-based non-fiducial method that uses a measure of similarity related to the Kolmogorov complexity of strings, called the Relative Normalized Compression;
- For obtaining those metrics we use extended-alphabet finite-context models (xaFCMs) on the quantized first-order derivative of the signal.

Method

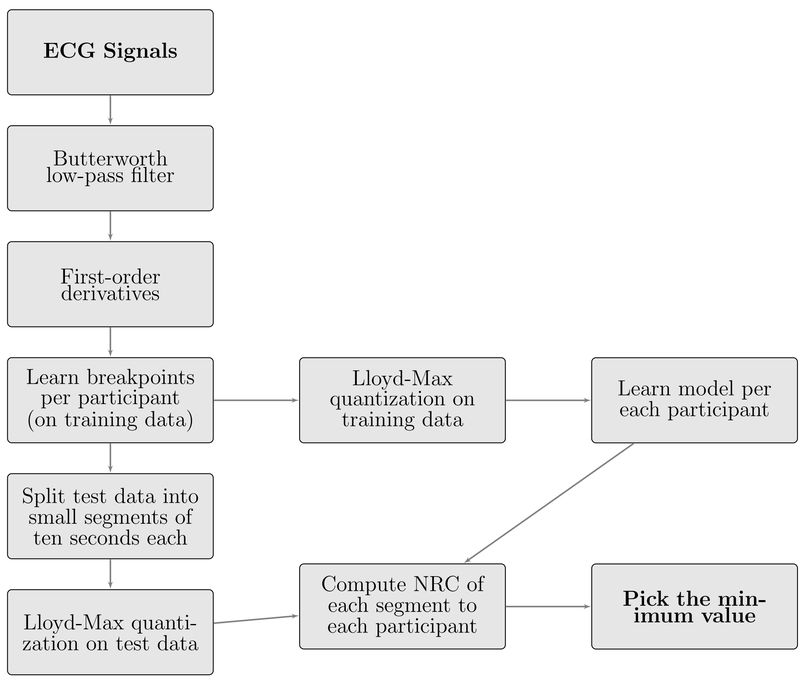

Fig. 1 Overview of the method used in this work.

The parameters/methods used were:

- Butter-Worth low-pass filter of 5th order at 30Hz to pre-process the signals;
- Quantization to an alphabet size of 17 on the consecutive differences;
- For the xaFCMs, context size $k = 35$ and depth $d = 2$.

Normalized Relative Compression

$$\mathrm{NRC}(x||y) = \frac{C(x||y)}{|x| \log_2 |\mathcal{A}|}. \tag{1}$$

Extended-Alphabet Finite-Context Models

$$-\log_2 P(X_i = t_i | x_{id-k}^{id-1}) \text{ bits}, \tag{2}$$

After processing the first n symbols:

$$-\sum_{i=1}^{n/d} \log_2 P(t_i | x_{di-k}^{di-1}), \tag{3}$$

Dataset

- Collected at the University of Aveiro and publicly available for research;
- Once per week, with 25 participants, using a different stimulus per day;
- Sampled at 1000Hz, using the MP100 system and the software AcqKnowledge (Biopac Systems, Inc.);
- During the preparation phase, the adhesive disposable Ag/AgCL-electrodes were fixed in the right hand, as well as in the right and left foot.

Results

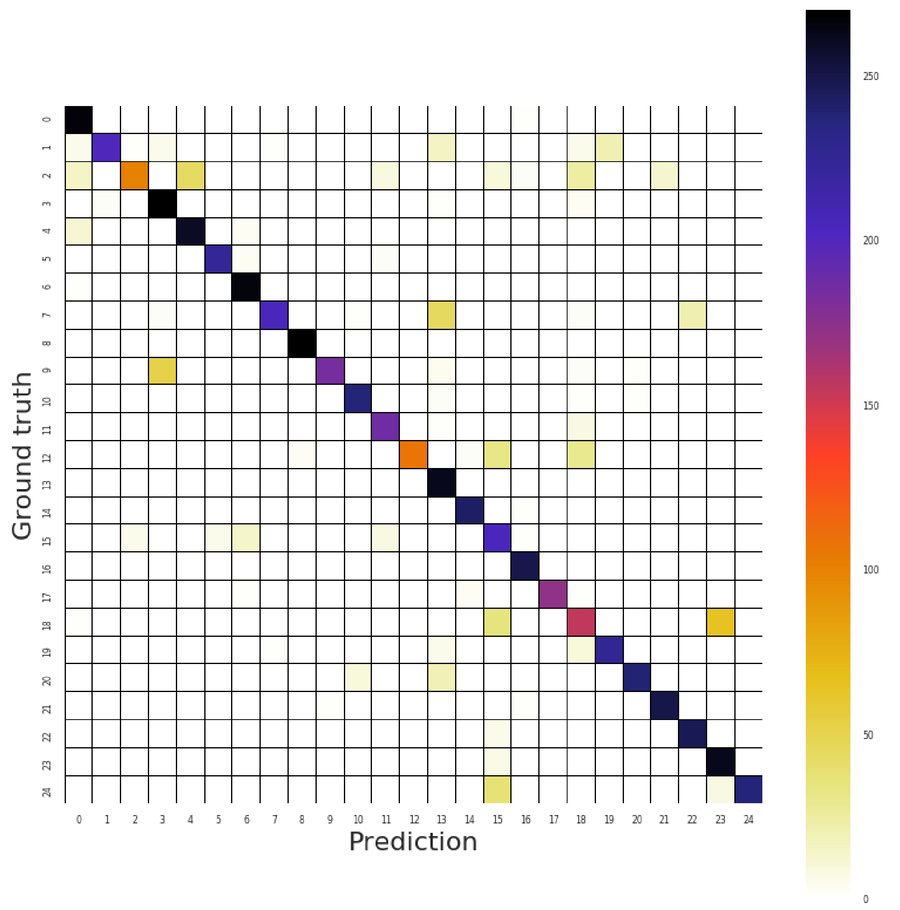

Fig. 2 Confusion matrix for biometric identification using a xaFCM of context $k = 35$ and depth $d = 2$. This test used two days for training and the other day for testing. Each test was performed using 10 seconds of ECG. This experiment achieved an accuracy of 88.5% and F1-score of 0.88.

Final Remarks

We have proposed a compression-based non-fiducial method that works with first order derivatives for performing ECG biometric identification. This method beats previous state-of-the-art methods using this database, achieving an accuracy of 89.3%.

References

[1] Brás, S., Ferreira, J. H. T., Soares, S. C., and Pinho, A. J. Biometric and emotion identification: An ecg compression based method. *Frontiers in Psychology 9* (2018), 467.

[2] Carvalho, J. M., Brás, S., Ferreira, J., Soares, S. C., and Pinho, A. J. Impact of the acquisition time on ecg compression-based biometric identification systems. In *Pattern Recognition and Image Analysis. IbPRIA 2017. Lecture Notes in Computer Science, vol 10255. Springer, Cham* (jun 2017), Springer, Cham, pp. 169–176.

[3] Carvalho, J. M., Brás, S., and Pinho, A. J. Compression-based classification of ecg using first-order derivatives. In *Intelligent Technologies for Interactive Entertainment* (Cham, 2019), P. Cortez, L. Magalhães, P. Branco, C. F. Portela, and T. Adão, Eds., Springer International Publishing, pp. 27–36.

[4] Carvalho, J. M., Brás, S., Pratas, D., Ferreira, J., Soares, S. C., and Pinho, A. J. Extended-alphabet finite-context models. *Pattern Recognition Letters 112* (sep 2018), 49–55.

[5] Karimian, N., Wortman, P. A., and Tehranipoor, F. Evolving authentication design considerations for the internet of biometric things (iobt). In *Proceedings of the Eleventh IEEE/ACM/IFIP International Conference on Hardware/Software Codesign and System Synthesis - CODES '16* (2016).

[6] Li, M., and Vitányi, P. *An introduction to Kolmogorov complexity and its applications*, 3rd ed. Springer, 1997.

[7] Pinho, A. J., Pratas, D., and Ferreira, P. J. S. G. Authorship attribution using relative compression. In *Data Compression Conference* (2016).

Acknowledgements: This work was funded by national funds, European Regional Development Fund, FSE through COMPETE2020, through FCT, in the scope of the framework contract foreseen in the numbers 4, 5 and 6 of the article 23, of the Decree-Law 57/2016, of August 29, changed by Law 57/2017, of July 19; and in the scope of the projects UIDB/00127/2020 (IEETA/UA). João M. Carvalho acknowledges the doctoral grant from FCT, ref. SFRH/BD/136815/2018.