Biometric Identification of Individuals based on ECG
Which Conditions?

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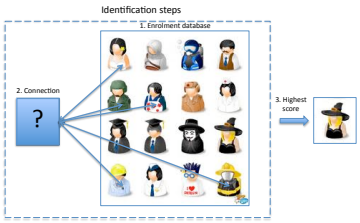
Abstract: Biometric systems have for objective to perform identification, or identity verification, of individuals. Human ECG has been recently proposed as an additional tool for biometric applications. However, most of the existing studies are set in supine rest and only consider the QRS morphology after, most of the time, feature extraction from the ECG. This paper is focused on identification based on pattern recognition by comparing ECG shapes. Experiments were conducted on a database containing 11 healthy subjects, recorded in three different experimental conditions (supine rest, standing, exercise) and repeated up to four times, over 16 months. We calculate the correlation coefficient between a shape coming from an unknown individual and all the shapes of the database. We also evaluate the influence of the recording condition, the shape length and the number of leads. Best results (100% of good identification in the first rank) are obtained using the whole enrolment database, 12 leads and a shape length of 500 ms.

Identification task

General system



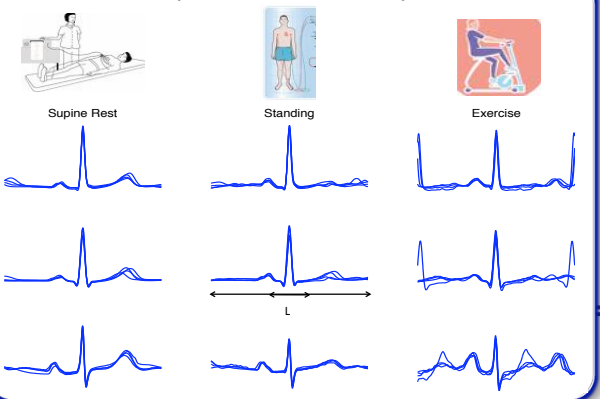
Specific questions related to ECG

- Is supine rest condition necessary?
- Is there an optimal enrolment database?
- What is the influence of others parameters (ECG shape length, number of leads)?

Database and Protocol

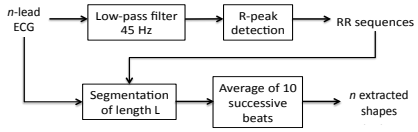
- 11 healthy subjects
- 12-lead ECG, f_e=1 kHz
- From 2 to 4 records/subject
- Up to 16 months
- 5 min supine rest (not recorded)
- 3 min supine rest (R)
- 3 min standing (S)
- 3 min exercise (E)

Examples of recorded ECG for 3 subjects



Methodology

Shape Extraction



Identification process

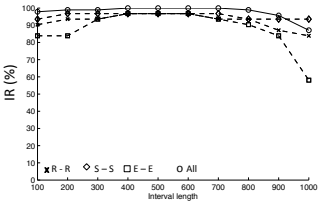
- One-to-many comparison
- Correlation coefficient (up to 12)
- Max value = “the nearest neighbour”

Criteria of performance

Percentage of good identification
= Identification Rate (IR)

Results using 12 leads

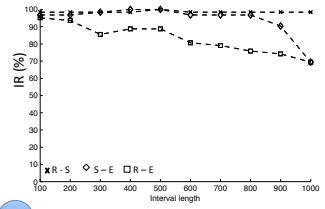
Intra-condition case



1
- Performances are close and high up to L = 900
- Slightly higher values of IR are observed in the case S - S
- The optimal value of L is between 400 and 600
- In the case E - E, values of IR are the lowest and are breaking down when L = 1000

There is no requirement or advantage to limit ECG-based biometric systems to the rest condition, as classically done

Inter-conditions case



2
- Values of IR are globally decreasing when L is increasing
- Decrease is low for R - S whatever L and for S - E up to L = 800
- For R – E, performances are really decreasing as soon as L > 500

Still good results if conditions are different (R – S or S – E)

3 Highest performances are obtained in the "All-conditions" case

Optimal enrolment: several conditions

Influence of the number of leads

Motivation

- It is difficult to collect 12-lead ECG!
- Is an efficient single-lead system possible?

Table 1. IR (%) as a function of the number of leads (n = 1, 3, 6, 12) and the interval length (L = 100, 500, 1000).

	n	All	Intra R - R	Intra S - S	Intra E - E	Inter R - S	Inter S - E	Inter R - E
L = 100	1	89.8 ± 3.9	75.8 ± 13.1	75.0 ± 8.1	75.5 ± 10.4	80.9 ± 7.6	75.0 ± 8.2	80.6 ± 5.3
	3	97.4 ± 2.3	86.3 ± 6.4	84.8 ± 5.0	85.0 ± 6.2	92.5 ± 4.5	93.4 ± 6.6	91.4 ± 5.4
	6	98.6 ± 1.4	89.1 ± 3.5	90.2 ± 2.3	86.9 ± 5.0	97.0 ± 2.6	97.0 ± 3.0	92.6 ± 5.1
	12	97.8	90.3	93.5	83.9	98.4	96.8	95.2
L = 500	1	91.4 ± 4.3	81.2 ± 11.4	76.1 ± 4.5	81.5 ± 9.2	83.1 ± 5.6	80.1 ± 7.5	57.8 ± 9.5
	3	98.2 ± 2.1	91.2 ± 4.6	90.7 ± 4.1	92.4 ± 4.7	94.0 ± 4.5	93.0 ± 5.5	76.0 ± 10.9
	6	99.4 ± 0.8	94.5 ± 3.4	95.0 ± 2.5	95.9 ± 3.3	97.6 ± 2.8	96.3 ± 3.5	83.6 ± 8.6
	12	100	96.8	96.8	96.8	100	100	88.7
L = 1000	1	68.4 ± 6.5	67.5 ± 10.8	65.6 ± 11.1	51.6 ± 5.4	68.4 ± 9.1	43.5 ± 6.2	41.5 ± 6.7
	3	82.3 ± 4.6	82.1 ± 7.2	82.7 ± 8.2	56.8 ± 2.3	84.9 ± 7.0	60.4 ± 8.5	57.6 ± 7.6
	6	85.9 ± 2.2	86.2 ± 2.9	89.0 ± 5.3	57.7 ± 1.0	93.1 ± 4.7	67.1 ± 6.5	64.3 ± 5.8
	12	87.1	83.9	93.5	58.1	98.4	69.4	69.4

- Best results are obtained with 12 leads
- Performances always increase with the number of leads
- Only low differences are observed between 6 and 12 leads
- The gain between 1 and 3 leads is high

Using 3 or 6 leads seems preferable than only one lead

References

Biel L, Pettersson O, Philipson L, Wide P. ECG analysis: A new approach in human identification. IEEE Trans Instrum Meas 2001; 50(3):808-12.

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