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Adding Sound to ECG

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Abstract

This poster presents preliminary results of a project aiming to develop tools for adding sound associated to medical data for potential medical applications. Sonification procedures, the methodology used for testing various sonic representations of ECG, and the results are presented.

Keywords:
Sonification; Data representation; ECG; Discriminant power.

Introduction

The use of sonification for representation of medical data, especially biosignals is not a new idea [1], but most previous work has limited approaches. A systematic study has yet to be completed, due to the diversity of methods to "sonify" a set of data. From this premise, we initiated a project: “Adding Sound to Medical Data”, with four steps [2]:

- preparing the sonification tools and methodology;
- testing the discriminant power of various sets of parameters;
- developing the procedure for clinical application;
- development of sonification modules for medical equipment.

This paper refers only to the first two phases.

Methods

The first stage aimed to reduce the degree of arbitration in mapping the physical parameters of the original signal (data).

Sonification procedures

In our approach [3], the relation between the sound pitch (f_i) and normalized data [0,1] of signal amplitude y_i was:

$$f_i = f_0 \times 2 \wedge (y_i),\ f_0 = 523.25 \text{ Hz (note C5)} \qquad (1)$$

Three major sonification levels could be defined:

- acoustic level, with a continuous frequency spectrum (f);
- sonic level (S) – with discrete spectrum, from musical scale;
- musical level (M) – multichannel, introducing rhythm and harmony. Level M will not be referred to in this paper.

We split the acoustic level into two (sub)levels:

- *continuous* representation, called (sub)level (A): for two neighbor points (t_i, f_i) and (t_{i+1}, f_{i+1}), the frequency will vary continuously from f_i to f_{i+1};
- *quasicontinuous* (sub)level (Q) representation: only the frequency f_i will be produced for the interval dt = (t_i, t_{i+1}), followed by f_{i+1} for the next interval dt , etc.

We used signals from PhysioBank [3] (sampling rate 250 Hz) from both healthy subjects and from patients with sleep apnea, arrhythmia and congestive heart failure. Additionally, we built a tool similar to a lens - tempolens, (TL) able to dilate or compress temporal sonic display, with fixed (f) or variable (v) magnification [2].

Results and Discussions

Computer programs

Our package was built on MATLAB R2011b platform, for sonifying a signal in levels A, Q and S and applying tempolenses. An example of the screen produced for an ECG signal of 10 seconds and the sounds can be displayed by accessing reference [4].

Discriminant power

We tested the discriminant power (the capacity of listeners to distinguish details and recognize signals). Our results showed:

- low preference for A mode (it sounds like a whistle), but had a high discrimination in sleep apnea (obstructive episodes);
- tempolenses with variable magnification did not bring the expected increase in resolution of the QRS complex;
- durations of 0.2 seconds or less in Q mode sounded like A.

Conclusions

We built and tested a methodology for adding sound to medical data to improve data analysis in various cases: HR variability recognition, differential diagnosis, exercise tests, help people with visual impairment, etc.

References

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