Chapter VI
Investigations about the Distributions of Important Information in ECG Signals

This chapter presents an investigation of the distribution of medically relevant information in ECG signal timelines. ECG records clearly represent a cycle of heart evolution; its components, although partly superimposed, follow the time-related dependencies of heart function. During the initial inspection of the ECG, the cardiologist focuses his or her attention on several points of the trace, seeking signs of disease. It seems obvious, but is not often considered, that some segments of the signal are more important for a doctor than the remaining parts. Depending on a doctor's habits and experience, the interpretation starts from the most severe or most suspected abnormality or from the most unusual signal component. The order of the ECG inspection is based on the investigation strategy and is determined by irregular distribution of medical information in the ECG. These assumptions have already been explored with regard to speech or audio signals, resulting in numerous successful applications, such as the MP3 compression algorithm.

Three alternative approaches to the investigation of standard medical information distribution in ECG signals are presented in detail. The first approach is the local spectrum of the signal as a common 'technical' strategy to the temporal data-stream variability. This approach is simplified as much as possible, thus it defines the statistically expected bandwidth neglecting medical aspects of the heart cycle. Several methods, including Short Term Fourier Transform and wavelets,

were used to estimate the local spectrum of the ECG. The literature review and original authors' research results are presented in this chapter with highlights of their advantages and drawbacks.

The second approach to the ECG data-stream assessment is output oriented and based on ECG diagnostic parameters. The parameters set is weighted according to parameters importance, and the resulting measure is used to correlate the diagnostic result deviation with the frequency and occurrence time of local bandwidth reduction. The main advantage of such an approach is the assessment of instantaneous transmission channel requirements, based on the measurements of the accuracy of diagnostic parameters that are derived automatically. Therefore, all differences resulting from bandwidth limitation are not expressed as a signal distortion (e.g., PRD), but directly as a deviation of diagnostic parameters.

Finally, the conceptual approach to the informative contents of the ECG signal assumes an analysis of observer gaze points during the manual inspection of the trace. The study yielded several general rules on how the cardiology expert perceives the electrocardiogram and revealed important steps in human reasoning. The results of this research are used to estimate the ECG signal features from on a background of medical findings and measurements of the waveforms. This approach is the one-dimensional analogy to the 'region of interest' commonly used to define special areas in images.

INVESTIGATION OF THE LOCAL SPECTRUM

Introductory Remarks

In the storage and transmission of an electrocardiographic signal (and for other sequences of samples), a full informative capacity (bandwidth) transmitting channel is usually used (Bailey et al., 1990). However, in the case of the ECG, the occurrence of particular signal components is limited by the physiology of intra-cardiac stimulus propagation. Additionally, the phases of a cardiac cycle are defined by cellular actions in tissues of different conduction speed, limiting their own variability and consequently the local bandwidth of the representing signal (Macfarlane & Lawrie, 1989). Moreover, the automatic recognition of the heart cycle phases, developed 40 years ago for medical purposes, is commonly used as a P, QRS, and T wave delimitation algorithm and nowadays yields results of acceptable reliability (Willems et al., 1985a, 1985b, 1987). These facts suggest that the electrocardiogram is a far more predictable signal than speech or audio signals, even in the case of pathologies. Therefore, the use of typical ECG pre-processing strategies (i.e., automatic wave recognition procedures) seems to be appropriate as