

Application of SCP for Stress and Holter Electrocardiography

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1. Introduction

Quantitative analysis of continuous (long term data like waveforms from monitoring) vital functions is performed by sampling of the signal in the time and amplitude domain – digital time series' are obtained. In computer assisted resting electrocardiography analysis intervals of, e.g., 10s have become a standard because 10s cover two – three respiration cycles. Many powerful analysis algorithms have been tuned for processing of such data segments. For this reason within the Hannover ECG system HES not only resting but also Stress and Holter ECGs are analysed by means of these algorithms.

Exercise and Holter electrocardiography are clinical routine examinations which produce a large amount of data if full disclosure records shall be provided. We describe a system for exercise and Holter ECG analysis which takes advantage of the data compression procedures and the data format of the standard SCP-ECG Protocol [1]. Processing of the XECG data and of Holter ECG data is performed "sectional" for consecutive 10 s data intervals, which results in six SCP blocks per minute. Using the SCP Interchange format for all subsequent 10s data segments of a long term record (with storing the segment sequence number) also Stress and Holter ECGs may be compressed and stored efficiently and viewed by utilisation of the same tools as developed for resting ECGs.

2. Material and Methods

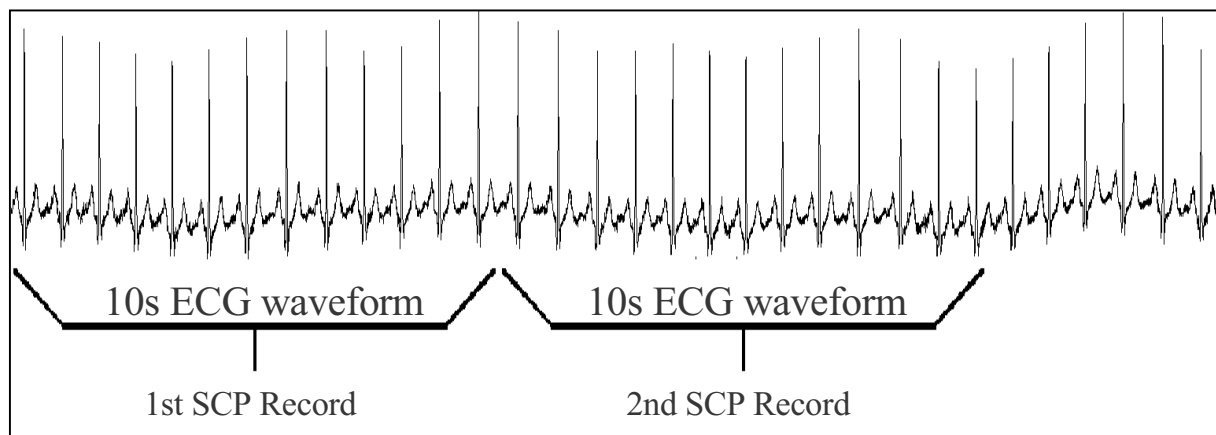


Figure 1 depicts the segmentation of long term ECG record into 10s data sections

The hardware of the analysis system for Stress and Holter ECGs consists essentially of a stand alone ECG amplifier with fibre optic bi-directional communication to a PC via the RS232 interface: Such a system has been described e.g. at CinC 2000 [2].

There are the following program modules:

- (a) The data acquisition module needs to work in one of the following modes: A monitoring mode for visual inspection of the ECG, electrode function etc. The regular recording mode with continuous storage of the ECG. An interrupt mode, if the patient e.g. leaves the bed for a while time stamps have to be introduced into the ECG recording for the respective interruption and additional recording times. At final termination of the recording the data sets of the recording periods are automatically assembled to make possible the continuous analysis of this record.
- (b) The ECG Analysis Module for processing continuously 10 s ECG data sections throughout the whole Stress- or Holter period. This module provides all relevant ECG analysis results, e.g. heart rate, ventricular premature beats and other rhythm information and sets of standard ECG measurements such as multiple ST-T values for all leads etc.
- (c) Viewers for the ECG data as well trendgraphs allow monitoring of the exercise process, of the heart rhythm, ST-T changes etc.

- (d) The HES SCP Compression Module processes all subsequent ten-second data sections following the SCP compression scheme. In case of significant arrhythmia the ECG data are redundancy reduced otherwise median beats and rhythm data are encoded as specified within the SCP Standard.

The respective SCP records contain the following sections:

1. The Global CRC Checksum and
2. Section 0 (pointers to Data Areas within the record)
3. Section 1 Header Information – Patient Demographics, Acquisition Data
4. Section 2 standard Huffman Table Identification
5. Section 3 ECG Lead Definition
6. Section 4 QRS Locations
7. Section 5 Encoded Reference beat data
8. Section 6 Encoded Rhythm data
9. Sections 7 Global Measurements
10. Section 8 Textual Processing Results
11. Section 128 Exercise Protocol

3. Results

Among other data from sleep recordings we processed 20 stress ECGs with recording intervals between 9 and 22 min. and 50 Holter ECGs with recording intervals of about 8 hours.

We found that the efficiency of SCP compression depends: a) to some extent on the heart rate, b) on the noise content (which may be influenced, e.g., by the exercise load), c) on the signal properties itself.

During compression of the 20 Stress ECGs a median compression ratio CR of 11.1 has been reached. For 90 % of the 10 s intervals a compression ratio between 8 and 18 has been achieved.

4. Discussion and Conclusion

1. Our work has shown that the SCP/ECG protocol and its compression method can be successfully applied during real time processing of Stress ECGs and Long-term/Holter ECGs.

2. A substantial data reduction was possible despite the fact that we have used only one Huffman table. Using optimised Huffman tables depending on the noise spectrum results in only marginal compression effects.

3. The SCP Stress/Long Term ECG compression makes possible to retrieve or even to transmit electronically a full disclosure ECG record, which may be legally required in specific health care situations – or, e.g., by FDA.

4. There are, on the other hand a couple of reasons to reconsider some of the technologically outdated specifications regarding messaging, communication and nomenclature. They are either superseded by new technologies or in conflict with more recent standards, e.g., the Vital Signs Information Representation Standard ENV 13734.

References

(Conference Proceedings)

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