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# Standard Communications Protocol for Computer-Assisted Electrocardiography Advanced Viewer

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## 1. Introduction

In February 2002 the Standard Communications Protocol for Computer-Assisted Electrocardiography (SCP-ECG) was approved by the European Community. In order to adopt this standard to decode and visualize 12-leads rest ECG recordings, with the goal of integrating devices from different vendors, we started in October 2002 a project involving the Cardiology Unit of the Hospital of Pordenone, the Electric, Electronic and Informatics Department of the University of Trieste and the INSIEL SpA Company operating in the sanitary field. A software prototype written in Borland C++ 4.0 Professional was first developed, as part of a degree in engineering, being able to handle all sections of a standard SCP file [1].

Then we decided to enter the programming contest for electrocardiography record handling applications and tools, using the SCP-ECG standard, announced by the OpenECG Consortium (http://www.openecg.net). Consequently we had to address several topics about the software: a) it should be released as free, b) it should be cross-platform, c) it should be improved. All these topics were successfully addressed. The final release, entitled SCP-AV (Advanced Viewer) rev. 2.1 was submitted and the Contest Judging Committee classified it at the 1.st place.

## 2. Materials and methods

Consensus was reached between co-authors to give up their respective copyrights in favour of the open-source philosophy. As a consequence, the software is freely downloadable at the OpenECG Consortium portal under the GNU General Public License. This means that anyone may register for free, download, use, modify and republish the software.

The programming language is now standard C/C++. Translation from Italian to English of strings and variable and function names in the source code resulted time consuming. The user interface, because originally implemented through the native GUI of Borland C++ Builder, had to be entirely rebuilt. After a search over Internet and testing of different packages, we finally chose the FOX-TOOLKIT library (freely available from http://www.fox-toolkit.org/), because written in C/C++ and extensively used on many platforms.

Intensive testing, bug fixing and optimization were also performed. Now the program correctly opens all the test files provided by the OpenECG Consortium to contestants, both high compression and redundancy reduction modalities. CRC is checked for the whole file and for each section. Root mean squares and maximal absolute differences, between the reconstructed and the original signal, are below the limits of the standard (with few well documented exceptions). Special effort was done, with decimated sample reconstruction and low-pass filtering of the signal, to avoid transients at the subtraction zones boundaries. Interpolation is performed between protected zones, while filtering intervals are broken by subtraction boundaries. In interpolation a default rounding was obtained (i.e. float v=(b-a)/4;... sample[i]=a+v*j;) from float to int. Any attempt to add +/-0.5 gave worst root mean squares. In filtering we used the recommended strategy. Furthermore, an additional menu driven low-pass filter was implemented outside the protected zones, as a whole interval, of the reconstructed signal. This showed an improvement of the root mean squares and may be visually appreciated, too.

Although the decoding algorithm should be able to reconstruct tracings recorded with different modalities, the graphical interface was designed only to show the 10 seconds / 12 leads rest ECG. The reconstructed tracings are shown on the screen in the 6x2 usual format by default (I, II, III, aVr, aVl, aVf on the left column and V1 … V6 on the right, with time flowing continuously from left to right). See Figure 1. A zoom in x2 function shows three leads at a time for 5 seconds. A full 10 seconds page was added later, as suggested by the Committee. The viewer may be fine tuned, specifying some parameters at startup, being able to show the tracings in real dimensions (one grid line every 0.5 cm of the screen). A validated anti-aliasing technique is applied to smooth pixels. This technique has been used in the last 12 years at our Institution [2].

Output of raw-ASCII data is provided to allow third part testing of the goodness of the decoding algorithm. The extension '.dat' is appended to the file name. The output is 5000 samples x 8 leads x 2 bytes interlaced, as

the original raw-data files are. A second output file with extension '.xxx' is also created to output intervals for protected and addition zones, if any. The viewer can also read raw-data files as a special filter in the open dialog has been added, as well as differences between reconstructed and original (*.diff) if available from the testing program (not included in the distribution).

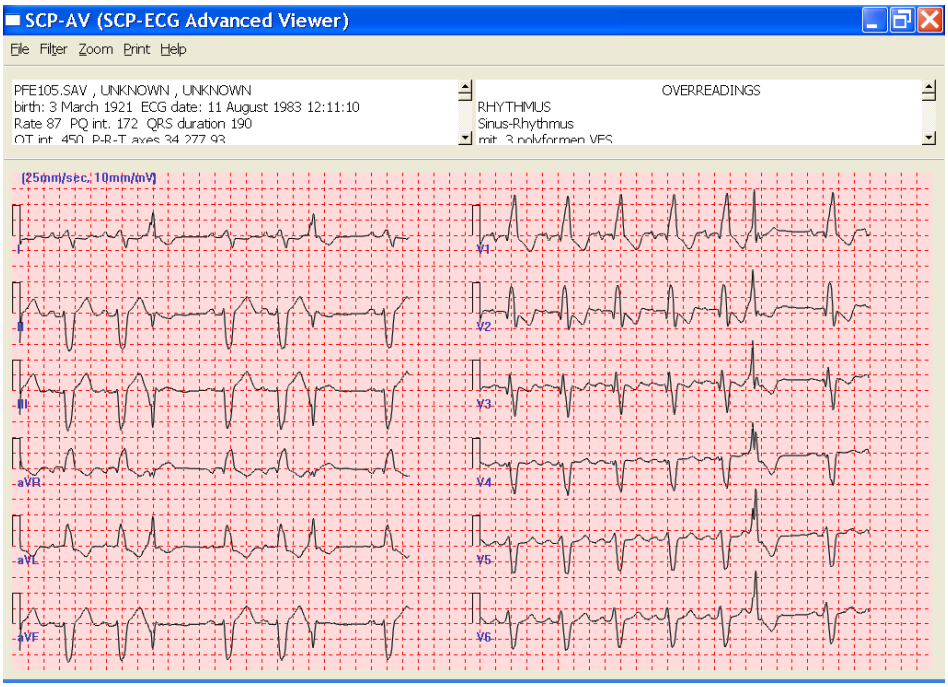

Figure 1. The graphic user interface of SCP-AV, based on the FOX-TOOLKIT cross-platform library.

ID data, global measurements such as RR and PP mean intervals, P-Q-T onsets, offsets and axes, Pacemaker spike measurements data, if any, are shown by the program in the upper-left box on the screen as plain text. Most important data are shown for first. A text version of the latest diagnostic interpretation of the ECG is shown by the program in the upper-right box on the screen (Figure 1).

High quality printing capability is directly supplied through the 'Print' menu for DeskJet (PCL3-raster mode-600 dot per inch) and LaserJet (PCL5-vector mode-400 dot per centimeter) printer families. Two parameters are needed at startup to specify the device or the file to output to and the emulation.

## 3. Conclusion

Big effort was made with C/C++ programming, English translation, bug fixing and in writing manuals. The SCP-ECG is well documented and the provided samples are very useful for testing the decoding algorithm. In our experience sample decimation, if applied, may be considered the highest critical aspect of the standard.

The features of the viewer have been highly appreciated by our cardiologists. We hope that SCP-AV could be appreciated also by the scientific community and could contribute to the SCP-ECG success.

## References

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