







creates representative attribute(s) of signal information (descriptive feature/s). The goal of this definition is clear separation of data that have only a single value within one event or can be replaced by one value without any loss of information.

Signal viewer is basic part for visualization of measured signals with possibility of caliper application for measurement of intervals lengths and signals amplitudes, averaging and marking of characteristics points in the signal. The title characteristics points are defined as function points (e.g. ECG points), as mark of some event in signal (e.g. ablation) or beginning and end of some interval (e.g. fibrillation). The example of signals with marking of ECG characteristic points is shown in the figure 5. Data model supposes composition of complexes (interval in the simplest case) from defined points. The way of composition is given as combination of points with number of order in the complex and definition of the complex. This simple way provides general approach for creation of complexes based on function aspects and/or user definition. Complexes together with points represent basic elements for analysis. The analysis means extraction of information from signal into descriptive features.

To the part of signal displaying, there belong also functions of advanced visualization of the signal and its properties that can be also used for analysis of the signal. These additional components of signal viewer are mainly trends of statistic parameters, overview of calculated signal parameters (correlation, coherence, fractal dimension, etc.) and visualization of time and frequency signal properties (spectrum, spectrogram, continuous and discrete wavelet transform) [4].

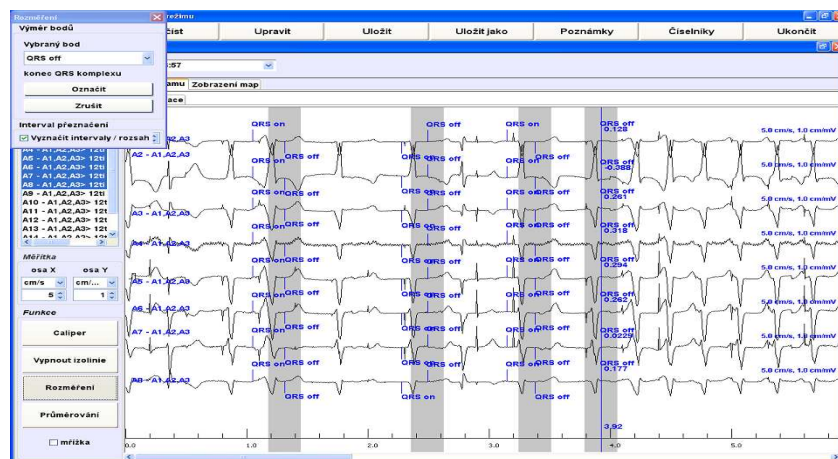
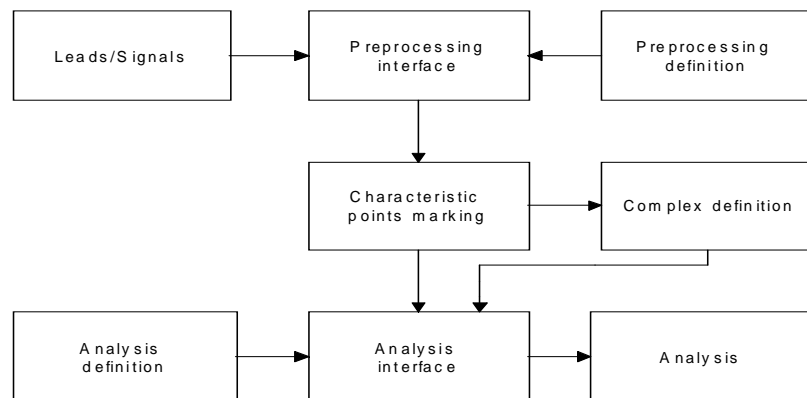


Fig 5. Example of ECG characteristic points marking

In the third part mapping is computed and displayed. Grid of maps is defined in the protocol again. Mapping part includes four types of 2D maps (immediate, integral, isochronal, differential), overview of map signals sorted based on map grid and creation of greater number of maps for preview of surface potential distribution in time. The last mapping option is creation of frequency map in given number of bands. Example of immediate potential map is shown in figure 7d). The maps can be used for analysis in the same way as signals.

The last part of application is analysis of signal and its parts. The analysis is basic process for description of signal and feature extraction. The analysis has the same assumptions as signal readers and preprocessing steps. Thus results of analysis are transferred to model using the transforming interface that allows use larger number of various algorithms. It is important that the application is oriented mainly to integration of data (it does not need to include all analysis algorithms). Hence there is defined a possibility to transfer analysis results from

external source (with storage of type analysis and its parameters). The diagram of points, complex and analysis ordering is shown in figure 6. The results of analysis and information about long-time and middle-term values are used in evaluations, which are in many cases well-founded by rules from previous analysis or knowledge of experts. This process is not one-stage and we suppose that the evaluations table will contain several level of evaluation. Very simple example can be the following one: simple level of evaluation is “QRS complex is normal”, in rules it means the length of QRS  $> 0.0.6s$  and  $< 0.1 s$ ; higher level of evaluation is “signal is normal”, in the rule from previous evaluations it means QRS complex is normal and QTc interval is normal, in basic rules it means length of QRS  $> 0.0.6s$  and  $< 0.1 s$  and length of QTc  $\leq 0.40 s$ ).



Created in Diagram Designer - <http://meesoft.logicnet.dk/>

Fig 6. Diagram of preprocessing, points, complex and analysis ordering

Examples of individual application forms for entering information about basic patient information, diagnosis, medication and laboratory results, signal caliper and an example of potential map are shown in figure 7.

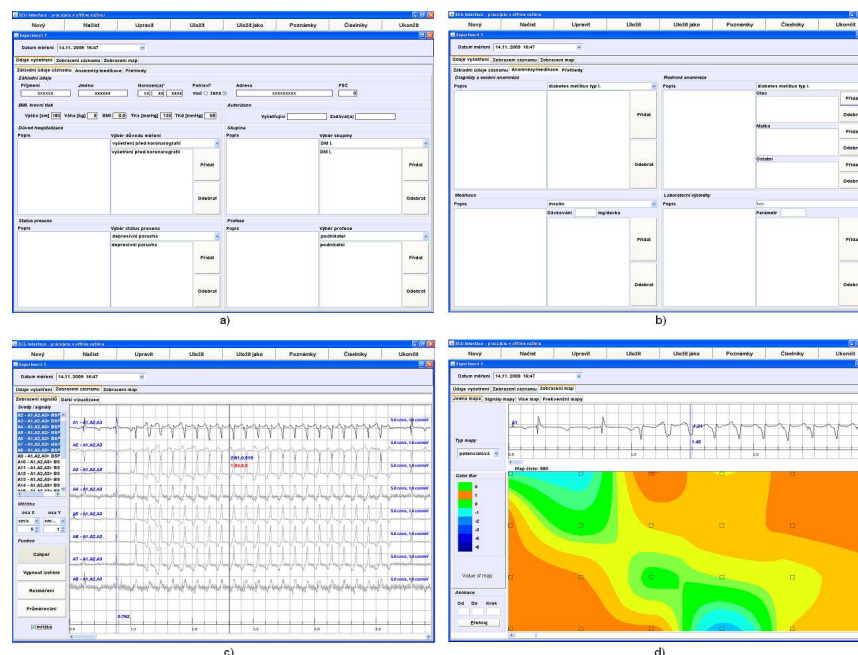


Fig 7. Example of application: a) Basic patient form, b) anamnesis, medication and results of laboratory tests form, c) signal caliper, d) immediate potential map

### 3 Results

The main result of this application is integration of basic patient data (age, gender, weigh, high, systolic and diastolic pressures), information about diagnosis, anamnesis and medication, laboratory results and measured signals. Further we define process for signals segmentation in order to acquire time structure as interval and complex. From both these elements (generally points, complexes) we can perform analysis for extraction of signal description useful for evaluation of signal part and signal as complex respectively. Thus we acquire comprehensive overview of the measured subject and we can extract related information for more complex evaluation.

### 4 Conclusions

The aim of our project is to provide extended data processing methodology in the area of heart field observation and classification. We have developed a tool for long traces of synchronous heterogeneous data explanation and rapid evaluation of new data modalities. The field of cardiologic data is exactly the large area for that this approach is intended (especially in experimental electrophysiology). We are also well aware that this extended approach can be used in more fields, unlike general description of all areas, but as a frame for creation of such a description. Complex evaluations in neurology, neurophysiology or neuropsychology are examples of such fields.

### Acknowledgments

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### References

- [1] Oracle, <http://www.oracle.com>
- [2] BioSemi system, <http://www.biosemi.com/>
- [3] Kligfield P., Gettes L.S., Bailey J.J., Childers R., Deal B.J., Hancock E.W., van Herpen G., Kors J.A., Macfarlane P., Mirvis D.M., Panum O., Rautaharju P., Wagner G.S.: Recommendations for the Standardization and Interpretation of the Electrocardiogram, *Journal of the American College of Cardiology*, 2007, Vol. 49.
- [4] Akay M.: *Time Frequency and Wavelet in Biomedical Signal Processing*, IEEE Press, Piscataway, NJ 08855-1331, ISBN 0-7803-1147-7, 1997