International Journal of Bioelectromagnetism *www.tut.fi/ijbem*
Vol. 5, 2003

From Databases to Knowledge Spaces for Cardiology

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Abstract. The paper discusses the evolution of the role of databases in cardiology and highlights several directions of future development. The proposed term of Knowledge Space integrates the signal with medical annotations as well as the information technology-based methods of data interpretation. The set of methods in the form of remotely executable subroutines may provide a high quality service for wide range of medical researchers over the Internet. The dynamic structure of the Knowledge Space is supported by the experts in biosignal interpretation and supervised by an International Scientific Committee validating new proposals in order to guarantee the representation of the state-of-the-art.

Keywords: Databases, Standards, Pervasive Computing, Interoperability, Open Source Software, Integration of Knowledge

1. Introduction

The relevance of recordings or sketches was never neglected in medical sciences, and even the oldest surgical manuals contain descriptions of reference cases. For many years the collections of ECG recordings were in paper only, except for long-term recordings stored on tapes. Today the digital storage remains the only data carrier, and we often wonder how we could even manage without it.

Since the first issue of American Heart Association standard of the ECG (1967), the databases played several roles in electrocardiology. The principal of them are listed below:

- As references for interpretation (manual or automatic) the databases standardized the medical knowledge.
- The worldwide use of databases imposes standards on data storage and transmission format.
- The databases are starting points for new challenges in the field of exploration of signal contents.

2. Data Format and the Medical Knowledge

The data format is an inherent part of the database, although it is usually specified by a separate document. The description of physiological parameters contains data of various origins (time sequences, text, still images, movies and audio) and the format has to support such diverse data. Despite the need of a general format, the recording-specific formats are in common use (e. g. SCP ECG Protocol, 1990, for the 12 lead ECG and VCG and recently proposed ISHNE Holter Standard Output File Format, 1998 [Zareba, 2001]). The existence of well-established common formats is of paramount importance to the patients because the examination possibility is no longer limited by the health center or by the equipment manufacturer.

The joint representation of signals with the medical knowledge was the principal area of applications for the early databases. The examples recognized worldwide are the MIT-BIH Arrhythmia Database (issue 3, 1993) and the CSE Multilead Database (1990) [Moody and Mark, 1988; Willems, 1990]. Many other databases were result of clinical trials performed in the leading research centers, some of them are freely available from the Physionet. Currently these databases are used for training of cardiology students as well as for tuning and validating the software. Apart from the problem-oriented databases, few data collections recently gathered describe the simultaneous vital signs (e. g. ICU-Database) that give the researchers the opportunity to study the correlation of different organ activity in the human body.

The clinical practice is under continuous development and the data format must provide support for the vital signs and annotations not known today. The most frequent disadvantage of the current formats is their poor flexibility as new parameters emerge and old die out. The format extensibility may be achieved in a combination of DICOM Waveform Interchange (or HL7 level 3.0) standards and XML-structured reporting forms.

3. Wedding Data and Methods

During the medical research various experiments have to be done resulting in unusual recordings made in atypical conditions (i. e. tele-ECG in rat). These data often requires specialized processing, very close to the clinically used procedures. The software engineers usually develop procedures for this purpose on demand, but in fact they repeat the work of others. Such software needs a long and expensive procedure of evaluation, because computation errors may lead to misinterpretations of results and to the erroneous conclusion.

The proposed extension of the database is the Knowledge Space (KS) and integrates the signal with medical annotations as well as the information technology-based methods of data interpretation. The KS is accessible for vide range of medical researchers over the Internet. As the conventional database, the service of KS contains the downloadable reference ECG data, however its main advantage is the offer of a choice of the most recent interpretation methods.

The server interface is able not only to demonstrate the ability of a particular method to solve a given problem, but also to perform the requested computation on the uploaded user data and to return the result. The source code is ready to use in multiple asynchronous threads remotely launched and controlled by the users via limited set of options. The role of user interface software is not required since the modern graphic-based web browsers support user file transfer, the selection of methods and options and the presentation of results. The transfer of computation results as a file is also under consideration, making support for text interface-based terminals. The graphics may be then reconstructed from the file in the vector format more suitable for publishing for its unlimited quality.

The user manual and the knowledge guide are provided in HTML format and contain links to the original papers. Although the medical library is not the main function of the KS server, the collection of publications provides the medical researcher with the most appropriate knowledge facilitating the preparation of the experiment and the right choice of data processing method and options.

4. Scientific Impact of Knowledge Spaces

The dynamic structure of the KS is supported by the experts in biosignal interpretation and supervised by the International Scientific Committee validating new proposals in order to guarantee the representation of the state-of-the-art. The KS is supposed to get soon wide recognition in centers of medical research confirmed by its impact in the development and standardization of electrocardiology. Thanks to the independent validation, the contribution to the KS may be considered as corresponding to a scientific paper.

5. Conclusions

The idea of providing a computational service in cardiology closes the gap between high quality but closed commercial applications and public domain subroutines of poor reliability. Since the source code of the method is not published at any stage, the user is not bored by technical issues like compilation etc. and the range of methods may include high quality patented algorithms or special versions of software typically embedded in the interpretive ECG recorders. The commercial ECG equipment manufacturers are also welcome to submit their contribution and to manifest their authorship by the company logo or name.

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