medical data warehouse and reporting systems,
medical diagnosis support systems

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INTEGRATED SYSTEM MERGING THE KNOWLEDGE OF DIFFERENT MEDICAL AND TECHNOLOGICAL DISCIPLINES WROVASC PROJECT

The paper presents selected aims of WROVASK project carried on by Regional Specialist Hospital in Wroclaw with cooperation with a number of academic and research centres. The project is of interdisciplinary kind and gathers researchers and experts of number different disciplines, like chemistry, agricultural, and technical sciences, especially mechanics and informatics. Some tasks aiming at development information systems are presented and described such as: data warehouse based reporting system for the hospital, the system supporting assignment management in teleradiology with optimization of its distribution, and intelligent decision support system for automated assessment of washing surgical tools quality.

1. INTRODUCTION

The reason of the WROVASC project is to develop the integrated system merging the knowledge and researches of scientists who represent different medical and technological disciplines. The main purpose of the project is to improve the healthcare in the area of the cardiovascular diseases. Project is to be realized by the County Hospital in Wroclaw in the cooperation with many Polish and German research and development centres:

- Wrocław Medical University,
- Institute of Immunology and Experimental Therapy, Polish Academy of Science,
- Military Clinical Hospital with Polyclinic in Wroclaw,
- Lower Silesian Centre for Cellular Transplantation in Wroclaw,
- Wroclaw University of Technology,
- The University of Wroclaw,
- Wroclaw University School of Physical Education,
- Universitats Gefasszentrum Carl Gustav Carus in Dresden,
- Klinikum Karlsbad-Langensteinbach, Lehrkrankenhaus der Universität Heidelberg,

to enumerate only a few.

One of the important parts of the project is design a several informatics tools supporting researches conducted within WROVASC project. The main goals of the aforementioned project are as follows:

- Developing software tools facilitating design of computer aided systems of medical diagnostic using expert and machine learning methods with multi-purpose reporting module. Obtained results can be used to design and build analytic-decision modules of regional knowledge base devoted cardiovascular diseases.

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- Designing models and projects of BAN (*Body Area Network*) monitoring patient's condition, enabling remote diagnostic, alarming about life-threatening patient states an at the same time make possible locating patients in hospital as well as outpatients.
- Working out comparative analysis of data transmission systems and distributed computing systems in terms of needs of medical and telemedical applications. Formulation, based on conducted analysis, models of the systems and algorithms of their optimization. Evaluation of effectiveness of developed solutions.

This paper will focus on the first topic only.

2. PROJECT DESCRIPTION AND RELATED WORKS

Expert systems are popular kind of decision support systems [1,2]. Methods usually used in order to design them are based on machine learning algorithms [3-6]. The reason of popularity of machine learning is the fact that obtained methods may be easily used for business, technology and medicine purposes [7,8].

Medical diagnostic is one of the most popular areas where supporting decision systems are applied. About 11% of expert systems are dedicated to computer-supported diagnostic and about 21% of publications are illustrated with medical examples [9]. Computer-based decision supporting system for medical purposed is described as computer program, designed for supporting medical decision-making process, basing on patient's symptoms and computer medical knowledge base. It is worth to notice, that the result of expert's report may not be the specific medical unit, but only suggestions supporting doctor to pick up her/his own decision.

The conception of those systems is not very new, e.g. work of well-known systems MYCIN [10] where finished nearly 40 years ago. It is easily to find studies connected with this matter. Part of them present the survey of working medical decision supporting systems [11,12], and other concentrates in selection of the best classification method for specified challenge from the area of medical diagnostic [13-17].

Project and prototype of the expert system supporting research conducted in WROVASC project should meet following functional, information, technological and technical requirements:

- support of (basic, fundamental, rudimentary, essential) processes of collecting, analyzing and reporting data (derived, originating, generated by) from selected research topics of WROVASC project, in particular research topics related to analysis of impact of various factors on occurrence of a disease,
- processing of collected data using basic and advanced methods of statistical data analysis,
- ability of basic and advanced multidimensional analysis of collected data to support reporting scientific research,
- for prototype of the system, define usefulness of automatic data-mining methods in WROVASC project. In case of obtaining satisfying results, enclose data exploration module to the expert system.

The main premise of formulating tasks related to realization of decision support systems is applying system approach to demographic, epidemiological, economic and organizational conditionings of effectiveness of diagnosing and treating cardiovascular diseases.

The expected results of the project are as follows:

- Creating functional tools for medical data collection, which are the base for decision support systems,
- Formulating information models obtained for medical systems, which may be used for outsourcing services for different kind of institutions,
- Designing expert system supporting studies within WROVASC project.

- Increasing ability of information system – creation and implementation of statistical reporting module and multidimensional data analysis one.
- Testing and implementation of data mining methods for medical purpose within WROVASC project.

3. NIR PROJECT

The effect of light on tissue has been already studied intensively for medical and biological reasons. The works relate to such subjects how: the regulation of circadian-rhythm by light [18], light therapy [19], the stimulating activity of light [20], diagnostics and medical analysis [21, 22]. The influence of near infrared (NIR) on various tissues has been reported in the last year [23-25] such as: the analgesic, antichloristic delay processes of aging the skin, accelerating the being healing the wounds and strengthening of the immunological arrangement. It also influences the facilitation of the microcirculation of the blood in organisms. The investigations over the influence of NIR on erythrocytes proved, that blood corpuscles subjected to radiation in the range 700-2000nm and the stream of energy 0.69 mW/cm2 elevate their mechanical endurance and degree of elasticity as well as extend the ability of distorting oneself and the resistance to the oxidative stress.

The aim of the experiment is to use the NIR as the factor protecting the blood corpuscle during treatments with the extracorporeal circulation. The first stage of the experiment is the answer on one of the question:

- Does NIR protect the blood during the extracorporeal circulation?
- Does NIR affect on the blood during the extracorporeal circulation?

The second stage is the selection of the optimum dose of the NIR radiation for every case. Experiments will be executed on animals:

- 10 pigs with the extracorporeal circulation,
- 10 pigs with the extracorporeal circulation and NIR exposition.

About 20 parameters the blood before, in the track, and after the experiment will be measured. The parameters of the blood are following: complete blood test, reticulocytes, hemoglobin free, bilirubina free and total, creatinine, urea, arterial blood gas, Active factors coagulation, fibrinogen, opinion of the oxidative stress.

It is possible, that not all described features of the blood are equally relevant. Some of them can be important only in relation to others and some might be only noise in the context of NIR exposition. The process of feature selection and extraction are necessary in this task.

The results of experiments can be very disturbed. The reason is the contact the blood with the biomaterial during the extracorporeal circulation.

4. OPTIMIZATION OF TELERADIOLOGY ASSIGNMENTS

Teleradiology is nowadays a good alternative for dealing with large and still growing number of services in widely understood radiology services such as tomography, radiography, USG diagnosis and many others. Instead of extending local base required for ensuring decent working environment for consultants involved in the diagnosis process, some services can be outsourced and preformed outside the hospital. That can effectively solve number of problems not only related with facility limitations. It also allows to develop larger base of experts regardless the place their work.

Developing the teleradilogy system meet some serious problems related not only with technical issues such as maintaining equipment base (see figure 1) required for:

- providing examinations,

- processing data gathered during examinations (digital picture processing, signal processing etc),
- storing collected and pre-processed data in unified format at well secured database server,
- ensuring fast and reliable channel for data interchange through the Internet among consultants involved in examination process;
- but also some management aspect of dealing with assignments, such as:
- managing with availability scheduler of the large number of consultants,
- creating and exploiting expertise profile of the consultant consisting of the detailed specification of the domain of expertise,
- assignments prioritizations and their sequence managements, to name only a few.

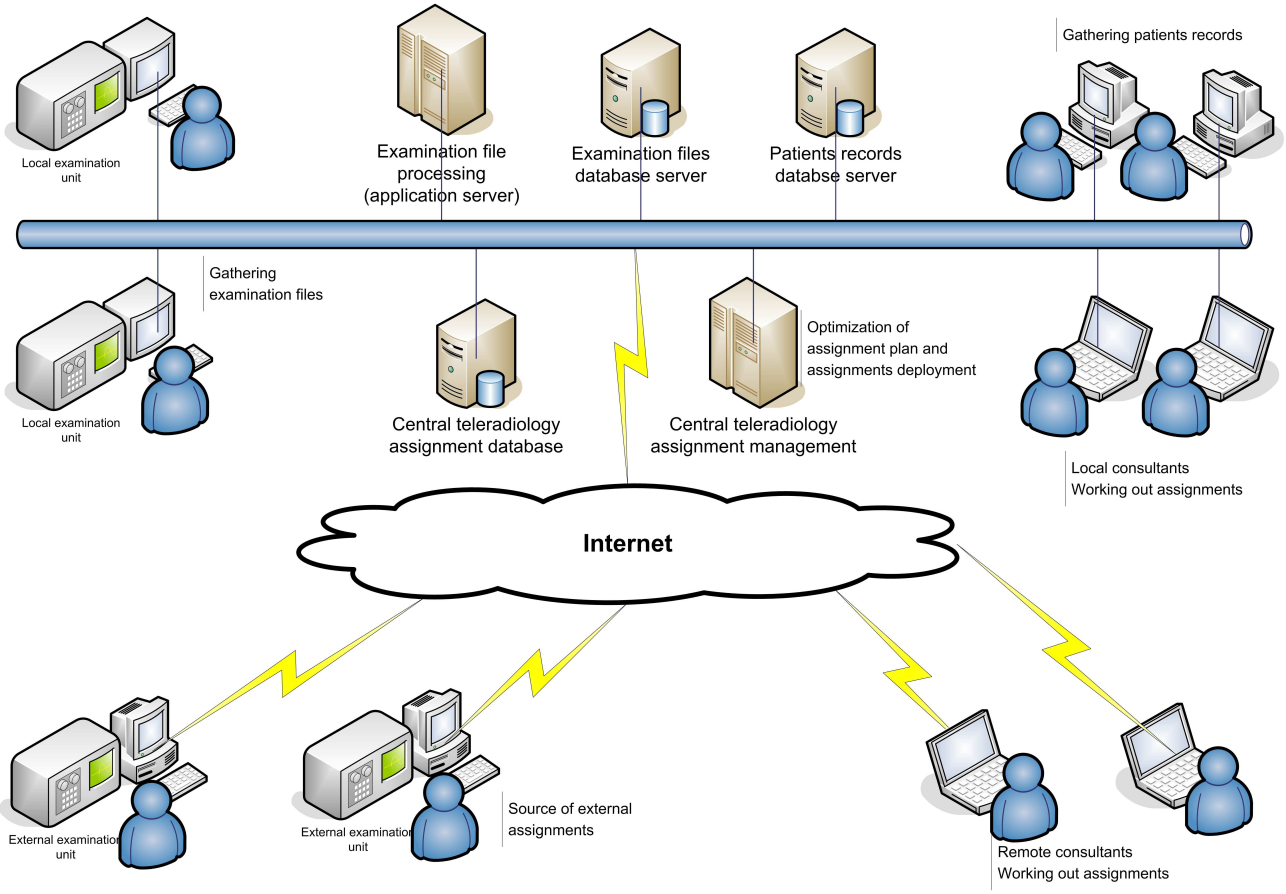

Fig. 1 Model of data gathering, processing and interchange in teleradiology system.

Furthermore, some aspects related to software engineering have to be considered too, as they also could affect effectiveness of the system, for example preferences regarding selection of the particular consultant.

Complexity of the issue is also proportional to:

- number of type of services covered by the system,
- number of departments that can generate assignments,
- number of consultants,

and some other. Summarizing all of those aspects, that have been only mentioned here superficially, we have to come to conclusion that we have got in hand quite complicated optimization problem in multidimensional space (i.e. dependent on large number of variables describing aforementioned facets) and with large number of limitations.

As in an optimization problem a key role plays also appropriately selected target. One can demand to build the system that effectively organizes assignments among consultants; nonetheless taking into consideration costs of running the business seems to be option definitely worth further deliberation.
Designing IT system that aims at optimization teleradilogy assignments is a compound task and it has been split into number of stages:

1. detailed inspection and analysis of working environment in which the system is to be implemented,
2. working out complete system requirements documentation including list of demanded functionality,
3. building a mathematical model of optimization problem,
4. research on available optimization algorithms that can be exploited in the system,
5. carrying out number of experiments in order to asses usability of selected algorithms,
6. working out detailed system specification,
7. launching a project of system implementation.

It has to be emphasized here that the system implementation is the separate project not covered by the work realized in WROVASC project.
Working environment consists of:

- facility pool (i.e. buildings, offices, etc.),
- hardware
  - used for examination (ex. RTG units),
  - workstations and servers used for data processing,
  - internal and external network,
- software
  - gathering and processing data during examination processes,
  - used for data transmission and management.

Well done recognition of all of aforementioned elements is essential for specification of the system requirements that is feasible to development and implementation as we can deal only with available information, i.e. gathered in existing systems.

5. ADVANCED REPORTING SYSTEM

The second project aims is designing Advanced Reporting System providing flexible and highly ergonomic tool for creating and running reports.
Input for the system consists of all the software currently used for data processing in the hospital consisting of:

1. patient files (history, examinations, etc),
2. list of services provided by the hospital,
3. task realization records,

and some other information. As there are number of software created by different providers and implemented by different vendors the problem of data unification and consolidation arises. That is rather typical situation when the reporting system is to be implemented in working environment that has been developed step by step for years. We selected the solution that has been created for such a purposes i.e. data warehouse system. Following advantages support that selection:

1. the system provide open interfaces that can be easily connected to a variety of database systems and data transfer protocols,
2. the system organizes imported data in a way that allow retrieving demanded information in any required form almost on demand.

Preliminary works that have been realized show high necessity of having got reliable reporting system that can provide information essential for further optimization of management processes. The list of the report, among the others, consists of reports on time of realization particular diagnosis tasks in a function of:

1. examination type,
2. consultant experience/position,
3. time of work of particular consultant.

The project has been organized as follow:

1. inspection and analysis of working environment in which the system is to be implemented,
2. working out list of demanded reports and aspects of data analysis and presentation,
3. selection software providing data warehouse reporting,
4. building interfaces among the software and existing systems,
5. designing set of demanded reports,
6. software implementation and carrying on courses and trainings.

6. AUTOMATED ASSESSMENT OF WASHING SURGICAL TOOLS QUALITY

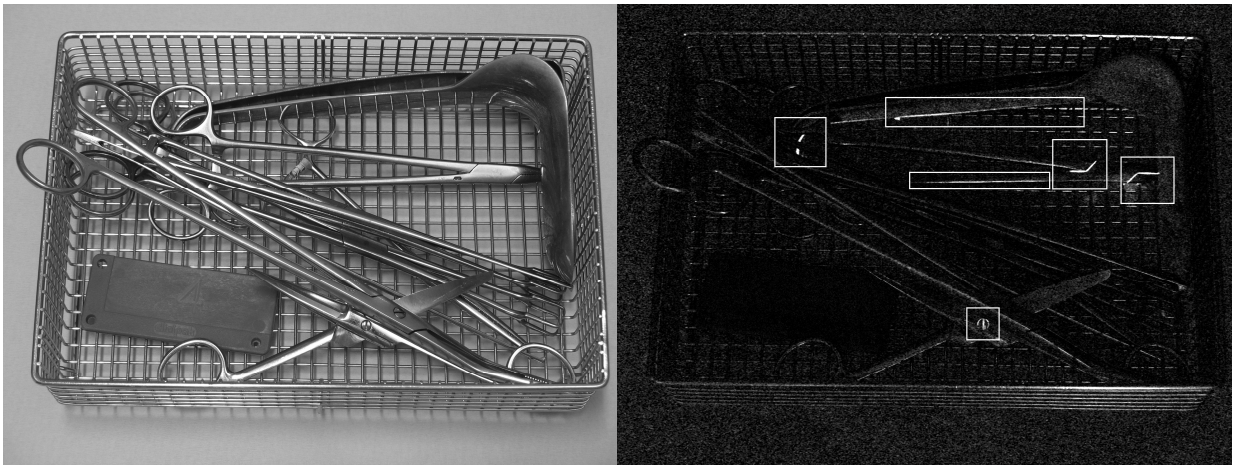

Fig 2 Surgical tools in natural light (left), in ultra-violet light (right)

The practical application of artificial intelligence is one of the main project aims. We are going to design decision support system that automates assessment of washing surgical tools quality. From the medical point of view the goal is to reduce the possibility of contagion which can appear as the result of insufficient washing process of med. sharps.

Utilization of luminol after washing surgical tools allows marking even very small stains of blood and the scraps of tissues. The luminol mixed with the oxidizing substance causes shining traces while exposed to the ultra-violet light as iron ingredient of the hemoglobin will work as the activator, what is shown in Fig.2. Digital processing of the picture allows amplifying the shining traces and separating them against the noise and background. Resulting image is to be analyzed by decision system to get the final classification.

7. CONCLUSION

Paper presented the main assumptions and preliminary results of selected works realized under the frame of WROVASC project. All of them focus on designing decision support tools using methods which

have their origin in machine learning approach and data warehouse concepts. We hope that progress in realization of other tasks will cause that scope of realized works during project devoted designing informatics tools aforementioned researches conducted within WROVASC project will be wider.

8. ACKNOWLEDGEMENT

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