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Decision support systems in ultrasound diagnostics*

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Abstract

Specific features of decision support systems in ultrasound diagnostics are considered, compared with decision support systems in other domains. Main characteristics of the system SonaRes are brought out.

1 Introduction: solutions, decision support systems

Solution is a result of conscientious activity intended to select one variant of actions from several possible ones. As well as human behaviour, the solutions are determined not only by logical reasoning, but inspiration, imagination and creativity too, and even by emotional state. Thus, no one pure information technology can replace the human in decision making. But all the same, each person, which makes responsible decisions, needs informational tools, which not only give necessary information, perform some routine and laborious operations over it, but also help to better understand his tasks, to put in order his priorities, and offer some acceptable alternatives. Such systems are being developed intensively during last 30 years for different activity domains under general title - Decision Support Systems.

Under a decision support system (DSS) we will understand a class of adaptive and evolutionary information systems oriented to person [1], in which information technologies of general use are integrated, as

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well as the specific ones, aimed at extending the limits and overcoming the restrictions of the system user in a sufficiently large number of actions in the process of solving the trivial tasks.

Any tool designed to facilitate the individual to carry out his work, in the first place must be adapted to his usual style of work (this is less applicable to the methods). The specialist's methods and working style are usually formed by degree of training and the environment in which he operates. But we do not exclude any solitary special instances for which this assertion is not indisputable.

In this sense, the design of DSS for a specific group of specialists saves the developers from too much diversity in the technological methods and interfaces. Yet, taking into consideration style, habits, and especially the specificity of knowledge, ability to make original decisions of individual decision maker imposes special conditions on the developers of DSS, especially when designing the system interface.

The destination of DSS is to introduce into the practice of the work of a decision maker a certain subset of adequate actions including:

- receiving queries from the user and their comprehension (understanding);
- processing elements of knowledge available in the DSS (updating, maintenance, accumulation, removal), in accordance with the needs of decision maker;
- issuing messages in user-friendly format.

User requests to the DSS on the knowledge that he needs – to make a decision (assessment of the possible user action, explanation of the previous system response, opinion about the action made by the user) as well as a command – on the acceptance and preservation of information transmitted by the user from other sources.

Processing of information and knowledge of DSS can be initiated on command from the user or by the system in connection with the internal processes required for updating and accumulation of knowledge and information.

Issuing messages to the user or other subsystems consists of:

- responses to user queries (issuance of the requested information, the request for additional explanation, if the user's query was not understood by the system, etc.);
- proactive communications (unsolicited by the user), in the cases of ascertaining by the system the actions unachievable in the given conditions, of revealing new information that has not been accounted by the user.

It is known that in a knowledge base a certain structured model of the problem domain is put, which, as any model, does not fully reflect its peculiarities and regularities, but only those which a knowledge engineer managed to "extract" from an expert.

The knowledge engineer often faces a situation when knowledge of different experts are uncoordinated and even contradictory. Such situations occur the more frequently the less formalised and structured is the domain.

The degree of confidence in the DSS varied over time from its complete rejection, when ad too optimistic expectations were not justified, to the understanding that the abilities of information systems have their limitations and that the role of DSS is not to replace the user, but to help him in gaining a deeper understanding of the problem essence, in regulation of his preferences, in evaluation of possible consequences of the adoption or rejection of concrete solution variant. That is to say, the DSS offers a variant of solution, that the decision maker can accept or not, depending on if it satisfies him and the system arguments (an explanation of why just this variant was proposed rather than another) are convincing.

V. Briefs [2] believed that automation is a big danger for human creativity, since users of information systems, because of the habit to get ready results, lose the ability to deeply understand their problems. G. Johannsen [3] also asserts that the decision maker, using a DSS, may lose skills and even take the wrong decisions in unusual circumstances.

There is another possible reason for the objections of leading experts against the use of DSS. The DSS, having in its base the embedded knowledge from leading experts, relegate them to the average level, which can be reached by the less experienced staff when working with the system. On the other hand some of the decision makers have the opinion that computers help only in calculations and information storage.

In connection with the above, the question arises of the extent to which DSS corresponds the specific needs of the decision maker to solve his problems in a particular area or for a wider range of tasks of decision-making.

Experience in the application found that the DSS success depends not only on technological solutions, but also on how your system meets the knowledge, abilities and habitual actions of the decision maker.

Note that one must distinguish between DSS intended for *individual* decisions and for taking *cooperative and group* decisions. In this article we will consider only the first ones.

Depending on type of support one must distinguish between systems of *passive support* (search for necessary information, simple calculations), *traditional support* (evaluation of alternatives proposed by the decision maker when answering the question "What if ...?"), *normative support* (the system with the help of optimization models gives a solution in conditions of a task when answering the question "How to ...?"), *cooperative support* (system stimulates the decision maker to add, improve, modify the proposed in the automatic mode solutions), and *extended support* (the system should influence the way to deal with the problem, providing the decision maker a priority to choose the way simultaneously stimulating new approaches to the solution. At the same time, the decision maker delegates additional functions for the system).

By technological "filling" and orientation one must distinguish between DSS oriented to data, models, knowledge, documents, communication component. Naturally an ordinary decision maker is difficult to understand this diversity. The incredible thing is known, which is being adduced by Prof. D. Pospelov. In one Moscow institute young staff put up a poster "Let's give the customer not what he asks for, but what he needs".

Sprague and Carlson [4] suggested an approach ROMC (Represen-

tations, Operations, Memory aids, Controls) according to which the user perceives the DSS. At the same time, this approach helps the decision maker to orientate himself in his demands to the DSS by:
Representations:

- *general:* lists, diagrams, organigrams, formulas;
- *specific:* decision trees, scenarios;

Operations:

- *at informing phase:* collection, validation, data aggregation, situation diagnostics;
- *at design phase:* alternatives generation, model parameters setting;
- *at implementation and evaluation phase:* issue of work orders, transfer of progress reports;

Memory aids:

- data bases, images, libraries, filters;

Controls:

- explanations, helps, errors indication;
- personalization and construction of user procedures;
- dialogue mechanisms: menu, languages of intercourse.

Using DSS in his activities, the decision maker can improve his skills in decision-making, mastering new ways of working, using new, deeper knowledge, which is included in the knowledge base, and received from the more experienced specialists. This creates prerequisites for better decisions and, consequently, may increase the confidence in science-based decisions.

Support provided by the DSS is objective and unbiased, it is not subjected to the influence of the decision maker interest or lack of knowledge. As an artificial object, the DSS does not have the imagination, creativity and not exposed to subjectivism and conservatism. Therefore, any DSS will be "successful" if it is deeply thought out at the design and implementation, if the knowledge base includes modern validated and tested knowledge, if, when needed knowledge processing, the successful algorithms are used and user-friendly and ergonomic interface is implemented that takes into account the user working style.

The first fundamental works in the field of DSS has not yet assumed a very close conceptual chumming up with technologies of artificial intelligence (AI), but in 90's of the last century, an undoubted priority of AI in solving the problems, for which there is no other effective methods, was noted [5, 6].

Filip, F.G., Břbat, B., noted in [8] that the AI methods have some (from average up to significant) application in goals setting and tasks classifications, and also are applicable to establish possible alternatives, especially by experienced users.

In expert systems there is implemented the possibility of "introspection" in terms of knowledge completeness and correctness, searching for connections between them, the possibility of replenishment at the expense of logical procedures.

Expert systems as a basic information technology based on the AI have a similar architecture (the knowledge base, inference engine, interface) with the classical concept of Bonczek, Holsapple, Winston (BHW) for DSS [9].

Decision support systems in medicine were the first who have been in the history of development of AI. Originally conceived as systems for medical diagnostics, they further covered aspects of management, healing process monitoring, administration, and naturally, the diagnostics as well.

2 Clinical Decision Support Systems (CDSS)

Development of decision support systems in medicine began with passive support, that is search for necessary information and implementation of some simple calculations, then gradually passing to a cooperative and even extended support, when the system encourages the decision maker to improve the proposed by CDSS solutions, influences the way to deal with the problem, giving him priority in selection.

Out of the many definitions of CDSS, we will follow the one placed in www.openclinical.org by Dr. Robert Hayward: "Clinical Decision Support systems link health observations with health knowledge to influence health choices by clinicians for improved health care".

In [16] the CDSS are classified as:

- *Administrative CDSS*, which provide support for clinical documentation, procedures authorization, prescriptions, recommendations for address to specific specialists.
- *CDSS of Management* of complex aspects in clinical activities, that provide support for the protocols of investigation and chemotherapy, support of referrals to physicians, monitoring the implementation of prescriptions and price control, that monitor the orders for medications, prevent duplication of analyses, exclude the non-obligatory ones.
- *CDSS of support for decisions in clinical diagnostics* and for maintaining the treatment plan, to stimulate advanced practice.

In this classification the problems of solutions for maintaining the treatment plan and stimulating the advanced practice, that hardly differ from the problems of diagnostics, are combined, in our opinion, somewhat arbitrarily. Also in the definition given in Wikipedia "Clinical (or Diagnostic) Decision Support Systems (CDSS) are interactive computer programs, which are designed to assist physicians and other health professionals with decision making tasks", no distinction is made between diagnostic and other types of CDSS.

CDSS realizing assistance to manager in carrying out his decisions on administration and management are close enough to traditional and other areas of activities.

Diagnostic decision support systems are fundamentally different from the systems intended for management and administration by the structure and methods of solving problems as well. One can see this especially well from the review of strategies used by early CDSS, Shortliffe, Buchanan and Feigenbaum [14] which distinguish the following classes:

- clinical algorithms,
- clinical databanks that include analytical functions,
- mathematical pathophysiological models,
- pattern recognition systems,
- Bayesian statistical systems,
- decision-analytical systems,
- symbolic reasoning (sometimes called expert systems).

Being not all-embracing, the review describes some of the early efforts that led to many classes of today's diagnostic systems. Current status of development projects and application as well as the already established terminology in the field of CDSS and diagnostic systems is given in [23].

3 Diagnostic Decision Support Systems (DDSS)

DDSS at early stages were perceived by doctors rather simplistically as: "a machine algorithm that supports the clinician in one or more components of the diagnostic process" [13] or as "a process of definition in the process of investigation of nature and circumstances of the disease formation" [12].

Establishing the diagnosis – is a process preceding the suggestion of therapeutic or surgical treatment. Diagnosis – is a process consisting of separate steps. These steps begin with establishing the certain facts in the process of examination and lead to the inference that the obtained facts correspond to some conclusion or begin with some preliminary diagnosis achieving the conformity of the set of objective facts of the patient state to confirm the presumptive diagnosis or reject it, if the facts do not correspond to or contradict the assumption. Even if the start and end points of the process may be identical, the steps followed by two doctors could differ very much, and at the same time, the diagnostician can take various steps in two almost identical cases. Since the investigation is a creative process based on knowledge, experience and creativity of the doctor, different people may face the problems in valuation of the same patient. Diagnosis as an interpretation of the results of a number of observations, is potentially recursive and essentially defined by consistently complicating classes of diagnostic tools.

In general, DDSS do not generate a single conclusion (diagnosis), and usually suggests several ones, based both on patient data, and on the knowledge embodied in the base, which does not contradict the observed facts and the relationships that exist between them. Because the doctor knows more about the inspected patient, and at the base the general knowledge tested on many patients are embodied, he must make the choice and leave the conclusion adequate to the state of specific patient.

It was considered that the aim of the early systems is to provide the user with information on his "questions", while the user was seen as a "filter" actively interacting with the system, rejecting the erroneous and useless information. This focus on user interaction with the system was important for determination of the ways of systems application.

Among the functions of decision-support systems in medicine E.Coiera in "The Guide to Health Informatics" [17] noted:

- Automatic provision of expert with relevant opinions, recommendations based on the updated sources, proceeding from the most competent knowledge and experience of specialists;
- Reducing qualitative variations in patient medical service;
- Support for education and improvement of physicians' qualifications;
- Providing immediate feedback to the patient;

- In the case of an integrated system – help in organizing the process to support medical history, diagnoses, treatment;
- Research support;
- Providing clinical information at any time and anywhere there is a necessity.

Kawamoto et al [11] studied the success factors for decision-support systems in medicine and consider that the four of them are basic for successful implementation of CDSS:

- automatic reminders/alerts are foreseen in the process of work;
- explanations of the issued decision (diagnosis) are foreseen;
- unacceptable recommendations are not generated;
- process is completely computerized.

As we see, on the whole, findings relate to diagnostic decision support systems, although the authors attributed them to all clinical medical systems.

In the structure of the majority of DDSS, one can pick out three components: knowledge base, the inference or reasoning engine, and tools to communicate with the user (interface), that is fully consistent with the concept of BHW, put forward by Bonczek, Holsapple and Winston [9].

Knowledge base of decision support system contains information about diseases and their symptoms. Knowledge base consists of the accumulated information, which is often but not always, in the form of rules "if – then". Forsythe, Osheroff and colleagues [10] pick out three components of information required in the examination process, which should be provided by DDSS:

(1) information which currently satisfies the needs (relevant for this investigation information known to clinician);

(2) realised information needs (information recognised by the clinician as important for the examination, but is not yet known to him);

(3) unrealised needs for information (information that is important for this examination, but not realised by the clinician as being important).

The process of knowledge acquisition is the key to the design of any DSS, including the DDSS. Practice of the development projects requires a good structuring of the problem domain. As a rule, knowledge is represented by a rigid scheme in a tree or a semantic network.

Mechanism of logical inference contains formulas which combine rules or associations in the knowledge base with actual patient data. The mechanism of logical inference reflects conformity of the patient's symptoms with presumed pathologies or diseases, and offers the physician via interface to consider a possible conclusion.

Mechanism of communication is a way to enter data about the patient into the system and obtain by the user the inference of the system via interface, for taking a decision. In some autonomous systems, data about the patient should be entered directly by the user.

DDSS gives the clinician recommendation on the request or draws his attention to the special cases (cases of alerts), automatically.

Luger and Stubblefield [15] identify five "defects" common to the technology of expert systems that put private problems associated with judgements in areas such as medicine. They are inherent in all knowledge-based DDSS with the knowledge base and inference or reasoning engine and summarised below:

- Lack of "deep" (causal) knowledge of the area (that is, systems do not sufficiently understand the physiology);
- Lack of reliability and flexibility. Systems, when faced with the problem not contained in their knowledge base, can not:
    - solve the problem,
    - recognize that it is not able to solve the problem,

- develop a strategy for further actions;

- Failure to provide profound explanations;
- Difficulties in conclusions control;
- Inability of systems to learn from the application experience.

4 Decision Support Systems in ultrasound diagnostics. Sonares.

Ultrasound investigation to diagnose is an effective and widespread procedure. Nevertheless, its use does not always come up to expectations, encountering some difficulties associated with dependence on the operator, which affects the quality of the obtained images, the way of their description and interpretation, as well as the method of interpreting the description of another specialist.

It should be stressed that consecutive losses of the information accuracy are inherent to the process of ultrasound examination. An analog signal transmitted by the probe is converted into a digital one and used to construct an image that (quite subjectively, depending on qualifications and experience) is interpreted by the operator. To overcome these shortcomings the information systems are being developed [21,22,26], whose purpose is to reduce the influence of subjective factors by assisting in the examination process.

These systems can be used as a second opinion, helping the physician-echographist in obtaining higher-quality images, in the process of interpretation of the obtained images, in the formulation of conclusions.

From the functional point of view one can distinguish:

- Systems attending the ultrasound apparatus (such as Integrated Cath Lab – the company Philips, SonoFly 3000 – Ukraine);
- Functionally separated (Siemens platform, SonoConsult, etc.).

From the conceptual point of view the DSS in ultrasound diagnostics are divided into two categories:

- Based on the analysis and classification of images;
- Based on the knowledge representation by rules.

Analysis of opportunities of a number of DDSS for ultrasonographic examination and their application experience became starting point to develop the system SonaRes [24].

The system SonaRes is designed to assist the doctor-diagnostician in the examination process of the abdominal zone – a particularly difficult both because of the large number of organs, and because of the need to take into account the interaction between them.

The system SonaRes operates the knowledge represented both by rules and by images, and has an integrated database, inhomogeneous elements of which are decision rules, original and processed images with annotations, etc.

Study of existing diagnostic systems permitted to identify the functions that they should have, but do not possess completely. Therefore, to be more useful, the system SonaRes is equipped with:

- Expert workplace with an interactive interface that supports the process of knowledge extracting;
- User workplace with intelligent interface;
- Examination reports generator;
- Tools to explain the conclusions;
- Ability to replenish the knowledge base on the basis of precedents that have occurred in the process of using the system and tested by experts;
- Ability to take the interaction between organs into consideration;
- Tools for image processing;

- Ability to use the system in training.

Main components of the system SonaRes are:

- Module of knowledge acquisiton and validation;
- Integrated base (of knowledge, images, annotations, examination reports) and tools for its management;
- Module of image processing and algorithms for fast search of the similar images;
- Tools for examination process support;
- Generator for examination reports.

Here is a brief overview of the SonaRes components.

The *first module* – knowledge acquisiton and validation – is designed to support and communicate effectively with experts in the development of a knowledge base. It is created by the principle of expert shell. The main stages of development are: problem identification, knowledge acquisiton, structuring, formalization and the direct implementation of expert system.

The experts experience and specialist literature served as the main sources of knowledge.

In order to work out the methodology and technology, that can be extended to the entire abdominal zone, the gallbladder and pancreas were taken. Necessary knowledge for the examinations of these organs were obtained from medical experts who have extensive experience in ultrasound diagnostics, and namely:

- Structured information about organs localization, including method of visualization of typical areas (also called zones of interest), objective conditions for visualization, considerations about possible non-vizualization, objective conditions of visualization complicating;
- Main characteristics of organs descriptions (number, size or volume, shape, contour, etc.);

- Structured information about pathologies and anomalies, each of them being determined from the characteristics modifications of organ (anomalies of shape, size, quantity, etc.);

The knowledge obtained from the experts is stored in the knowledge base and presented in a hierarchical tree. Initially, this structure was also the basis of some other components of the system SonaRes, which are also based on tree structure: interface for examination, validation of rules. Rules have been checked by the validation tool which has an interface that allows one to imitate the process of examination, save and restore sessions.

Doctor (user of SonaRes like of any other system) has its own habits in the examination, his way of thinking, specific knowledge and experience that usually do not meet the strict tree-like structure.

In the process of checking the functioning of the system there had revealed a need and was offered a complementary alternative matrix form of representation of the knowledge base, which permitted to eliminate some "discomforts" at the interaction of interface with the knowledge base in terms of technology, to make the interface more and more common for everyday practice of the diagnostician, to accelerate the process of routine examination (at that, do not excluding the possibility of detailed organ examination).

A number of contradictory demands was taken into account in the development of the *second component* – a unified base of data, images, annotations, examination reports. Since the examination is conducted in real time, sometimes, especially in emergency situations, response time is the critical value. On the other hand, some information from the database, namely, personal data of the patient, must be reliably protected. And, finally, being designed for widespread use, the system can not be focused on the most powerful and modern equipment, but must ensure the reliability, performance and security features, even in cases when the system operates at the computer with limited resources. The unified base is independent of the platform, provides easy exchange of data and is multilingual. For the beginning, Romanian and English languages are taken.

The *third component* performs image processing (preprocessing), the search of similar images.

Besides the advantages, the method of ultrasound examination has serious shortcomings – the noise, poor contrast are inherent to ultrasound images, they suffer from changes in lighting and from appearance of shadows hindering the identification of regions of interest. Thus, for the beginner in ultrasound examination, or even for a doctor with a lack of experience it is difficult to identify the organ pathology, basing on only one image. In addition, getting a "qualitative" organ image is directly dependent on the experience of a doctor. Developing a system for both experienced and inexperienced ecographists, we considered that the main purpose is the quick search for images similar to that obtained in the examination process.

First, all the images from the database are classified (clusterisation I), depending on the diagnosis of organ – if there is some pathology or a description of the organ normal state. The organ diagnosis is based on the qualitative and quantitative values of the descriptors – characteristics of the organ, which are defined by a doctor-ecographist in the examination process. One of the important tasks, as already noted, is to find those images that are "close" to the being examined image. Further clusterisation (clusterisation II) is carried out depending on the images statistics. It is necessary to identify regions of interest for calculating the difference between the investigated image and images from the database.

Therefore, some statistical descriptors (eg, histogram, mean and standard deviation of the intensity of the image, the average standard deviation of the intensity of the zone) were calculated for each image. The advantage of these statistical descriptors, compared to the mentioned above, is that they are independent from the experience of the doctor and refer to a particular image.

For images included into the database the hierarchical structure of quantitative descriptors is built, which is used for quick search for images similar to the being examined one.

The last task – one of the most difficult.

Tools to support the examination process, included into the fourth component, permit to select one of the main ways of examination, which correspond to the doctors usual methods of work:

- *step by step*, i.e. studying the obtained image, the physician selects the attributes from a list and fixes their values. Depending on the values of selected attributes, one or more conclusions are proposed which correspond to the rules from knowledge base, that satisfy the obtained values. The conclusion may be accompanied by the image, in which areas of interest are highlighted, if the diagnostician thinks it is necessary for the treating physician. By special request, the annotated images from the integrated database, similar to the one obtained in the current examination, are given out, which allows to consult with cases approved by experts. This method significantly reduces the time required to obtain a conclusion, i.e. examination results, raises quality, promotes the formation of correct actions and mentality in the field of ultrasound diagnosis, which is a very important point in teaching, encourages the use of correct terminology.

- *from the presumed pathology* to its confirmation or refutation. Following this path, the physician determines whether or not there are facts contained in the rule, which corresponds to the presumed pathology. This path can be used by more experienced physicians.

- *mixed* path, which allows the clinician to alternate in the examination process both, the procedure from pathology and the more detailed one – step by step.

To assist in the examination process thesaurus has been developed. A sufficient number of terms should be presented in it, that provide a clear picture of the full spectrum of clinical concepts. It can be used autonomously as encyclopedic reference book, and also as the help function, integrated in examination interface, to obtain information and explanations of terms that appear in the process of examination. For each term its definition is given, synonyms, translation (at first in Romanian and English languages). All terms may have only a single meaning and every meaning corresponds to only one term. Encyclopedic reference book is also supplied by videos (remember that ultrasonography can see the organ in dynamics). Inquiries from the thesaurus can be obtained by various criteria: key words, combinations of words, search by topic.

The last component of the system - generator of examination reports. Traditionally, the medical conclusion of the examination consists of: data about patient, image, quantitative measurements in the examination, and a physician conclusion in arbitrary form. The examination report given out by SonaRes, contains data obtained during the examination, so they are structured, and the conclusion consists of the rules corresponding to the measured values. Data that can not be obtained during the diagnostic session, and bear a specific nature (require biochemical or analysis of other nature), are recorded by a physician in his usual free form.

Operation of the system is provided by the developed:

- formalized descriptions of the abdominal organs, pathologies, anomalies;
- formalized descriptions of the ultrasound investigations methodology;
- means of extracting and presenting knowledge about organs and their pathologies,
- means of representation the data obtained during ultrasound examination,
- tools for validation of hypothetical diagnoses,
- tools for images processing to improve their perception,
- tools for regions of interest picking out,
- algorithms for similar images search,
- an ergonomic, dynamically generated and user friendly interface, by means of which the examination process is supported,

- generator of examination reports.

SonaRes: peculiarities

- Guides the examination process, adapting it to different levels of doctor's experience
- Supports the reporting, assuring common standards
- Prevents possible errors in the process of examination (such as omitting the examination of some important aspects, skipping some characteristics or admitting some inaccuracy in formulation of conclusions etc.)
- Offers the possibility to use experts' experience, which is collected in the data base of the system, to view annotated images, similar with that under examination.
- Processes captured images in order to increase their quality or to distinguish some special zones or characteristics
- Offers the possibility to be used for training
- Keeps electronic records of investigations (to have the possibility to observe the disease dynamics, to collect statistics etc.)

5 Conclusions

Benefits from the use of computer systems in hospitals was among the most contentious issues for health care workers within a decade. In developing the early clinical computer systems it was supposed that the ability of computers to store information from the patient history, physical findings, and laboratory data will help in the decision making, allowing the physician to focus on other aspects of clinical work.

However, enthusiasm about the potential of computer systems as an intelligent tools, was quickly destroyed. There have been studies that conclude that such systems do not have any useful role in diagnostics.

Gradually there came the understanding that the computers' strength is not so much the ability to store large amounts of information and performing calculations with great speed, but in intellectual analysis and bringing up variants of decision.

Shortliffe [28] first applied in 1973 a clinical expert system based on the rules for the diagnosis and therapy MYCIN1.

Over the years, there was developed by a large number of rule-based DDSS, most of which are devoted to narrow application areas and because of the extreme complexity of the maintenance of rule-based systems with thousands of rules, they are not widely used.

Perhaps this is natural if the tools simplifying the process of examination and making it closer to the usual practice of a physician are not found.

In SonaRes it was a success to find new principles and a less rigorous method of presentation and management of structured knowledge than as a tree or a semantic network, which in turn allowed a more familiar and comfortable for the physician interface.

Two elements of DDSS, regardless of the environment in which they are used, are important for their success. They are:

- the mechanism by which the system acquires knowledge used in decision-making algorithms;
- user interface, providing interaction of the system with clinicians, to report on their results.

Both of these mechanisms in the system SonaRes showed their efficiency and convenience for the user.

References

[1] F.G. Filip. *Decision support systems*, Editura tehnica, Bucureşti, 2007

[2] V. Briefs. *Re-thinking industrial work: computer effects on technical white collars workers.* Computers in Industry, 2(1), 1981

[3] G. Johannsen. *Integrated systems engineering the challenging cross discipline*, Proceedings IFAC Conference on Integrated systems engineering, Pergamon Press, Oxford, 1994

[4] *Building Effective Decision Support Systems*, Prentice Hall, Englewood Cliffs, New Jersey, 1982

[5] C.W. Holsapple, A.B. Winston. *Decision Support Systems. A Knowledge-based Approach*, West Publishing Co., Minneapolis, 1986.

[6] V. Dahr, R. Stain. *Intelligent Decision Support Systems; The Science of Knowledge Work*, Prentice Hall, Upper Sadle River, New Jersey, 1997.

[7] T.J. Hess, L.P. Rees, T.R. Rakes. *Using autonomous software agents to create the next generation of decision support systems*, Decision Science, 31, (1), 2000.

[8] F.G. Filip, B. Barbat. *Industrial Informatics: new paradigms and applications*, Editura Tehnica, Bucureşti, 1999 (in Romanian)

[9] R.H. Bonczek, C.W. Holsapple, A.B. Winston, *Foundations of Decision Support Systems.* Academic Press, New York, 1981

[10] D.E. Forsythe, B.G. Buchanan, J.A. Osheroff, R.A. Miller. *Expanding the concept of medical information: an observational study of physicians information needs.* Comput Biomed Res 1992;25:181-200.

[11] K. Kawamoto, C.A. Houlihan, E.A. Bala, D.F. Lobach. *Improving clinical practice using clinical decision support systems: a systematic review of trials to identify features critical to success.* BMJ 2005;330:765.

[12] . F. T. de Dombal. *Ethical considerations concerning computers in medicine in the 1980s.* J Med Ethics 1987;13:179-184.

[13] R.A. Miller. *Why the standard view is standard: people, not machines, understand patients problems.* J Med Philos 1990;15:581-591

[14] E.H. Shortliffe, B.G. Buchanan, E.A. Feigenbaum. *Knowledge engineering for medical decision-making: a review of computer-based clinical decision aids.* Proc IEEE 1979;67:1207-1224.

[15] G.F. Luger, W.A. Stubblefield. *Artificial intelligence and the design of expert systems.* Redwood City, CA: Benjamin/Cummings Publishing Company, Inc.; 1989.

[16] www.openclinical.org

[17] E. Coiera. *The Guide to Health Informatics*, 2nd Edition, Arnold, London, 2003.

[18] F.T. de Dombal, D.J. Leaper, J.R. Staniland, A.P. McCann, J.C. Horrocks. *Computer-aided diagnosis of acute abdominal pain.* Br Med J. 1972 Apr 1;2(5804):9–13.

[19] K. Kawamoto, C.A. Houlihan, E.A. Balas, D.F. Lobach. *Improving clinical practice using clinical decision support systems: a systematic review of trials to identify features critical to success.* BMJ. 2005 Apr 2;330(7494):765. Epub 2005 Mar 14. Review.

[20] M. Huettig, G. Buscher, T. Menzel, W. Scheppach, F. Puppe, H.P. Buscher. *A Diagnostic Expert System for Structured Reports*, Quality Assessment, and Training of Residents in Sonography. Medizinische Klinik, 2004, 99, nr.3, p117–122.

[21] http://cabinet.fromru.com

[22] M. Huettig, G. Buscher, T. Menzel, W. Scheppach, F. Puppe, H.P. Buscher. *A Diagnostic Expert System for Structured Reports*, Quality Assessment, and Training of Residents in Sonography. Medizinische Klinik, 2004, 99, nr.3, p117–122.

[23] *Clinical Decision Support Systems. Theory and Practice.* Second Edition Eta S. Berner, EdD, Springer Science+Business Media, LLC, 2007

[24] S.Cojocaru, C.Gaindric. *Clinical decision Support System Sonares,* International Journal Information Theories & applications, v.15, N 2, 2008 pp.137–143

[25] I. Secrieru. *Structured knowledge management techiques for the development of interactive and adaptive decision support system,* Computer Science Journal of Moldova v.17 N1 (49), 2009, pp.58–73

[26] l. Burtseva, S. Cojocaru, C. Gaindric, E. Jantuan , I. Secrieru, D. Sologub, *SONARES-A decision support system in ultra sound investigation*. Computer Science Journal of Moldova v.15 N2 (44), 2007, pp.153–177

[27] E. Boian, L. Burtseva, S. Cojocaru, C. Gaindric, V. Turcanu. *Architecture of the ultrasound diagnostic system SonaRes,* Proceedings ECIT 2008- 5th European Conference on Intelligent Systems and Technologies, Iasi, Romania, July 10 -12, 2008, CD, Performantica

[28] E.H. Shortliffe. *Computer-based medical consultations: MYCIN.* New York: Elsevier; 1976.

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