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CLINICAL DECISION SUPPORT SYSTEM SONARES

Svetlana Cojocaru, Constantin Gaindric

Abstract:. A decision support system SonaRes destined to guide and help the ultrasound operators is proposed and compared with the existing ones. The system is based on rules and images and can be used as a second opinion in the process of ultrasound examination.

Keywords: decision support systems, knowledge acquisition, image processing, ultrasound examination.

Introduction

We will describe a decision support system SonaRes, destined to support ultrasound diagnostics. The system plays a consultative role and offers to users its variants of diagnosis. System's solutions are motivated by presenting method(s) of its obtaining and the corresponding images that help to understand its reasons.

The problem of assuring an adequate medical assistance to the population depends both on training and qualification levels of medical personnel and on performance of the used diagnostic equipment. Nowadays it is impossible to offer medical services, even at the most modest level, without using of medical equipment, apparatuses, devices and technical complexes. Applications of medical equipment are very diverse and include diagnostics, treatment, supervision, compensation of a lesion or a handicap, etc.

There is no doubt that technical assistance in medicine is as important as in pharmaceutical assistance. The technical assistance in medical examinations is impossible without strong qualification of staff that exploits this equipment and interprets the obtained information. The quality of medical services also directly depends on how correctly and efficiently the medical diagnostic and treatment/recuperation equipment is used.

Ultrasound equipment is much cheaper than the MRI - Magnetic Resonance Imaging, CT – Computer Tomography, digital radiography etc, and its rational and efficient use could fill in many gaps in medical diagnosis. Technical progress of the last years in the field of ultrasound diagnostics allowed these methods to come to a leading position among imagistic procedures.

Echography has proved to be one of the most usable and beneficial paraclinic investigations as it is non-invasive and extremely efficient, has a great accuracy in its area of application, and is executed easily by a well-trained specialist. Despite the enthusiasm it meets, the echography has its real limitations like any other procedure.

They are expressed sometimes through false-negative or false-positive images; sometimes these limitations are imposed by an examining physician's ability to obtain qualitative images or to interpret them.

In order to obtain quickly correct information on the specific case based just on images and their descriptions, it is important to create a unified system that will allow storing of the images and their annotations. Special techniques should be developed to annotate images. This collection of images and annotations will help ultrasound technicians to justify their final conclusions.

The primary use of the system might be as a 'second opinion' in difficult cases and in emergency; it does not replace physician who interprets echograms. Thus, SonaRes is destined to improve health care by providing a highly efficient diagnostics tool. The tool is well-suited to needs and current state of the medical equipment in hospitals and clinics.

A comparison with existing systems

Presently, there are only a few decision support systems for ultrasound diagnostics in the world, even though the attempts to elaborate systems of the kind have been started since 1970's. We can refer to publications in the mentioned field [Diez, 1997-Cabinet].

Some of the most known systems created for ultrasound investigation we can mention are DIAVAL [Diez, 1997] designated for echocardiography, ProtoISIS [Anderson, 1994, Kahn] (ultrasound and computerized tomography), SonoConsult [Huettig, 2004] et al.

Till now two basic approaches were applied to development of computer assisted ultrasound diagnostic systems:

a) Systems based on image analysis and classification.

Such systems pursue the purpose to make the decision on the basis of comparison of the initial images with those from a database (DB). The comparison helps to classify the available image according to classification existing in a database and/or give the user an opportunity to define a degree of its similarity with images available in a database. In the case of detection of similarity to any image (precedent) the decision based on already known decision for the existing precedent is given out.

b) Systems based on rules.

Such systems pursue the purpose to make the decision on the basis of the description obtained from the user and the data available in system and rules. More often such systems serve for information or training purpose with or without an additional diagnostic component.

In ProtoISIS the classification of images is made on the basis of 4 sets consisting from 25 precedents each. The probability of correct classification makes 72-84%.

Better results have been received in the system described in [Huo, 2001 - Drukker, 2004] concerning the domain of computerized detection and classification of cancer on breast ultrasound. A two-stages computerized method has been developed: the detection stage and classification stage. At the first (detection) stage the suspicious regions in ultrasound images are detected and subsequently distinguished among different lesion types. After the detection stage all candidate lesions are classified by a Bayesian neural net, based on computer-extracted lesion features. Two separate tasks are performed and evaluated at the classification stage. The first classification task is the distinction between all actual lesions and false-positive detection; the second classification task is the distinction between actual cancer and all other detected lesion candidates (including false-positive detection's).

First stage, gives the performance values of 94% and 91% for training and testing data sets respectively. Second stage, based on candidates lesion classification, gives the performance values of 87% and 81% for training and testing data sets.

SonoConsult is a knowledge-based system which uses simple and complex rules to make a required decision, promotes completeness and carefulness of input of patient's state, and thus helps to minimize an opportunity of reaching the erroneous judgment.

The following table contains the main features to be incorporated in the developing system and points those features which reside in the existing systems.

	SonoConsult	Bayesian Network	ProtoISIS	LookInside	tCaUD	Syngo US WS	IMAGE-IT	ULTRA 32(64)	Makhaon PACS	Roentgenprom WS	SonaRes
Use of both the images and their descriptions	_	X	–	X	–	X	X	X	X	X	X
The interactive interface for knowledge acquisition	–	–	–	–	–	–	–	–	–	–	X
The intelligent interface	–	–	–	–	–	X	X	X	X	X	X
Expertise reporting	X	–	–	–	X	X	X	X	X	X	X
Explanation of the decision	–	–	–	–	–	X	X	X	–	–	X
Possibility of adding to knowledge base on the basis of precedents	X	X	X	X	–	–	X	X	–	–	X
Examination of the organs interaction	–	–	–	–	–	–	–	–	–	–	X
Image processing	–	–	X	–	–	X	X	X	X	X	X
The standardized descriptions and decisions	X	–	X	X	X	X	X	X	X	X	X
Possibility to use the system in automated learning	X	X	X	–	–	X	X	X	X	X	X
Treating of patient's state in dynamics	–	–	–	–	X	X	X	X	X	X	_

One can compare ten best and well-known existing systems using the data from the table:

- SonoConsult [Huettig, 2004], which is an expert system for structured and case-adequate documentation of sonographic findings with an additional diagnostic component;
- Bayesian Network [Haddawy, 1994] is a technique for reasoning under uncertainty, currently is being developed for application to medical decision making;
- ProtoISIS [Anderson, 1994, Kahn] is a decision support system, based on comparison of initial researched image with the images from the images' database for the purpose of similarity determination;
- "LookInside" [capabilities] is designed to operate with database of patients amenable to ultrasound examination;
- "The Cabinet of Ultrasound Diagnosis" (tCaUD) [cabinet] is also designed to operate with database of patients amenable to ultrasound examination.
- Syngo US Workplace [Syngo] is developed by Siemens Medical Solutions. It offers tools for archive, reporting and image processing.
- IMAGE-iT [IMAGE-iT] is developed by ASHVA TECHNOLOGIES and presents a software oriented to image processing, storage, reporting.
- ULTRA 32 (ULTRA 64) [ULTRA] is developed by SONULTRA CORPORATION. It is a system to support the reports construction, acting directly from data obtained by ultrasonographic scanners.
- Makhaon PACS [Makhaon] is a workstation supporting DICOM standard, contains a reporting module based on patterns international pathologies classifier.
- Roentgenprom [roentgenprom] is a system to support the investigation process. It offers some patterns for organs description according to a standard methodology.

From the table one can determine good characteristics and weak points of analyzed systems. We can see that no one system is taking into account interaction between organs. The system SonoConsult, which shows some performance results during its utilization, and is very appreciated by the specialists-physicians, has the most similar aim.

Main goal and system structure

Our goal is to develop an approach which includes interaction between organs and uses current and precedent similar images in decision making process. Special attention is paid to ergonomic user interface, which is

generated dynamically by system according to the DB content and is adaptable to preferences and objectives (of investigation type) of the physician-echographist.

We will offer to specialist, even without wide experience, an access to a resource where the process of ultrasound examination is detailed and formalized and includes an enormous amount of useful information on anatomy, ultrasonic semeiology, differential diagnostics as well as condensed presentation of the main nosologic entities that should appear in the physician's mind at the moment of examination of each organ.

The system SonaRes helps the specialist in ultrasonic analysis to draw the conclusion more correctly, especially, in emergency cases or in unspecific clinic/paraclinic cases, which do not seem to be included in any classical presentation; in cases where they obtained ultrasonic semeiology can provide a correct diagnosis without complicated and, often difficult of access, medical investigations.

SonaRes offers to a user a second opinion with necessary explanations and images that are similar to the examined case. Images can be processed and problem zone, if it is necessary for the user-physicist, can be marked out.

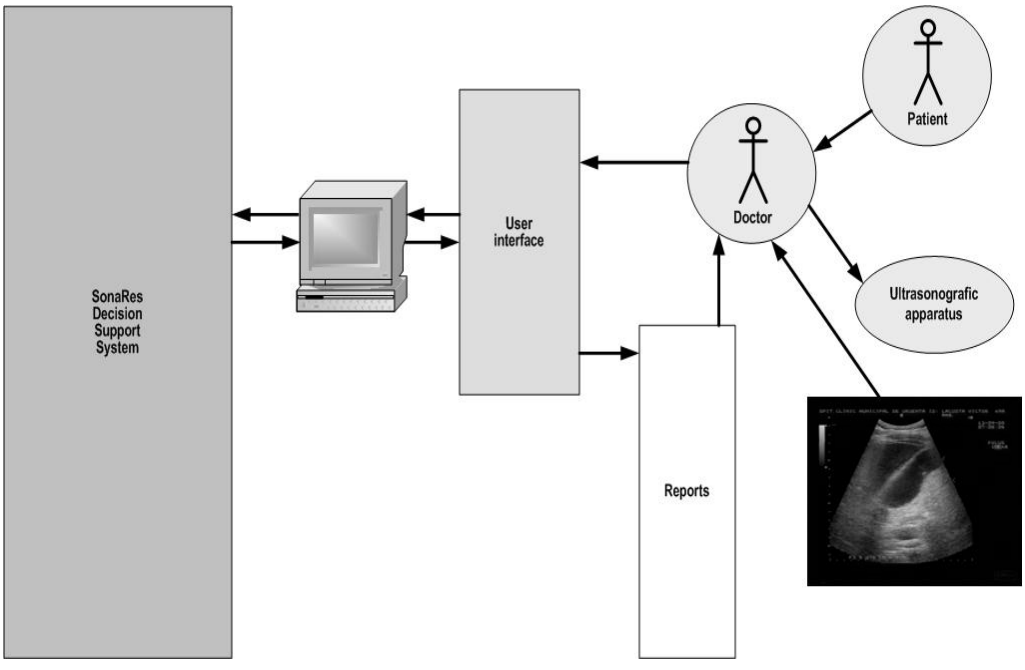
The main components of the system are the following:

- Knowledge acquisition
- Examination support
- Unified database (knowledge, images, annotations etc.)
- Image processing algorithms
- Reports generator

In order to develop these components we are elaborating and adapting:

- formalized descriptions of the abdominal organs, pathologies, anomalies;
- formalized descriptions of the ultrasound investigations methodology;
- unified, standardized disease descriptions;
- knowledge acquisitions methods based on ultrasound investigations characteristics;
- a diagnostics validation tool;
- a database model for medical images, their annotations and fuzzy information storage;
- images clusterization and quick database searching algorithms;
- an ergonomic, dynamically generated and user friendly interface;
- reports' prototypes and their generator.

The scheme of patient investigation process



At the first stage we deal with abdominal zone investigation. The investigation process of this zone is especially difficult (more organs with additional interactions, higher level of confusion, etc.). We have approved our technique on gall bladder and extend it on other organs.

Knowledge structure modeling

As models of knowledge representation in the medicine domain a model based on rules or a semantic network usually are chosen. In both cases the problem is reduced to [Secrieru, 2007, Popcova, 2006] :

- determination of objects, concepts and their attributes which are used in the given problem area;
- definition of links between concepts;
- determination of metaconcepts and detailed elaboration of concepts;
- construction of the knowledge pyramid, being scale of metaconcepts ranks, rising on which means the deepening in understanding and increasing the level of metaconcepts generalization.
- validation of rules representing knowledge.

Knowledge validation

A set of trees representing decisions rules are constructed based on data tree structure and using knowledge about organ's pathologies and anomalies. These trees contain all the necessary factors which can help to produce a conclusion. The validation goal is to evaluate the knowledge base correctness and completeness. One can obtain this information by testing the existing rules. The testing is performed by physicians, in order to do this work in more efficient way a validation tool was elaborated, which permits to simulate the examination process and evaluate the obtained conclusions.

The tool offers the possibility to obtain various conclusions modifying the attributes values. During the validation process the current session containing all the selected attributes values is saved. Thus to simulate a new examination which differs from the previous one just by one attribute it is sufficient to modify only one value. Also it is easy to establish the list of rules containing a specific combination of attribute-value [Jantuan, 2007].

Image processing

Non-using of images during decision-making process can lead to the loss of the valuable information and does not correspond to daily practice of the doctor. Therefore we use a collection of annotated images stored in Image DB, which can be used as illustrations in similar disease cases. Ultrasound images from DB will be preprocessed in interesting zones to facilitate their clusterization (this is necessary for quick and relevant search).

Image preprocessing will be performed using existing algorithms (image processing algorithms, adapted to ultrasound diagnostic methodology), as well as by using the new ones (based on heuristics, fuzzy, pattern-oriented filters etc.). The following image processing methods [Dzung, 1998 - Popcova, 2004] were applied: statistical treatment, noise reduction, contrast adjustment, borders and organ contours determination etc. and their combination to obtain more efficient result.

Examination support

The proposed method of acquisition (by means of expert shell) and storage of expert knowledge in Unified DB permits to effectuate a quick search of necessary information in two directions or modes. The first direction is from the concrete case description to determination of pathology and/or an anomaly; and the second one – from formulation of a hypothesis to its confirming or denying.

Following the first direction the user gives the necessary information describing a concrete case, and the system tries to determine if it is a pathology and/or an anomaly. To exclude at the early stage the input of inconsistent, erroneous or excessive information, this direction is followed step-by-step. If at any step the system can determine, on the basis of the entered information, a pathology and/or an anomaly, it informs the user.

Following the second direction, the user forms a hypothesis about presence in the concrete case of pathology and/or an anomaly. Then the system by means of additional questions tries to confirm or to deny this hypothesis.

Realization of both modes within the framework of unified support system of ultrasonic investigation process corresponds to the daily work of physicians. The first operating direction satisfies the requirements of the detailed patient examination; and the second direction corresponds to a simplified one, when it is necessary to confirm or to deny any diagnosis

A convenient dialog with user-physician (due to dynamic intelligent interface which includes a standardized explanation of the decision proposed by system) involving images in decision making process (based on visualization and comparison of ultrasound examined image with similar images from Image DB) will permit to create a comfortable environment for physicians and will help him to prepare a standardized report, containing the examination results and, if necessary, the recommendations for additional investigation.

Conclusion

The proposed system does not intend to replace completely the physician; it just will offer him a second opinion. In all cases user will receive all rules and judgments on the basis of which the decision was made. If the user doesn't agree with the decision, proposed by the system, his opinion will be sent to expert group for examination.

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AUTOMATED RESPONSE TO QUERY SYSTEM

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Abstract: SMS (Short Message Service) is now a hugely popular and a very powerful business communication technology for mobile phones. In order to respond correctly to a free form factual question given a large collection of texts, one needs to understand the question at a level that allows determining some of constraints the question imposes on a possible answer. These constraints may include a semantic classification of the sought after answer and may even suggest using different strategies when looking for and verifying a candidate answer. In this paper we focus on various attempts to overcome the major contradiction: the technical limitations of the SMS standard, and the huge number of found information for a possible answer.

Keywords: mobile text messages, text message analysis and question-answering system

ACM Classification Keywords: I.2 Artificial intelligence: I.2.7 Natural Language Processing: Text analysis.

Introduction

This paper represents results of our further research in the text data mining and the natural language processing areas [1-5] restricted by mobile's text-based SMS messaging. SMS is now a very powerful business communication technology widely used from small businesses and home users through to large corporations, governmental and non-governmental organisations. However, many of these users have little or no experience of SMS technology and only a vague idea of how successful they could be when properly harnessing the power of SMS communication.

SMS text messaging is currently being evaluated in many different areas:

- Mobile Banking. Mobile Banking Services including: Account Balance Enquiry, Account Statement Enquiries, Cheque Status Enquiry, Cheque Book Requests, Fund Transfer between Accounts Credit/Debit Alerts, Minimum Balance Alerts, Bill Payment Alerts, Bill Payment, Recent Transaction History Requests, Information Requests i.e. Interest Rates/Exchange Rates. (e.g. the HSBC's SMS Enquiry Service [6]). Although these services are appearing they do raise specific issues concerning security, especially when