

Concept of Clinical Computer-based Shared Platform in Domain of Ultrasound Diagnostics

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The concept's general goal is to develop and provide a computer-based multilingual platform designed to assist dialogue within and between the divided communities from both banks of Dniester – stakeholders from medicine, academic staff and policy makers. Utilization of this platform by clinicians and researchers in domain of ultrasound diagnostics from both banks will: 1) permit to collect and store a vast database of ultrasound images and registered cases of pathologies and anomalies, representing a shared experience of clinicians from both banks of Dniester; 2) increase the patients' confidence in physician's conclusion; 3) help to build face-to-face personal contacts; 4) create a good base to promote a common standards in description of ultrasound images in order to facilitate their understanding and interpretation.

Index Terms — clinical computer-based shared platform, domain formalization, knowledge base validation, medical expert knowledge acquisition, ultrasound diagnostics.

I. INTRODUCTION

Physicians are persons who enjoy the confidence of people contacting them. Therefore, establishing ways of cooperation between the representatives of medical communities from both banks of the Dniester can serve as a catalyst to facilitate contacts and increase the confidence level between people from both banks.

Medical diagnostics is inevitable stage in treatment of any patient, and ultrasound diagnostics is the most common method of medical imaging, which continues to expand its area of operation.

Given the above, a team, which includes well-known experts in domain of ultrasound diagnostics and medical informatics, recognized on both banks of the Dniester, proposes as a goal to develop a computer-based shared platform for clinicians and researchers in domain of ultrasound diagnostics, in particular of the hepato-pancreato-biliary system.

II. EARLY DIAGNOSTICS BASED ON ULTRASOUND EXAMINATION TECHNIQUE

Increased incidence of neoplastic processes of abdominal organs, as well as acute pathological states such as severe inflammatory processes and injuries of abdominal organs, and not least chronic hepatitis resulting in cirrhosis and portal hypertensions, determines a high level of morbidity and mortality. A correct early diagnostics allows prescribing an optimal treatment in order to increase survival rate. This is extremely important because the progress of hepatitis and pancreatitis is a risk factor for cancer of these organs.

Ultrasound examination, being a modern technique of imaging, is one of the most widely used methods of medical diagnostics thanks to its accessibility, noninvasive nature and possibility to visualize organs' anatomy in real time. It provides data about shape, volume, structure and organ vascularization, as well as particular relations of lesions with different anatomical structures in the region of interest. Ultrasound is reliable and accurate method for diagnostics of the diseases of

hepato-pancreato-biliary region with sensitivity more than 70-80%. Another important advantage is that ultrasound diagnostics is by far inexpensive compared to many other imaging methods of diagnostics like MRI, CT, etc.

However, this diagnostics technique has its own drawbacks. One can mark out three basic drawbacks, related to the specific character of this method, and one drawback appeared as a result of separation of the medical community from two banks of the Dniester.

The accuracy of ultrasound in detecting pathologies is a good one, but has some limitations, because of both false-positive and false-negative results. In addition, ultrasound images are noisy, blurred in shape, and suffer from echoes. So, the first problem is to obtain a good image, the most relevant and useful for physician's decision-making. This is the main task of an operator, and the reason for which ultrasound investigation is considered highly operator-dependent.

Ultrasound diagnostics of pathological modifications is based on the analysis of characteristic signs from images, obtained for the investigated organ. The resulting conclusion is quite subjective, and widely depends on a physician's experience. So, the second, and probably more important problem, is the interpretation of the obtained ultrasound images.

The third problem is associated with the development of new transducers or improvement of old scanners. This does not simplify, but rather complicates physicians' diagnostic thinking, because they have to analyze a much larger number of diagnostic data, which typically reduces the accuracy and increases the time of diagnosis determination.

For solving difficult and rare cases consultation with more experienced physicians (experts) is a common practice in medicine. It is a time- and money-consuming procedure. So, the consultation high cost is the fourth problem. The main cause of the costs increasing is the lack of a unique methodology of description and interpretation of ultrasound images. Thereby, a pathological case, described by a physician, might not be understandable for another physician. In this case, a

consultation needs for additional explanation phase. A more difficult situation is when a consultation is needed, but the physicians are working on different banks of the Dniester. In present, such cases are rare, and occur only as private ones. This situation has been created not only because of the Dniester conflict, but due to the dominance of two different schools in the education of medical specialists on different banks. One school is oriented more on Russian (former USSR) standards, other – on the European ones.

However, such problems are familiar to the researchers in the field of medical informatics, and have some specific solutions.

Since precedent-based reasoning implies keeping in mind all data, which participate in medical diagnostics, and the volume of information is in a continuous growth, the practicing physicians have an evident necessity in aids for storage and retrieval of the existing professional knowledge (including their own).

A formalized description of the experts' experience and recommendations from both banks of Dniester (for selection the optimal ways of approach in images acquisition and/or for adjustment of scanner settings), embedded into computer-based platform with possibility of search for precedents, will be a good solution to increase the confidence in physician's conclusion.

The drawback of the existing computer-based systems specific to ultrasound domain is that the case collections consist of isolated, incomplete and non-standardized data [1-3]

III. DESIGN OF CLINICAL COMPUTER-BASED SHARED PLATFORM IN DOMAIN OF ULTRASOUND DIAGNOSTICS

The computer-based platform to be developed under this concept, in fact, is an multilingual (Romanian, Russian, English) information system based on expert knowledge, which will permit to clinicians and researchers in domain of ultrasound diagnostics of the hepato-pancreato-biliary system, other medical staff, lecturers and students of medical faculties from both banks of the Dniester:

- to share professional experience;
- to obtain a consultation from the recognized experts;
- to find documentary registered cases, annotated by expert;
- to familiarize with well-trying recommendations of effective scanning;
- to write clear and correct descriptions/interpretations of ultrasound images;
- to disseminate information about good practice to follow and malpractice to avoid.

Hence, the following activities are necessary:

1. Design and development of the clinical computer-based shared platform.

Specialists in medical informatics domain together with the experts in ultrasound diagnostics from both banks of the Dniester will design structure and interface of the computer-based platform. The main modules of the platform will be developed and integrated into the

platform prototype. The functionality of the obtained prototype will be tested and approved by the experts and consultants.

2. Expert knowledge acquisition. Formalization of domain of ultrasound diagnostics of the hepato-pancreato-biliary system.

Specialists in medical knowledge acquisition together with the experts in ultrasound diagnostics from both banks of the Dniester will formalize the domain of ultrasound diagnostics of the hepato-pancreato-biliary system. Each organ of this system – gallbladder, pancreas, liver and bile ducts – will be formalized separately. This process will take place through video chat, or in direct communication of the knowledge engineer with the experts. As a result two formal descriptions, one corresponding to the work of a physician from the Dniester's right bank, and another – from the left bank, will be obtained. Specialists in medical informatics domain will combine the obtained descriptions into one joint multilingual formalized description. This description will be validated by the experts from both banks of the Dniester.

3. Validation of the acquired knowledge and the obtained multilingual formalized domain description by consultants.

Public seminars will be organized to discuss and validate the obtained joint multilingual formalized description of diagnostics of the hepato-pancreato-biliary system by the consultants and other stakeholders.

4. Incorporation of the formalized domain into the clinical computer-based platform and testing.

Specialists in medical knowledge acquisition and medical informatics will integrate multilingual formalized description of diagnostics of the hepato-pancreato-biliary system into the computer-based platform prototype. The obtained platform will be offered for testing to the experts and consultants.

5. Implementation and evaluation of the computer-based shared platform for clinicians and researchers in domain of ultrasound diagnostics from both banks of Dniester.

The experts group will provide access to the platform for members of the medical community from both banks of the Dniester. The effectiveness of the platform implementation will be assessed by specialists.

The main modules of the clinical computer-based shared platform for clinicians and researchers in domain of ultrasound diagnostics of the hepato-pancreato-biliary system will be the following:

I. Database containing information about normal states, pathologies, anomalies of the hepato-pancreato-biliary system organs (gallbladder, pancreas, liver and bile ducts):

- sample sets (documentary registered cases – anamnesis, diagnostics, ultrasound annotated images);
- laboratory sets;
- clinical features;
- standard diseases treatments;
- cause-effect relations.

II. Knowledge base containing:

- declarative knowledge in terms of nosological

sonographic signs, describing normal and pathological states (base of facts);

- formalized diagnostics process (base of decision-making rules).

III. Module of acquisition of medical data and expert knowledge;

IV. Module of inference, search for similar cases and explanation for drawing conclusion;

V. User interface adaptive to different categories of users (specialized physicians, general practitioners, students).

The development of all mentioned modules will be based on SonaRes methodology and technology [4, 9, 11, 14], as well as on knowledge management techniques specific to medical domain.

IV. SONARES METHODOLOGY AND TECHNOLOGY UTILIZATION

SonaRes methodology is a comprehensive and integrated approach for design and development of clinical decision support systems, which provides clinicians with information support in all decision making stages [15], and currently has no analogy in the world.

SonaRes methodology combines new advanced methods for acquisition and management of medical professional knowledge with effective algorithms of ultrasound images processing.

SonaRes methodology:

- offers principles to select the acquisition method and mode, corresponding to the application domain;
- proposes an original alternative form for representation of the acquired knowledge;
- gives new original methods and algorithms for inference, ultrasound images processing, quick search, encryption of personal data about patients, creation of adaptive interfaces.

Under the presented concept, SonaRes methodology will be used: to select the strategy to acquire expert knowledge, properly at the stage of clinical knowledge acquisition and to choose the method for representation of the acquired knowledge [13].

SonaRes technology provides effective algorithms for storage and documentation of specific cases, corresponding to normal/pathological states and anomalies of organs from the hepato-pancreato-biliary region, detected by ultrasound diagnostics. This technology allows in reasonable terms to formalize the same organs with another degree of particularization, other organs, or some other types of medical diagnostics.

SonaRes technology will be used to incorporate the kernel of SonaRes knowledge base of four abdominal organs (gallbladder, pancreas, liver and bile ducts) into knowledge base of clinical computer-based shared platform in domain of ultrasound diagnostics of the hepato-pancreato-biliary system.

The kernel of SonaRes knowledge base, which will be incorporated, includes the following data and expert knowledge:

- the knowledge base for gallbladder contains of 335 facts and 54 decision rules, 166 model images annotated by the expert group, 226

images with regions of interest (ROIs) marked;

- for pancreas – 231 facts, 52 decision rules, 106 model images, 137 images with ROIs marked;
- for liver – 167 facts, 31 decision rules, 87 model images, 111 images with ROIs marked;
- for bile ducts – 257 facts, 15 decision rules, 30 model images, 37 images with ROIs marked.

By degrees the collection of images (with ROIs marked) will be completed for new specific cases.

Knowledge management techniques specific to medical domain [5-8, 10] will be used for structure modeling of domain of ultrasound diagnostics of the hepato-pancreato-biliary system and development of module of inference and adaptive user interface of the clinical computer-based shared platform.

V. EXPECTED RESULTS. DIRECT AND INDIRECT BENEFICIARIES.

Implementation and use of the clinical computer-based shared platform in domain of ultrasound diagnostics of the hepato-pancreato-biliary system will allow physicians to expand the cooperation between the medical communities from both banks of the Dniester by increasing personal contacts and mutual consultations. This will enhance the confidence level on three layers:

- between physicians from both banks of the Dniester by using a common standard of ultrasound images description;
- between a physician and his patients by providing a more accurate diagnostics;
- between a patient and a physician from different banks of the Dniester, if in the investigation of the patient a consultation of a physician from another bank of the Dniester was required.

In terms of quality, the computer-based platform will enable:

- clinicians and researchers in domain of ultrasound diagnostics of the hepato-pancreato-biliary system to collect and share medical data and information about rare cases, and to obtain a consultation, basing on documentary registered cases, annotated by expert(s);
- operators to familiarize with well-trying recommendations of effective scanning;
- health care policy makers to disseminate information about good practice to follow and malpractice to avoid.

In the future, the obtained results can be used in education, training and retraining of medical staff in domain of ultrasound diagnostics [12].

The direct beneficiaries are the Society for Ultrasound in Medicine and Biology of the Republic of Moldova, clinicians and researchers in domain of ultrasound diagnostics of the hepato-pancreato-biliary system, other medical staff, lecturers and students of medical faculties from both banks of the Dniester.

The indirect beneficiaries are patients, because the clinical computer-based platform will allow practitioners to make a more accurate and informed diagnoses, and the ultrasound examination reports will be more understandable.

VI. CONCLUSION

Joint efforts of medical experts and specialists in medical informatics in creating a computer-based shared platform for clinicians and researchers in domain of ultrasound diagnostics of the hepato-pancreato-biliary system it's a good solution for solving the main drawback of the existing systems – medical data and information isolation, incompleteness and non-standardization.

The clinical computer-based shared platform will intensify, simplify and facilitate knowledge exchange that otherwise would be difficult or even impossible. Moreover, the increased number of contacts between physicians from both banks of Dniester will significantly influence the level of trust between people.

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