Informational systems for medical diagnosis

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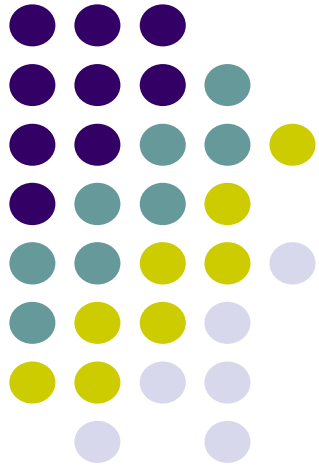
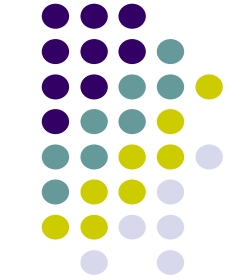


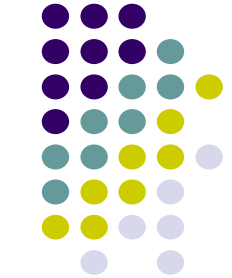
Diagnosis is a process...



... consisting of separate steps. These steps

- Begin with establishing the certain facts 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).

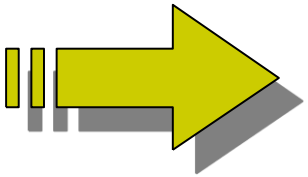
Diagnostic decision support systems in medicine



- Do not intend to replace the physician, their role being to give clinician recommendation on his request or draws automatically his attention to the special cases
- Targeted on a specific area or a diagnostics method

Ultrasound examination

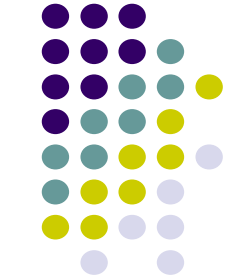
- Non-invasive and not expensive
- Ultrasound image – the primary (input) information for every ultrasound examination



Two-layer structure:

- the first layer – the image itself (graphical features)
- the second layer – its textual description in medical terms (medical features)

Difficulties in ultrasound image interpretation

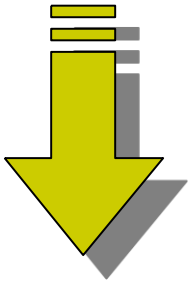


associated with the dependence on operator:

- Affects the quality of the obtained images
- The way the results are differently described and interpreted by several specialists.

Development of diagnostic decision support systems

- Knowledge-based systems
- Image-based systems



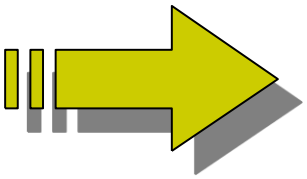
A joint realization of decision making and image retrieval leads to new explicit domain-specific knowledge and better results in many applications

Success in development of diagnostic decision support systems

i. Knowledge acquisition and formalization

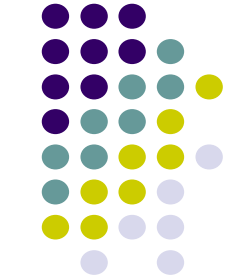
ii. Image processing (with extraction of knowledge from the images, if possible) and search for similar ones

iii. Interaction with user



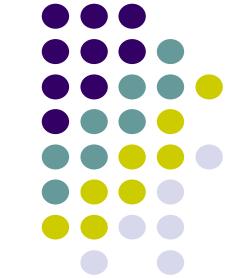
determines the functionality, user attitude and, as a result, adequacy of generated conclusions

5 main stages in the development of knowledge-based systems



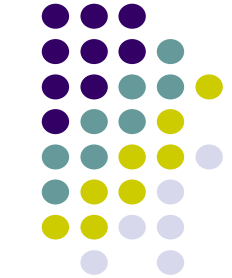
1. Problem identification
2. Knowledge acquisition
3. Knowledge structuring
4. Knowledge formalization
5. Prototype development

Stage 2: Knowledge acquisition methodology, applied to ultrasound investigation domain (gallbladder)



- about gallbladder localization;
- about the gallbladder pathologic states (chronic cholecystitis, compressed gallbladder etc.);
- principal characteristics for organ description (dimensions/volume, shape, tonicity, gallbladder contour etc.);
- info about gallbladder anomalies and pathologies.

Stage 3: Knowledge structuring

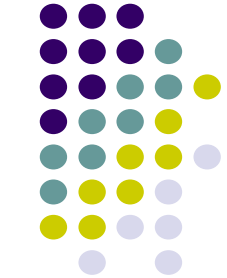


The structure of the subject domain acquired knowledge is defined:

- the list of the basic concepts and their attributes (facts),
- the relationships between facts,
- the structure of the input/output information,
- decision-making strategy, etc.

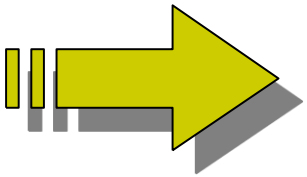
The aim is the informal knowledge description of the problem domain as a graph, table, diagram or a formatted text.

Stage 4: Knowledge formalization



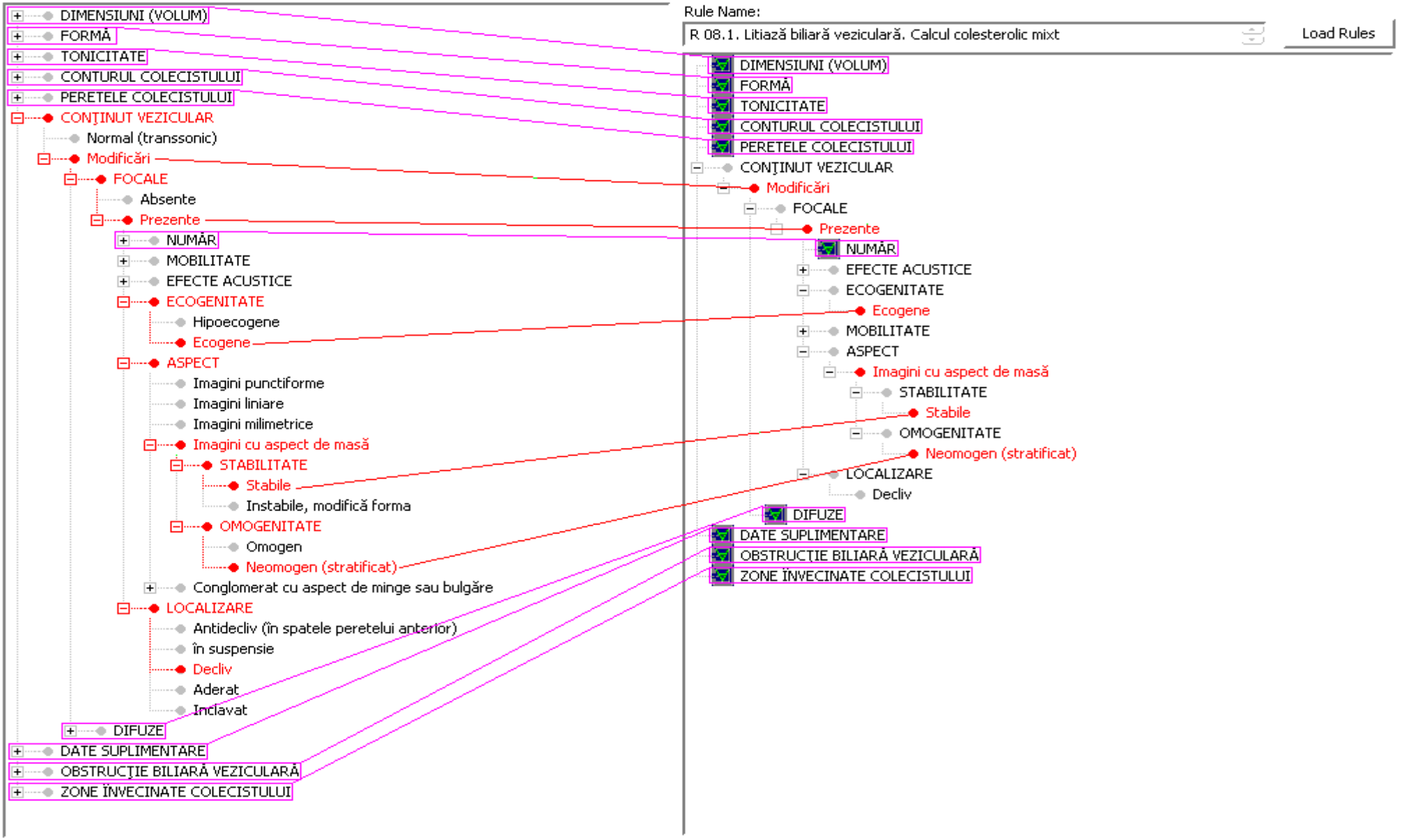
- the representation form for acquired and structured knowledge is selected

- the formalized representation of problem domain concepts is created basing on of the chosen knowledge representation form (should correspond completely to knowledge structure and allow creating the prototype of the future system)

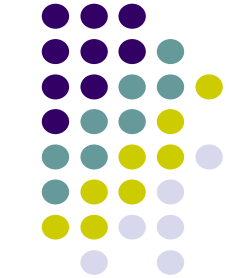


semantic nets, decision trees, frames and description logics are more suitable to represent medical knowledge

Expert shell interface (version 2)



Results: distribution of the rules for gallbladder pathologic and non-pathologic states



	Basic groups of pathologic/non-pathologic states	Number of rules
1.	Normal cholecyst	2
2.	Anomalies of conformation, dimension, number, localization	5
3.	Acute cholecystopathies	14
4.	Chronic cholecystopathies	4
5.	Modifications of gallbladder contents: cholecystolithiasis, sludge	14
6.	Benign and malign neoplasms	6
7.	Hyperplastic cholecystoses	8
8.	Secondary cholecystopathies	1
Total:		**54**

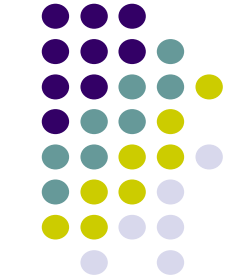
Results: distribution of the rules for pancreas pathologic and non-pathologic states

	Basic groups of pathologic/non-pathologic states	Number of rules
1.	Normal pancreas	3
2.	Anomalies of the pancreas	4
3.	Inflammatory diseases of the pancreas (mild variants)	8
4.	Inflammatory diseases of the pancreas (severe variants)	7
5.	Pancreatic pseudocysts	4
6.	Chronic pancreatitis	1
7.	Pancreatic lipomatosis	1
8.	Benign pancreatic tumours (lesions)	5
9.	Acquired pancreatic cyst. Parasitic cyst	1
10.	Malign pancreatic tumours (lesions)	5
11.	Functional secreting pancreatic tumours	5
12.	Solid epithelial secreting non-functional neoplasms	1
13.	Pancreatic metastases	1
Total:		**46**

Results: distribution of the rules for liver pathologic and non-pathologic states

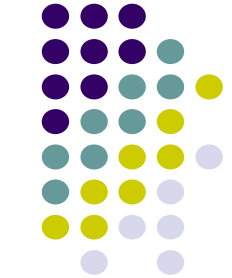
	Basic groups of pathologic/non-pathologic states	Number of rules
1.	Normal liver	1
2.	Benign hepatic tumours (lesions)	11
3.	Malign hepatic tumours (lesions)	8
4.	Hepatic metastases	1
5.	Metabolic liver diseases	5
6.	Inflammatory and infectious hepaic diseases	8
7.	Portal and hepatic venous system diseases	4
8.	Hepatic trauma	1
9.	Intrahepatic biliary obstruction	1
Total:		**40**

Results: distribution of the rules for bile ducts pathologic and non-pathologic states



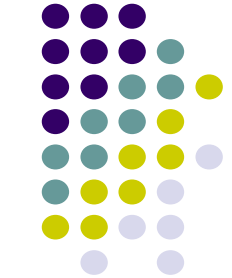
	Basic groups of pathologic/non-pathologic states	Number of rules
1.	Congenital biliary diseases	8
2.	Choledocholithiazis	2
3.	Malign tumours of extraheptaic biliary tree	1
4.	Inflamatory diseases of biliary tree	3
5.	Biliodigestive fistulas	1
6.	Obstruction of biliary tree	2
Total:		**17**

Interaction with user: requirements



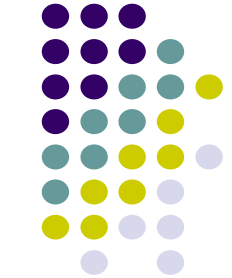
- interface should be simple and understandable
- should correspond to the end-user's daily work and preferences
- the proposed solution should be easily to verify
- non-linear structure of dialogue with the end-user (opportunity to return step back)
- interface should be adaptive, depending on time available to the end-user to make a decision
- should not restrict unnecessarily the end-user's actions

Interaction with user: interface



- dialogue – the most common form of communication and information transfer
- an alternative representation scheme proposed – separation of knowledge into one, used in the inference, and other, used only in the interface

Alternative representation scheme (1) gallbladder example



- there were determined facts of the decision tree, involved in the inference
- for each fact a question concerning the existence or non-existence of this fact was formulated

F1=<gallbladder volume, normal>

Q1="Is the volume of gallbladder a normal one?"

F2=<gallbladder volume, enlarged>

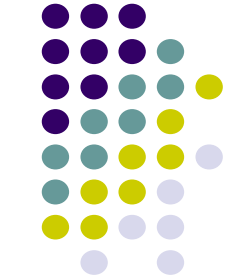
Q2="Is the volume of gallbladder enlarged?"

F3=<gallbladder volume, reduced>

Q3="Is the volume of gallbladder reduced?"

203 questions

Alternative representation scheme (2)

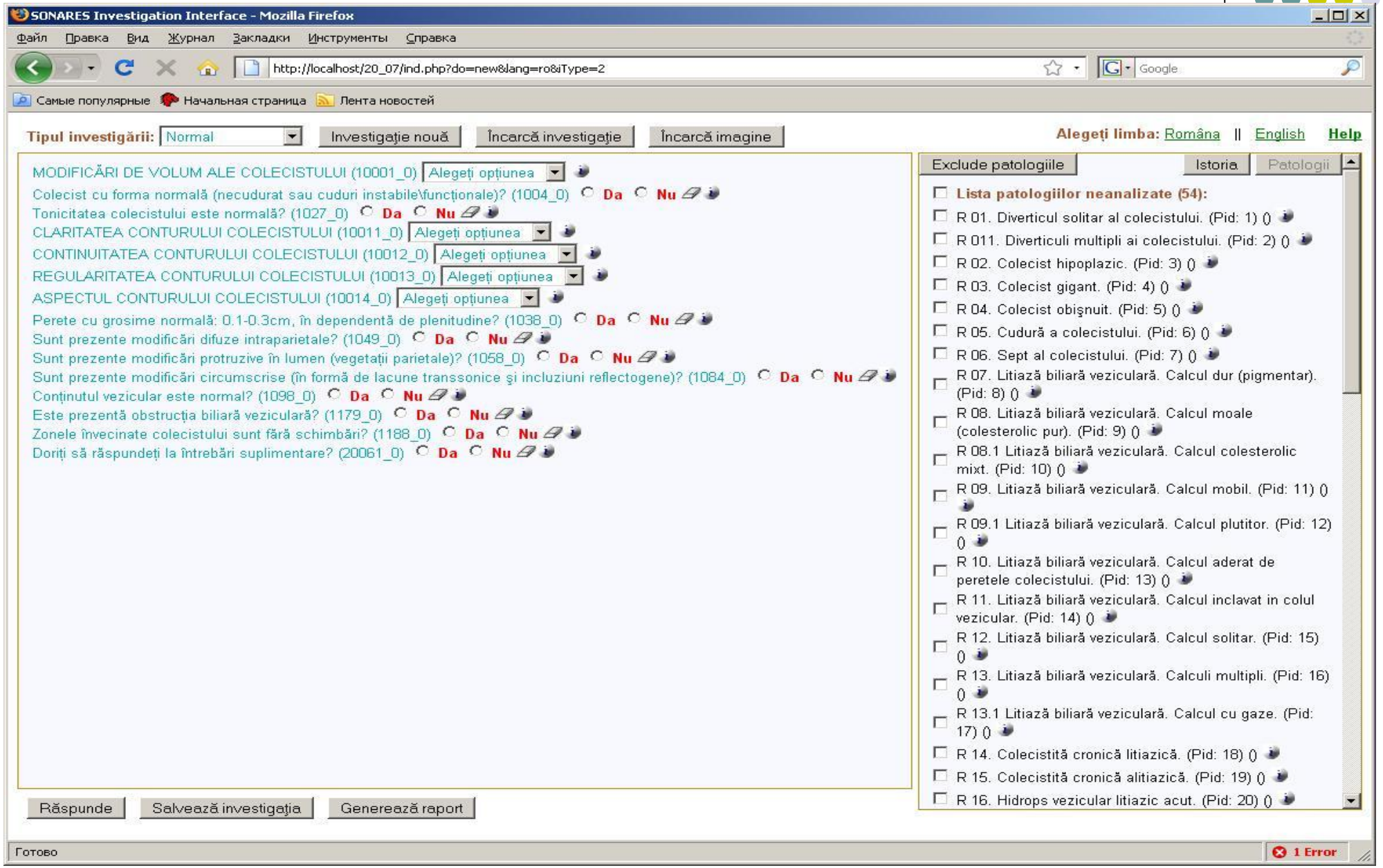


We have stored all existing relationships between the facts (interconnection system between all formulated questions)

Two types of relationships between facts in the decision tree:

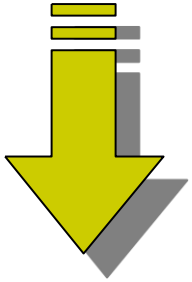
- The first one indicates the position of a given fact in the knowledge base hierarchy
- The second type of relationships indicates the existence of interdependence between the facts

User interface



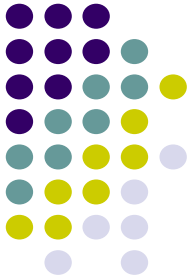
Interaction with user: results

Separation of the existing relationships between the questions in two groups allows to create a high-quality adaptive interface based on the individual characteristics and habits of the end-user



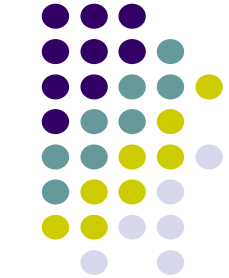
The user can define himself the subject and the form of dialogue (by changing the visualization relationships between the questions), without any fear to influence the inference

Challenges and solutions in utilization of ultrasound images (1)



- collection of "model" (representative) annotated ultrasound images
- ground truth provided by the experts-physicians
- association between images and corresponding rules
- on static images the regions of interest (ROIs) are marked out (ROIs are associated to particular characteristics of the organ)

Challenges and solutions in utilization of ultrasound images (2)

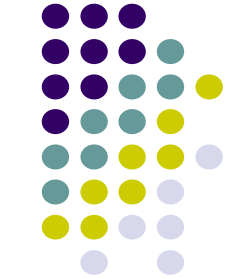


Tools helping experts to realize:

- ROIs management – allowing marking out the ROIs (as a contour of connected points) as well as other operations: addition, deleting and viewing ROIs
- visualization of all ROIs corresponding to the selected node on different images
- visualization of all ROIs (corresponding to different nodes) on the chosen image

Challenges and solutions in utilization of ultrasound images (3)

SonaRes Diagnostic DSS: conclusions



- considering two-layer structure of the information contained in ultrasound images, the combination of image-based and knowledge-based approaches is natural
- knowledge acquisition and formalization is key stage in successful development of diagnostic decision support systems
- interaction with user, corresponding to the daily work and habits of physician is essential
- image retrieval techniques serve as help to the end-user in search for a visual representation for textual description of medical features.