INTELLECTUAL MODELS AND MEANS OF THE BIOMETRIC SYSTEM DYNAMICS OF RINOSINUSITE

Oleksii Vasilenko, Oleksandr Kuzomin, Tatyana Khripushina

Abstract: *The object of the research is the processes of modeling the diagnosis of clinical medicine, the development of methods for the analysis and synthesis of biomedical data and the identification of knowledge from them and the creation of medical expert systems (MES) of clinical medicine.*

The purpose of this work is to research and compare existing MES, to formulate requirements and to develop their own MES, and to present the results of a study on the presentation of medical data in the MES. The developed algorithm for implementing the medical expert system was used to create a software tool for medical diagnosis.

Keywords: *Medical Data, Expert System, diagnosis, Graph.*

Introduction

Now in Ukraine there is a very big problem of keeping a person's life. The problem of acute inflammatory diseases of the upper respiratory tract, acute rhinosinusitis (GMS) in particular, is one of the most urgent in modern clinical medicine. In recent years, there has been an increase in the frequency of nasal and sinus diseases, which manifests itself as an increase in both absolute (morbidity and prevalence) and relative (share in the structure of otorhinolaryngology) indicators. In Ukraine, the prevalence of acute rhinitis, rhinosinusitis and rhinopharyngitis has reached 489.9 cases per 10,000 population, and the incidence–5-15 cases per 1000 population depending on the season. Such patients make up 60-65% of ambulatory patients of otorhinolaryngologists.

To address the above issues, appropriate studies are needed to improve the quality of treatment. In particular, it is necessary to develop the direction of the study of diagnosing GDS high-quality, without errors and high level of clinical thinking of the doctor. Diagnosis of GDS is based on clinical data. The physician's conclusion is based on patient complaints, anamnesis, symptoms and signs of the disease, the data of the medical examination and includes a subjective assessment of the severity of the disease by the patient. So it is very important that in the early stages of the disease have the most accurate diagnosis. This is possible with the presence of a doctor's intellectual system for conducting a primary examination of a patient and anamnesis. In general, the physician makes decisions regarding the diagnosis of GDS in conditions of multiple uncertainty of the signs of illness, symptoms and multicritality of the requirements for the diagnostic process, which confirms the relevance of my research.

In addition, according to the order of the Ministry of Health of Ukraine of February 11, 2016, № 85 was introduced the "Unified clinical protocol of primary, secondary (specialized) and tertiary (highly specialized) medical care acute rhinosinusitis."

Development of models and diagnostic tools

According to the chosen object of research in the work models and methods of development of medical clinical diagnosis (MIC) of GDS are investigated.

Among the modern methods of research in medicine is the direction that uses the intellectual methods of system analysis of the development of MCD. In addition, the publications have long been the information that is sufficiently well applied by medical expert systems (MES).

This study uses statistical diagnostic materials for patients that were published [ ] and were collected directly in hospitals (Fig.1.1). It should be emphasized that electronic medical records (EHR) for patients are often used in the MES. This allows clinicians to increase access to large volumes of medical data collected during diagnosis of a patient [2.5].

In addition, the classification codes of ICD 10 [] were used. In particular, we have the following definitions for the following diseases: acute sinusitis–J01; acute sinusitis–J01.0; acute frontitis–J01.1; acute etiomyiditis–J01.2; acute stenoiditis–J01.3; acute pansionitis–J01.4; another form of acute sinusitis–J01.8; acute sinusitis unspecified–J01.9

Acute rhinosinusitis–is a sharp inflammation of the mucous membrane of the nasal cavity and paranasal sinuses (Fig.1). The code for MIC-10 acute rhinosinusitis has–J01, but when identifying the pathogen, an additional code should be indicated (V95-V97).

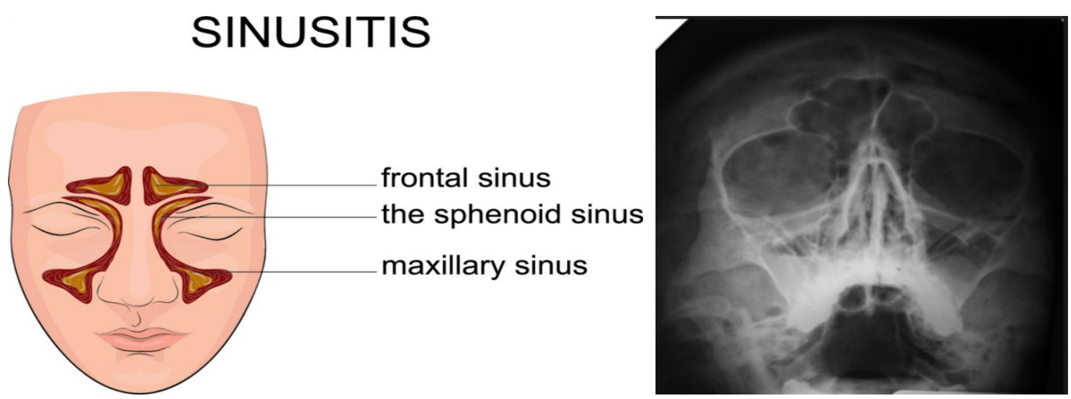

Figure 1 -The layout of cavities relative to the sinusoid and CT scaling

According to the epidemiology we have the following [Lukovkina A., 2013]:

• on average, the episode of sinusitis develops annually in 1 person out of every 7;

• Among women, morbidity is higher than among men;

• The peak in the incidence is from the age group of 45 to 74 years.

According to the etiology, we have the following [Lukovkina A., 2013]:

• respiratory viruses (influenza viruses, parainfluenza, rhinoviruses, adenoviruses, respiratory syncytial virus, enteroviruses, coronaviruses);

• bacteria (pneumococcus, hemophilic stem, moraxelle);

• fungi (in patients with immunodeficiency, for example, HIV, or with poorly controlled diabetes).

Regarding the classification of the disease, depending on the pathogen (V95-V97) we have the following varieties:

• acute viral rhinosinusitis;

• acute bacterial rhinosinusitis.

Depending on the location, the following varieties are distinguished:

• sinusitis (defeat of the maxillary sinuses);

• etiomyiditis (damage to the sinuses);

• frontitis (lesions of the frontal sinuses);

• Stenoiditis (damage to the sphenoid sinuses)

Depending on the course, the following varieties are distinguished:

• acute (<4 weeks);

• subacute (4-12 weeks);

• chronic (> 12 weeks).

Risk factors for acute rhinosinusitis [Lukovkina A., 2013], [Kuzomin, 2017]:

• acute viral infection of the upper respiratory tract. The most frequent OVIVDP encounters OVRs. Thus, according to the results of computed tomography, the objective signs of sinusitis are determined in 87% of cases of acute respiratory viral infections on the second to third day and in 39% of cases on the seventh day, 2,3 of the disease. OBRS is found much less frequently (0.5-2% of all cases OVIVDP1);

• allergic rhinitis;

• Any anatomical features or pathological changes that interfere with the drainage of cavity of the sinuses: nasal polyps, distortion of the nasal septum, etc.;

• violation of mucociliary clearness (local protection of the mucous membrane of the respiratory organs from external influences) as a result of smoking, cystic fibrosis;

• odontogenic infections;

• swimming;

• immunodeficiency (HIV infection, chemotherapy, prolonged use of corticosteroids, etc.).

Clinical manifestations and symptoms for acute rhinosinusitis (viral and bacterial) have the following:

• nasal congestion;

• mucosal purulent discharge from the nose (purulent character of excrement itself is not evidence of secondary bacterial infection);

• head and facial pains, which increase when inclining forward;

• slight increase in body temperature;

• hyposmia or anosmia;

• bad breath.

Diagnosis of acute bacterial rhinosinusitis is based on the presence of one or more three criteria [Kuzomin, 2015]:

• Sustained symptoms of sinusitis lasting 10 or more days without clinical improvement;

• severe OVIVDP symptom (fever> 39 ° C and purulent nasal discharge or pain in the face) for at least three days from the onset of the disease;

• worsening of symptoms (headaches, nasal discharge, fever) after an AED that lasted 5-6 days and was initially accompanied by an improvement in the condition.

Diagnosis of the disease takes place in the following sequence: interviewing a patient during an objective examination by a doctor and fixing a complaint and anamnesis.

During an objective survey it turns out:

• pain in palpation of the characteristic points of the projection of the paranasal sinuses;

• rhinoscopy;

• purulent discharge in the region of the middle nasal passage;

• diffuse swelling of the mucous membrane, narrowing of the middle bowel movement;

• hypertrophy of the nasal concha.

X-ray examination and computed tomography of subcutaneous sinuses can not differentiate OVRs from the OBP. These studies are shown only when suspected of intracranial or orbital complications [Lukovkina A., 2013].

In the following cases, the study of choice is the CT with contrast: reduction of visual acuity; diplopia; periorbital edema; severe headache or altered mental status. CT is more informative than X-ray examination, and can be informative in recurrent sinusitis or with preservation of symptoms, against the background of treatment (in this case, it is sufficient CT without contrast) [Lukovkina A., 2013].

In one study, the thickening of the mucous membrane of the paranasal sinuses in CT was found in 42% of healthy people with no symptoms. Such changes can not be the basis for the diagnosis of sinusitis without a corresponding clinical picture.Sowing of aspirates from sinus to culture is indicated only in those cases where there is no positive dynamics in response to antibiotic therapy or complications [Lukovkina A., 2013]. Sedation or nasal discharge is not recommended, as the results are unreliable.

Data mining methods used in medicine can be divided into several groups in accordance with the tasks solved by them (Tab. 1): predicting the course of the disease, the effect of a drug or group of drugs, the mortality rate; examination - diagnosis based on a set of symptoms; classification - clarification of the diagnosis; the search for associations is the search for hidden dependencies between various patient health indicators [36]. Consider further the basic methods of data mining used for processing medical information.

For the design of the expert system [Kuzomin, 2017] a fairly narrow branch of medicine was chosen - otorhinolaryngology, in particular, the problem of non-sense. The program allows to differentiate diseases such as:

- acute rhinitis (simple undead);
- acute sinusitis (inflammation of the sinuses of the nose);
- allergic rhinitis (runny nose and indigestion associated with allergies);
- acute respiratory viral infections (colds).

Table 1– The tasks of the intellectual analysis of data in medicine and the methods used to solve them

Purpose of the analysis	**Methods with a teacher**	**Methods without a teacher**
Forecasting	The smallest method squares Logistic regression Neural networks Adoption trees making SVM Splines	–
Survey	Decision tree	Main method components Clustering Link Analysis
Classification	Decision tree Neural networks Discriminant analysis Busing Naive Bayes Classifier	Clustering Self-organizing cards Kohonen
Association Search	–	Factor analysis Apriori algorithm

In this EU , the rules of diagnostics are implemented, which, depending on a given situation, will ask the user the necessary questions and receive a response in a strictly prescribed form (it will be necessary to choose the number of the corresponding answer). Further diagnostics will be conducted taking into account the previous answers to the questions given to the user. That is, the intellectual dialogue with the MES is supported on the basis of the analysis of the text content of the symptoms. As a result of the work of an expert system with a fairly high probability, it is possible to conduct a differential diagnosis between diseases associated with non-life. The MES analysis [https://www.med2000.ru/library2/diagnostika3.htm] gives two main conclusions:

1. On average, the MES have from 56% to 90% of the correct diagnoses.
2. The main principles for the development of the MES are production rules and the use of network neurons,Bayesian networks trust networks that give a very large percentage of correct diagnoses.

Development of intelligent diagnostic system

The theory of fuzzy sets was used to diagnose the GDS. A fuzzy expert system (FES) was developed based on the rules. He used the selected factors in the first stage and modeled the behavior of a specialist for diagnosis of GDS. Fuzzy expert systems are basically systems based on knowledge using fuzzy logic, fuzzy IF-THEN rules and membership functions (MF) (37). On (Fig.2) is shown the general architecture of a fuzzy expert system that displays the flow of data throughout the system (38). Its main structure includes four main components:

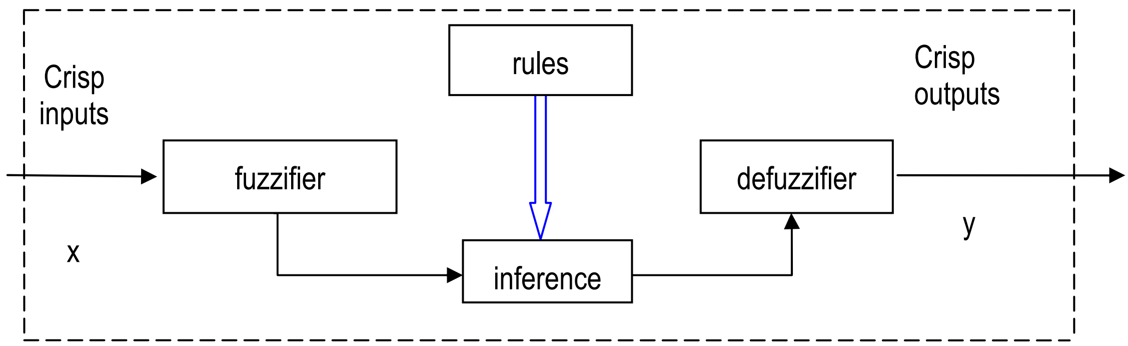

Figure 2 – Known common architecture of a fuzzy expert system [Kuzomin, 2017].

- Fuzzifier, which interprets clear input data (classical numbers) into fuzzy values;
- An inference mechanism that uses the fuzzy reasoning function to produce a fuzzy inference (in the case of Mamdani's inference);
- Knowledge Base, which includes a set of fuzzy rules and a set of membership functions that display fuzzy sets of linguistic variables;
- Defuser, which interprets fuzzy output into clear values [Kuzomin, 2017].

The first stage in the development of a fuzzy expert system is the definition of input and output variables. Differential diagnosis was conducted with nasopharyngitis, adenoiditis, allergic rhinitis, migraine, the presence of foreign bodies in the nasal cavity, pathology of the teeth. In complex cases, differential diagnosis with rare conditions, such as: central nervous system damage, skull bone pathology, facial pain syndrome, vasculitis, invasive fungal sinusitis, nasal liquorice should be performed.

System development

For a accurate definition and understanding of the system processes, a sequence diagram was used. For the role creation operation, the user initially administers the search queries at the patient's address and displays the search results if that user is found, then after confirming the entry, the client application passes the server to the address that the user has and the new role for him. After that the server sends editing queries to the user with this address and if the operation was successful, then the client application sends a successful response (Fig.3). For a clinical analysis operation, the doctor first introduces a list of symptoms that have been detected and finds the patient at his initials. Then, this list of confirmed symptoms with the patient ID is passed to the server, where he first finds the symptoms that are denied to ours. Further, the user ID finds the recorded history, and to what knowledge they lead. Then, from the database, a graph of illnesses that includes these symptoms and signs of history are loaded. All illnesses that are denied leave the further analysis, if the disease is not overlooked, it is believed to be probable with documented facts. Then in a disease with the greatest probability is characterizing its symptom, which contains a confirmatory question, which will be sent to the doctor to support the dialogue. Calculated illnesses and the next question with the disease ID will be sent to the doctor to maintain a dialogue. The Diagnosis Diagram is presented on (Fig.4).

An analysis of the presentation of symptoms and signs of disease in diagnosis

From the preliminary consideration of the above problems to solve the problems posed in this study, it is necessary to use methods of system analysis, system engineering intellectual modeling and algorithmization taking into account uncertainty, multi-criteria and fuzzy logic.

Hierarchical relations reflect the stages Diagnostic algorithm of the diagnostic procedure: data entry, data analysis, syndrome diagnosis, and design of the results.

These important remarks should be taken into account in this study. Thus, the diagnostic process is a complex multilateral procedure, which includes various stages of the analysis of clinical information [4,5]. In the most generalized form, the diagnostic algorithm can be represented in this way (Fig.5).

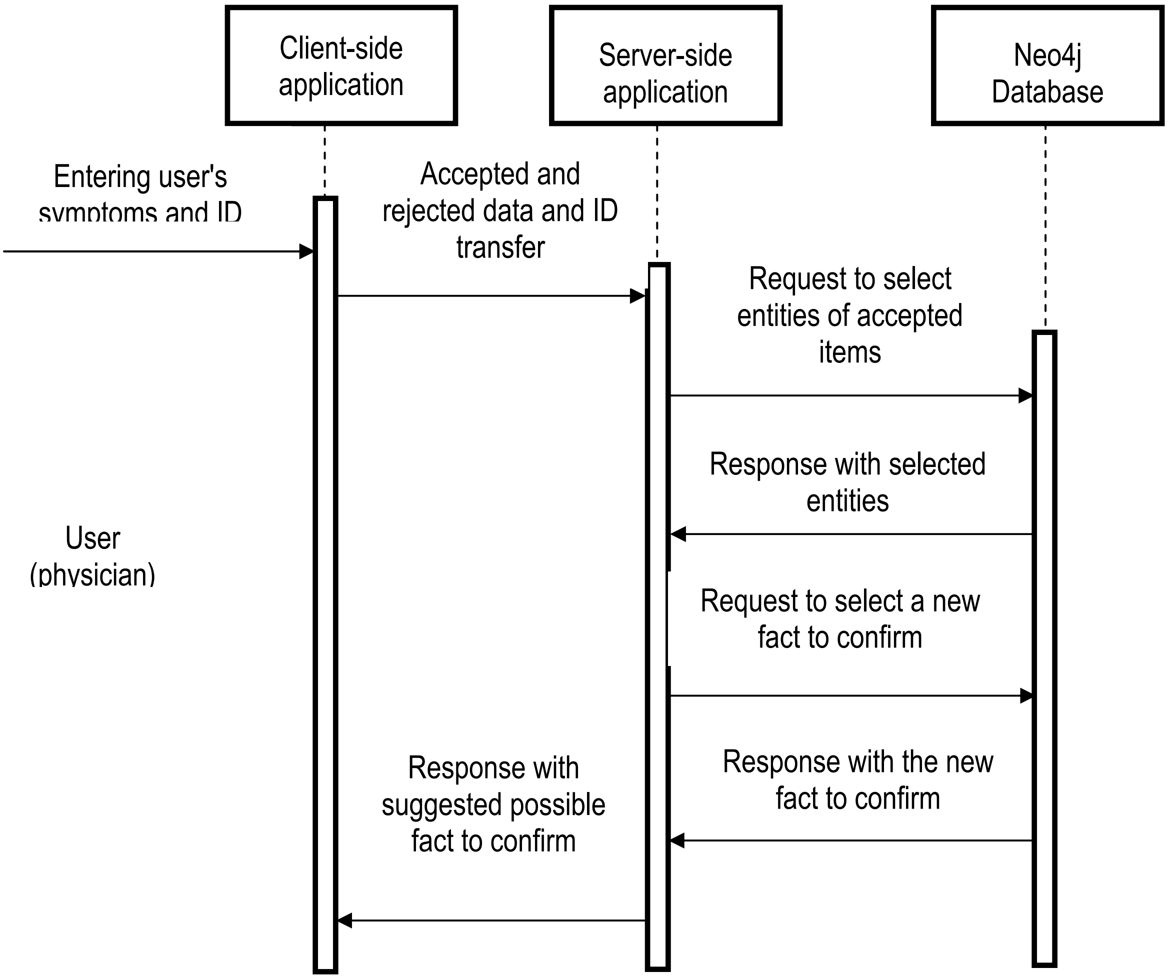

Figure 3 - Chart of

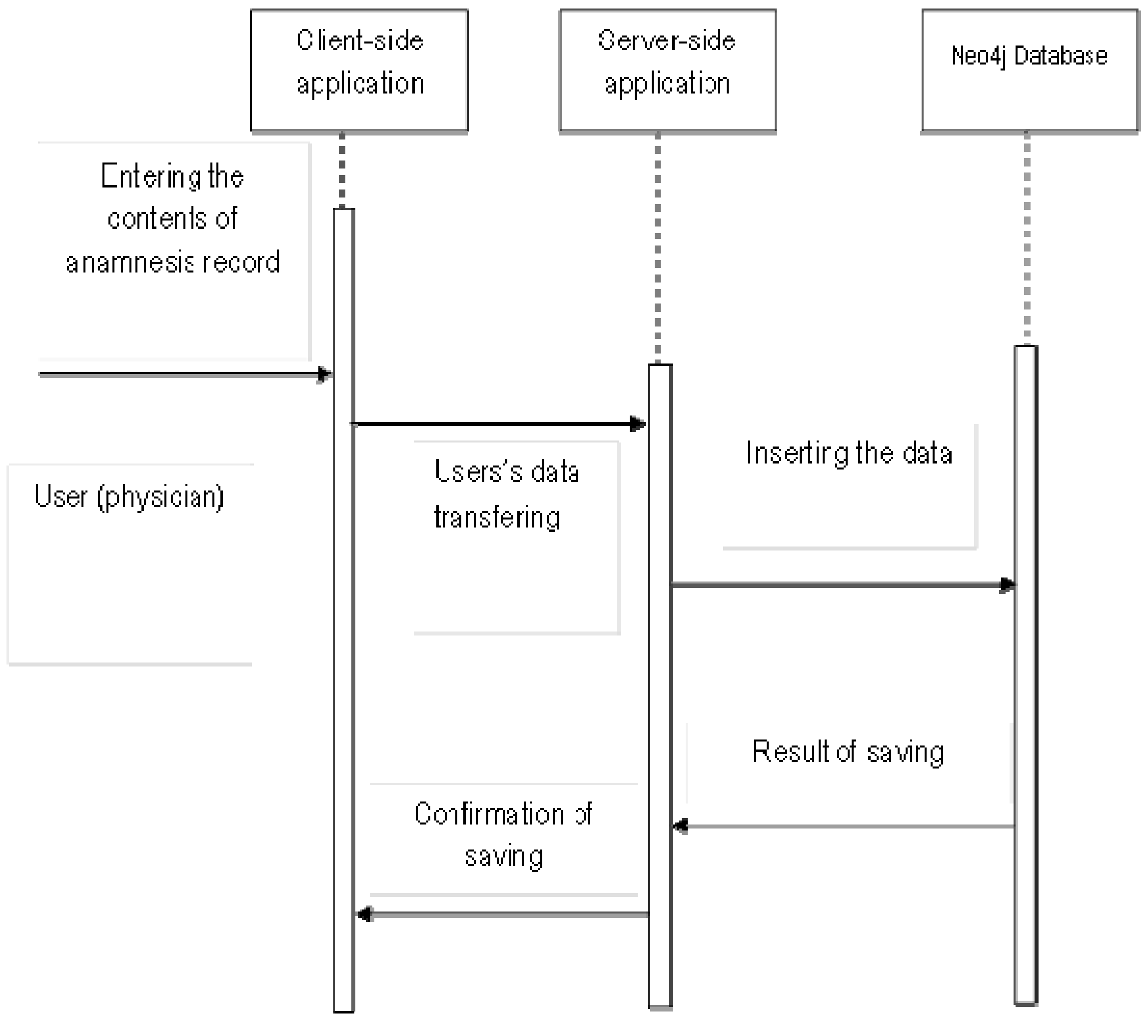

Figure 4 - Diagram of adding a history record

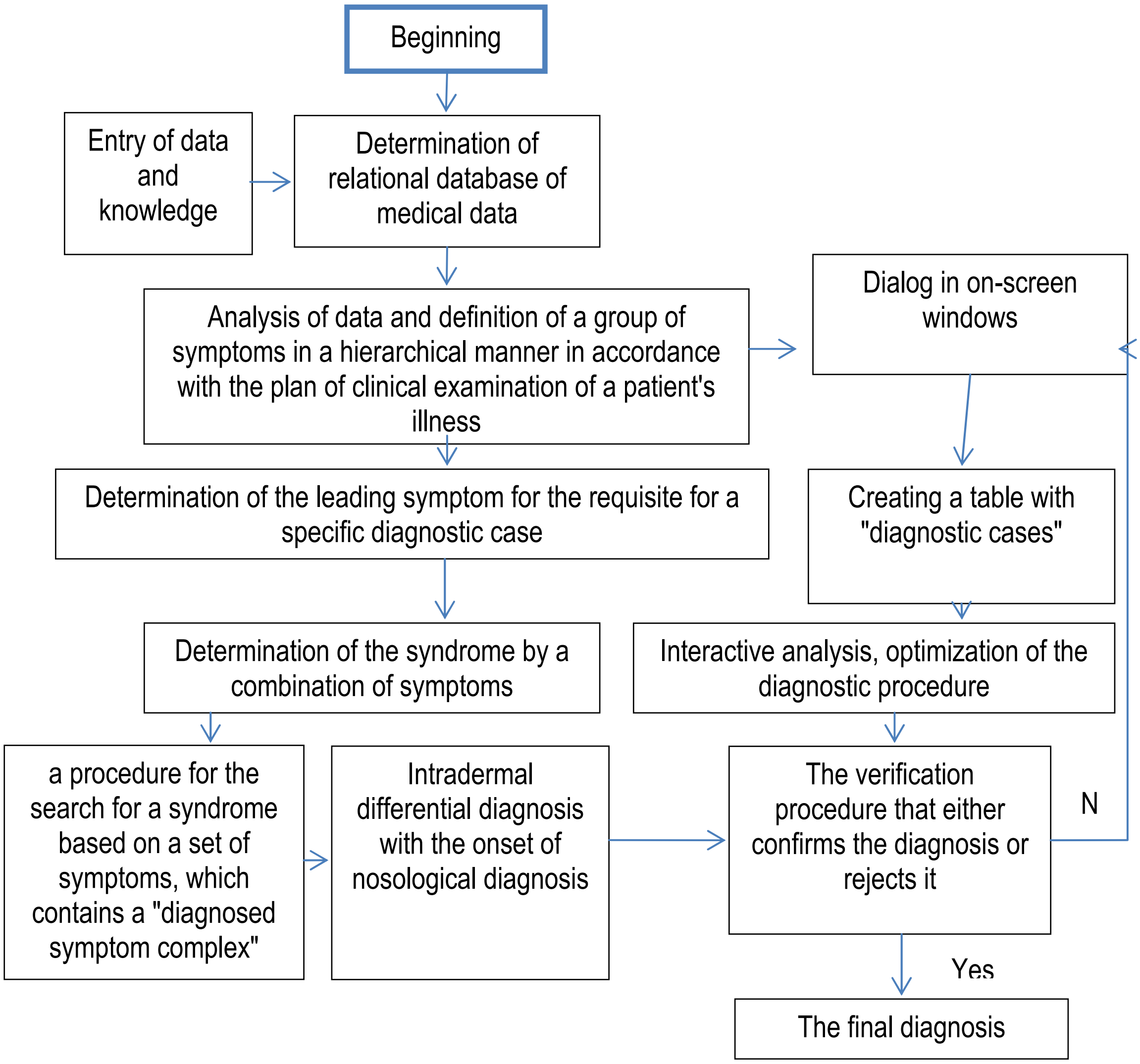

Figure 5 - Diagnostic algorithm

Conclusion

The resolving of the set of tasks allowed to get the following results:

- For the first time a method has been developed for the distribution of clinical medical conditions into dangerous and safe classes, which determine the most important factors of influence on the clinical condition of the patient, which makes it possible, through the measure of proximity of microsituations (with the greatest influence of parameters), to propose a methodology for predicting the patient's condition;
- For the first time, a reliable backup method for storage of biomedical Big Data has been developed, which in practice provided high reliability in comparison with existing methods;
- Method of constructing a structure of expert systems has been acquired the further development for clinical medicine, which is distinguished by the repeated use of the ontology of successful results and provides an opportunity to increase the reliability and speed of processing of input data, as well as the efficiency of decision-making;
- Situational model of clinical medicine has been improved for analyzing the patient's condition, which, unlike existing approaches, uses situational presentation of a crisis situation based on the three "doctor who manages the influence or decision for re-use of ontology-patient", which allows to predict dangerous and safe situations for a patient faster and with greater accuracy than existing models.

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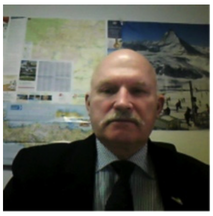

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