MEDICINE

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AUTOMATED TRAINING TEST-SYSTEM OF DOCTORS TRAUMA ON THE BASIS OF EXPERT MODULE SUPPORT DIAGNOSTIC DECISIONS

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Abstract

The aim of the study was to develop the structure of the automated training system test type based on autonomous intelligent management diagnostic solutions for use in professional development on the example of post-traumatic thromboembolism. The scheme of the automated offline expert support module diagnostic solutions through the use of direct and inverse decision rules to implement acceptable for clinic clustering condition of the patient. The technique of risk assessment for ball clustering metrics measure the characteristics of the patient. The results of approbation of the expert module in a clinical setting.

Keywords: the improvement of professional skill of medical workers, the classification of the patient's condition, the prediction of thromboembolism.

Section title: education.

Introduction

Professional activity of the doctor requires continuous improvement to improve quality of care. The improvement of professional knowledge and skills, and the use of modern computer and technologies embodied in articles 73 and 87 of the Federal law of the Russian Federation [10], that proves the necessity of state support development of technologies and automated systems for training of health workers. The peculiarity of the educational process of improving the skills of physicians is a wide use of practical experience of clinicians. This determines the necessity of creation of the automated training systems, including support systems and diagnostic solutions-automated or Autonomous expert modules (subsystems) (AMESDD), allowing the individual decision maker (DM) to form the most optimal and acceptable for effective therapy recommendations for various stages of therapeutic effects and with sufficient efficiency, specificity and sensitivity clinically proven.

Purpose: development patterns automated training system test type based on the interactive interface is trained and/or certified physician travmatologi with the expert module of the adoption of diagnostic solutions by the example of prediction of post-traumatic thromboembolism.

In the research process were solved the tasks:
- development of the structure of the compliance level of the doctor-travmatologi certain quality features in the areas of professionalism evaluation of the prediction of thromboembolism by use of AMESDD;
- development of structure of informational-analytical model AMESDD, allowing on the basis of the simultaneous application of decision rules mapping the analyzed object (the patient) to known clusters (for which we defined a set of optimal therapeutic interventions) and identifying the presence of certain values recorded in the patient characteristics having an acceptable quality of diagnosis;
- develop a formalized method to assess the risk of making diagnostic decisions in the application of a metric ball of the detected characteristics.

To implement goals and solve these research problems were used the following materials and methods: decision theory, system analysis, methods of synthesis of knowledge bases for expert systems, applied statistical analysis in medicine [7], clinical data prediction of thromboembolism.

Results and discussion.

Thromboembolism is a major cause of death and / or disability as a result of trauma or in the postoperative period and

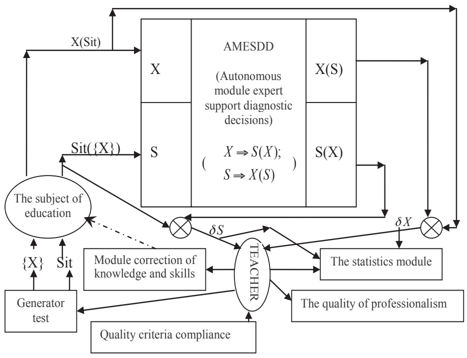
relates to poorly predictable processes, because it is caused by many reasons, each of which separately as a rule, does not lead to the development of the pathological process.
In the clinical setting the physician for optimal therapy in each specific case it is necessary to quickly and adequately assess the patient's condition and to take the necessary decisions for certain therapeutic effects. The risk of making incorrect diagnostic decisions high, the consequences of improper therapy be disastrous and poorly predictable. In this regard, the role of the experience of the doctor-travmatologi (both practical skills and theoretical knowledge) and, consequently, there is the problem of continuous increase professional level – including courses independently and with the help of automated training systems training.

Automated training system (ATS) [5] work in two modes: training and exam. The learning process includes the following stages: initial, current and final control (test, exam) the quality of the learning material and mastering certain skills, training, tips and fixing mistakes (or the accumulation of statistical material).

Controlling components of ATS doctors in most cases are, for example [1], tests in the form of questionnaires. Thus, a passive process implemented by the ATS in relation to the learner with certain intellectual (analytic and cognitive) skills. In contrast to this paradigm, it is proposed to use the scheme of testing (presented in figure 1) as a testing subsystem is proposed to use AMESDD, knowledge base which is built and verified on clinical material and the modifier in use in the diagnostic process.

Thus, from the paradigm of "Man-computer" we propose to shift to the paradigm of "Human – Expert system". Since the latter is an autonomous artificial intelligence [6], the interface between natural and artificial autonomous intelligence should reflect the individual cognitive characteristics of each. Under the cognition refers to the active ability and willingness (availability targets and acceptors of performance) the acquisition of new knowledge, motivating the achievement of maximum values of positive emotions. Under the cognitive autonomy is understood as independence and individuality in the implementation cognitologists tasks.

The educational process is carried out under the guidance of a TEACHER, who on the basis of information about mismatch of actions of the subject of training with a proper assessment of the situation (and/or) using criteria of quality of compliance affects the subject through the module the correction of the acquired knowledge and skills, evaluates the level of technical knowledge, forms of statistical reporting. In the process of learning is active testing of the subject by generating tests, including: value characteristics of the virtual patient's, or his hypothetical state Sit.



Here: X is the set of values of informative features, S(X) – the condition of the patient, obtained by deciding the rules implications ; X(S) be the set of values of X required to identify the state S, according to the implications ; {X} is the set of values of informative features X virtual patient; Sit({X}) – the state of the virtual patient according to the subject taught; Sit is the state of the virtual patient (situation); - the mismatch between X(Sit) and X(S): - mismatch between Sit({X}) and S(X); - blocks calculate the signals of the error (difference).

Рисунок 1 - the scheme of using AMESDD in interactive and intelligent testings professional skills.

On the basis of the information obtained and own experience and intellectual opportunities of the subject of education (a doctor trained at courses of improvement of kvalifikatsii) forms, respectively Sit({X}) or X(Sit) received on the corresponding inputs AMESDD. AMESDD on the basis of direct and inverse decision rules [3] or diagnose the state of the virtual patient (form S(X)), or determines the presence of his classifying informative attributes (X(S)). Evaluators of the error between the correct ("reference") solutions (formed AMESDD) and suggested the trainees form the corresponding signal values of the error (s) on which the TEACHER implement defined procedures for the management of the learning process. The error signals are calculated by the formulas (1) and (2).

$$\delta X = \frac{\sum_{i=1}^{N}(true(x_i^*))}{N}, (1) \qquad \delta S = \frac{\sum_{i=1}^{N}(true(x_i(S)))}{N}, (2)$$

here: x_i - informative the i–th characteristic; x_i^* - the characteristic value of the object of study; S – the state of the object of study; N – number of characteristics; $true(x_i^*)$ =1 if $x_i^* \subset (x_i \pm \Delta x_i)$; $true(x_i(S))$=1, if $x_i(S) \subset (\tilde{o}_i \pm \Delta x_i)$.

In the diagnostic process AMESDD encouraged to use the scheme presented in figure 2.

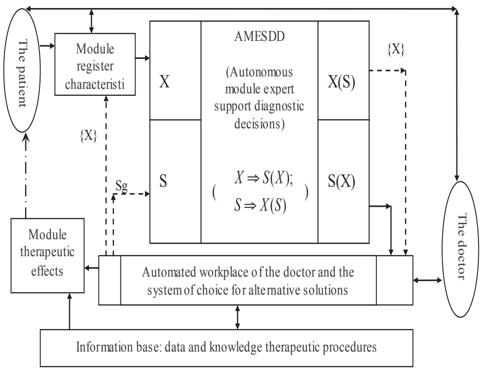


Рисунок 2 - The scheme of using AMESDD in the diagnostic process

As shown in the figure 2 diagram, the doctor performs a diagnostic process or at the same time differentiated in two ways: by the values of the registered module specific informative characteristics using AMESDD diagnose the patient's condition *S* or confirms the put forward hypothesis about the state of *Sh* by checking the patient of characteristic values {X}. Then, on the basis of information contained in information base data and knowledge of therapeutic procedures, using therapeutic interventions is a necessary correction of the patient's condition.

When organizing educational process of increasing the professional level of the therapist directly in a clinical setting (for example, as a practicing physician's assistant) module AMESDD encouraged to use the scheme shown in figure 3.

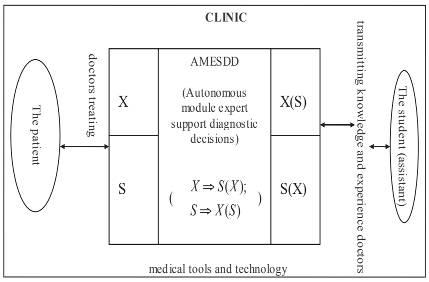


Рисунок 3 – The scheme of using AMESDD in the educational process in the clinical setting

Consider the operation of the module AMESDD.

1. Metric characteristics in AMESDD can be used in three forms: logical and semantic values (obtained during a definite answer to the existence of certain characteristics or in the process of applying the test-questionnaires (for example, presented in [9]), numerical values – in this case, it is recommended to use methods of obtaining values of latent or integrated (system) of indicators, as described, e.g., in [2, 4, 11].
2. In accordance with the provisions presented in [3], the functioning of the module AMESDD, proposed by the information-analytical model of formation of the diagnostic is shown in figure 4. AMESDD are implemented in direct and inverse decisive diagnostic rules [3] by logical structures (3) and (4).

"IF F({x}) corresponds to the set of conditions {c}, the state of the object belongs to the class G with certainty P and may be subject to impact from the set {u}", (3)

here x is the recorded attributes, p – possible, u – possible control actions, F({x}) – functionals that allow you to apply to the features of the x comparisons.

"IF the state of the object belongs to class G , with confidence q must be present signs {x} c defined values (range of values) {RV} and it is manageable impacts from the set {u}". (4)

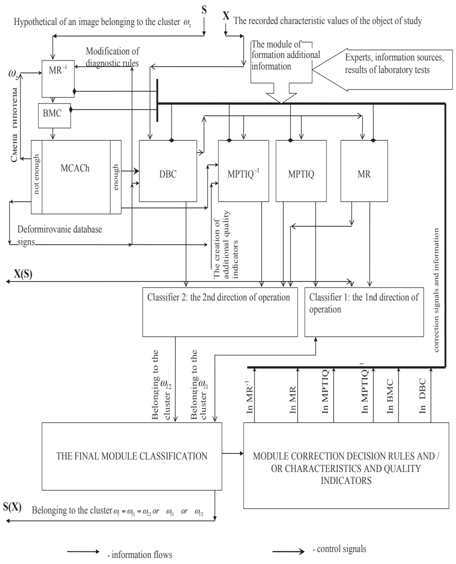
During the training phase AMESDD formed the content of the modules MR, MR^{-1}, MPTIQ, $MPTIQ^{-1}$ by the synthesis of multiple decision rules (learning sample) – type (3) and (4) and the corresponding tuples of indicators of quality (examination sample) is not contradictory to the principles of evidence-based medicine. (The tuples of indicators of quality included: the diagnostic sensitivity, specificity and efficiency of decision rules for each cluster is diagnosed.)

In BMC is the set of all sets of characteristics defining the object of study needed to correlate to a specific cluster for the prediction of the object trajectory in the state space under certain influences – internal and external (decision-makers and the environment). In DBC are the values of characteristics for the object that MCACh selected on the basis of information BMC (return decision rule) or registered in the analysis of the object of study (decision rule).

Management of the object of study in the state space (the therapeutic effect) is as follows. Decision-makers (DM), based on their own research experience and/or indirect signs, puts forward the hypothesis about the belonging of an object to a particular cluster.

This information comes in MR^{-1} which generates a set of possible combinations required in this case (as many in BMC). If this operation cannot be performed (as analysed in MCACh), we replace its hypothesis. If many signs are formed, "Classifier 2" relates an object to a hypothetical class, using the direct decision rules from the module MR, on the basis of the detected values of the selected set of characteristics optimized by the tuples from $MPTIQ^{-1}$. As "Qualifier 2" direct uses decision rules, it information from MR and MPTIQ.

At the same time, on the basis of the detected object and the values of certain characteristics (BDC), through the use of direct decision rules from Mr. and relevant quality indicators from a module MPTIQ "Classifier 1" relates an object to a particular class. The information from the classifier enters "THE FINAL MODULE CLASSIFICATION", which in interactive mode is identified by a cluster – state S.



MR^{-1} - a module for inverse decision rules, the MR – module direct decision rules, In $MPTIQ^{-1}$ - module of the plurality of tuples of quality indicators for inverse decision rules, MPTIQ - module of the plurality of tuples of indicators of quality to direct decision rules, the BMC is the base of many characteristics, the DBC – database characteristics, MCACh– module comparison of availability characteristics.

Рисунок 4 - the structure of the informational-analytical model of formation of diagnostic decisions in AMESDD.

If necessary, correction of the work by AMESDD formed in "The module of formation additional information" information analysis of opinions of experts of different scientific sources and laboratory findings (including an additional observation of the object of study).

3. If the characteristics of the patient's condition are determined by the questionnaire, the decision rules (direct and

inverse) are defined according to the excess risk of belonging to the cluster, the user-defined threshold, as follows [3]. Each answer on the availability characteristics of the patient assessed "points of importance" $B(\tilde{o})$ (values $B(\tilde{o})$ recommended skanirovat in the range from 0 to 10 with increasing the informative value), defined as expert way, and statistically [7]. We denote this risk as $Risk(B(\tilde{o}))$.

Characteristics are grouped by semantic pre-load, forming G groups, each of which are determined by the values of private (group) risk $Rg_m, m = \overline{1, M_g}$ (here M_g is the number of semantic groups). Values Rg_m are defined as expertise-based, and statistically – for example, as the frequency of occurrence of the object in the cluster in an informative confidence interval. Then,, calculated values of the risk of belonging to the cluster ω_l according to the formulas (5) and (6).

$$ORg_m = 1 - \prod_{j1=1}^{J_i} (1 - \frac{B_{m.j1}}{\max(B_{m,j1} / j1 = 1 \ldots J_m)} \cdot Rg_m) \,, \quad (5)$$

here: J_m is the number of considered characteristics in the m-th group, $B_{m,,j1}$ – score j1-th characteristic in the m-th group, ORg_m – the total value of risk in the group characteristics of m (taking into account all points in the group).

$$Risk(B(\tilde{o})) = 1 - \prod_{m=1}^{M_g} (1 - \hat{I}\ Rg_m) \,. \quad (6)$$

The results of testing of the module AMESDD.

In the computational experiment is based on the experience of treatment of 400 patients with injuries of the musculoskeletal system, who was hospitalized. The study was considered informative characteristics of the health status of 490 people with the release of the following groups [3, 8]:

Group 1 – patients with trauma, which complicated by development of phlebothrombosis of different localization (200 patients with deep vein thrombosis (DVT) without pulmonary embolism (PE) and 100 patients with DVT complicated by pulmonary embolism). Control group - patients with trauma in whom the occurrence of deep venous thrombosis were observed.

Group 2 - patients with trauma, which complicated by development of pulmonary embolism (100 patients). Control group - patients with trauma, which was complicated by phlebothrombosis occurs without the development of pulmonary embolism.

Group 3 – healthy (volunteers), which were measured in the pressure inside the muscle-fascial sheaths of the tibia and measuring the volume of the lower leg using hardware and software diagnostic complex [3] (90 people). Among 400 patients examined: man - 208 (52%), women - 192 (48%), 308 (77%) surveyed over 40 years of age, died in 133 patients (33%).

The analysis of statistical material, literary sources and personal experience revealed 159 characteristics to diagnose a possible forecast of thromboembolism (embolic thrombosis, embolicescie thrombosis, pulmonary embolism type, the form of pulmonary embolism, the outcome is death, recovery), based on which we offer a basic interface with decision-makers AMESDD is presented in figure 5 (russian version).

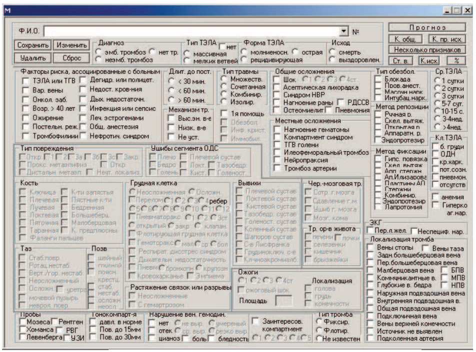


Figure 5 – basic interface AMESDD predict thromboembolism in trauma and arthroplasty.

Characteristics were combined into 26 groups: associated with patient risk factors - 14 characteristics, type, damage - 6 , bone - 13 , bruises segment, the SLM – 8 , chest - 8, the spine – 7, a sprain, or tearing – 2, the dislocation – 10, traumatic brain injury – 4, injury of abdominal organs – 5, burns -4, POS – 2, method of fixation – 9, classification of pulmonary embolism -6, localization of thrombus – 17, the type of anesthesia -4, the method repositions – 5, local complications – 6, anemia –1, sample – 6, pressure – 3, the violation of venous hemodynamics to 5, the concerned compartment -1.

In the research of diagnostic possibilities AMESDD were synthesized fuzzy decision rules straight type [8], showed the following values for diagnostic efficiency: embologenic thrombosis - 0,88, embologenic thrombosis is 0.84, PE is 0.91, fatal outcome of pulmonary embolism to 0.94, a favorable outcome of pulmonary embolism - 0,82.

(Note: the return result in decisive rules coincided with the diagnosis direct)

Conclusion

The conducted researches allowed:

- develop the structure of the computer aided learning training physician travmatologi based on Autonomous intelligent module expert support diagnostic decisions of the forecast of the situation (for example thromboembolism);
- to develop a scheme (analytical model) Autonomous expert module (AMESDD), allowing through the application of direct and inverse decisive diagnostic rules to carry out acceptable for clinic clustering of the patient;
- to propose a methodology for assessing risk clustering in the case of ball metrics measure the characteristics of the patient's condition on the basis of questionnaires;
- to carry out clinical testing of the main module of the testing system training system, proving the prospect of further studies in the considered direction.

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