Information Technology in Medical Diagnostics II

Editors:
Waldemar Wójcik, Sergii Pavlov
and Maksat Kalimoldayev

CRC Press
Taylor & Francis Group
A BALKEMA BOOK

CRC Press/Balkema is an imprint of the Taylor & Francis Group, an informa business

© 2019 Taylor & Francis Group, London, UK

Typeset by V Publishing Solutions Pvt Ltd., Chennai, India

All rights reserved. No part of this publication or the information contained herein may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, by photocopying, recording or otherwise, without written prior permission from the publisher.

Although all care is taken to ensure integrity and the quality of this publication and the information herein, no responsibility is assumed by the publishers nor the author for any damage to the property or persons as a result of operation or use of this publication and/or the information contained herein.

Library of Congress Cataloging-in-Publication Data

Names: Wojcik, Waldemar, editor. | Pavlov, S. V. (Serhii Volodymyrovych), editor. | Kalimoldayev, Maksat, editor.
Title: Information technology in medical diagnostics II / editors, Waldemar Wojcik, Sergii Pavlov & Maksat Kalimoldayev.
Other titles: Information technology in medical diagnostics 2
Description: London, UK; Boca Raton: CRC Press/Balkema, [2019] | Selected and extended conference papers from Polish, Ukranian and Kazakh scientists. | Includes bibliographical references and index.
Identifiers: LCCN 2019000914 (print) | LCCN 2019002784 (ebook) | ISBN 9780429057618 (ebook) | ISBN 9780367177690 (hardcover: alk. paper)
Subjects: | MESH: Diagnostic Techniques and Procedures | Biomedical Technology | Models, Theoretical | Congress
Classification: LCC R857.M3 (ebook) | LCC R857.M3 (print) | NLM WB 141 | DDC 610.28--dc23
LC record available at https://lccn.loc.gov/2019000914

Published by: CRC Press/Balkema
Schipholweg 107C, 2316 XC Leiden, The Netherlands
e-mail: Pub.NL@taylorandfrancis.com
www.crcpress.com – www.taylorandfrancis.com

ISBN: 978-0-367-17769-0 (Hbk)
ISBN: 978-0-429-05761-8 (eBook)

Information Technology in Medical Diagnostics II – Wójcik, Pavlov & Kalimoldayev (Eds)
© 2019 Taylor & Francis Group, London, ISBN 978-0-367-17769-0

Table of contents

Preface ix

About the editors xi

Application of 3D printing technologies in building patient-specific training systems for computing planning in rhinology 1
O.G. Avrunin, M.Y. Tymkovych, H. Farouk Ismail Saed, A.V. Loburets, I.A. Krivoruchko, A. Smolarz & S. Kalimoldayeva

Virtual training system for tremor prevention 9
K.G. Selivanova, O.G. Avrunin, S.M. Zlepko, S.V. Tymchyk, B. Pinaiev, T. Zyska & M. Kalimoldayev

Some technical propositions for electromyographical human interface device 15
T.V. Zhemchuzhkina, T.V. Nosova, V.B. Vassilenko, D.Kh. Shtofel, Y.P. Liskov, M. Duk & G. Duskazaev

Formalization of the diagnosis of olfactory disorders 23
O.G. Avrunin, Y.V. Nosova, N.O. Shushlyapina, A.S. Zlepko, A.I. Bezuglyi, T. Zyska & G. Ziyatbekova

Determination of the odorivector evaporation intensity during an olfactory study 31
O.G. Avrunin, Y.V. Nosova, N.O. Shushlyapina, V.V. Kuzmenko, A.S. Zlepko, W. Wójcik & D. Nuradilova

Possibilities of apnea diagnostics by fuzzy logic methods 39
O.G. Avrunin, E. Mustetsova, S.M. Zlepko, N.I. Zabolotna, D.M. Baranovskiy, A.M. Dyvak, M. Maciejewski & A. Bazarbayeva

Mathematical simulation of the structure of pulsed arterial pressure relations with vascular damage factors in patients with arterial hypertension 47
O.V. Vysotska, Y.G. Bespalov, A.I. Pecherska, S.M. Koval, O.M. Lytvynova, A.M. Dyvak, M. Maciejewski & A. Kalizhanova

Selective irradiation of superficial tumours depending on the photosensitiser fluorescence in the tissue 53
O.M. Chepurna, V.V. Kholin, I.O. Shton, V.S. Voytsehovich, S.V. Pavlov, M.V. Lysyi, P. Kisala & Y. Amirgaliyev

Bioengineering system for professional recruiting and prediction of physiological changes in the body of extreme activities operators 59
V.D. Kuzovyk, A.D. Gordieiev, I.I. Burdenyuk, M. Maciejewski & S. Kalimoldayeva

Mathematical modeling of change in color coordinates of superficial injuries of human soft tissues for forensic medicine 67
S. Kvaternuk, V. Petruk, O. Kvaternuk, O. Mokyanuk, A. Kotyra & A. Kozbakova

Complex assessment of the flight crew's psychophysiological state 77
V.D. Kuzovyk, O. Bulyhina, O. Ivanets, Y. Onykiienko, P.F. Kolesnic, W. Wójcik & D. Nuradilova

Methods and computer tools for identifying diabetes-induced fundus pathology 87
S.V. Pavlov, T.A. Martianova, Y.R. Saldan, Y.I. Saldan, L.V. Zagoruiko, O.Yu. Pinaieva, Z. Omiotek & K. Dassibekov

Information system for recognition of biological objects in the RGB spectrum range 101
Y.G. Bespalov, O. Vysotska, A. Porvan, E. Linnyk, V.A. Stasenko, G.D. Doroshenko, Z. Omiotek & Y. Amirgaliyev

Diagnostics of early human tumours in microwave with UHF-sensing 111
A.D. Cherenkov, N.G. Kosulina, S.M. Zlepko, T.A. Chernyshova, N.A. Shpakova, Z. Omiotek & M. Kalimoldayev

Study of the peripheral blood circulation of an abdominal wall using optoelectronic plethysmograph 119
O.V. Katelyan, S.D. Himych, P.F. Kolesnic, A.S. Barylo, V.S. Pavlov, T.I. Kozlovska, M. Maciejewski & A. Kalizhanova

Prevention of complications in children in the early postoperative period after surgical treatment of the single ventricle heart 127
O.K. Nosovets, V.S. Yakymchuk, V.Y. Kotovskyi, E.M. Bairamov, V.G. Paliy, R. Dzierzak & K. Dassibekov

Automation equipped working place of the neurologist of a perinatal centre 137
S.V. Kostishyn, S.M. Zlepko, M.V. Moskovko, V.V. Bychkov, H.S. Lepekhina, D. Sawicki & A. Kalizhanova

Database development for the automated workplace of the perinatal neurologist 145
S.V. Kostishyn, D.K. Shtofel, S.V. Tymchyk, I.V. Fedosova, S.V. Yakubovska, O.Yu. Pinaieva, J. Tanaś & A. Kozbakova

Formalisation of the problem of the matched morphological filtering of biomedical signals and images 155
A.I. Povoroznyuk, A.E. Filatova, L.M. Kozak, S.V. Danilkov, O.V. Sherbakov, Z. Omiotek & M. Kalimoldayev

Developing a mathematical model of instrumental examination of patients 163
A.I. Povoroznyuk, A.E. Filatova, A.S. Kovalenko, O.Yu. Azarkhov, N.B. Savina, O.Yu. Pinaieva, A. Smolarz, K. Gromaszek & A. Kalizhanova

Optoelectronic plethysmography method for evaluation of peripheral blood circulation 173
Y.O. Bezsmertnyi, H.V. Bezsmertna, A.S. Barylo, V.S. Pavlov, T.I. Kozlovska, A.M. Korobov, D. Harasim & D. Nuradilova

Frequency-selective heart defibrillation model 179
T.A. Smerdova, E.L. Pirotti, M.V. Bachinsky, V.E. Krivonosov, S.M. Goncharuk, M. Maciejewski & S. Kalimoldayeva

The complex degree of coherence of the laser images of blood plasma and the diagnostics of oncological changes of human tissues 185
O.V. Dubolazov, A.G. Ushenko, Y.A. Ushenko, M.Yu. Sakhnovskiy, P.M. Grygoryshyn, N. Pavlyukovich, O.V. Pavlyukovich, V.T. Bachynskiy, S.V. Pavlov, R. Dzierzak & O. Mamyrbaev

Laser Müller matrix diagnostics of changes in the optical anisotropy of biological tissues 195
O.V. Dubolazov, A.G. Ushenko, Y.A. Ushenko, M.Yu. Sakhnovskiy, P.M. Grygoryshyn, N. Pavlyukovich, O.V. Pavlyukovich, V.T. Bachynskiy, S.V. Pavlov, V.D. Mishalov, Z. Omiotek & O. Mamyrbaev

Information Technology in Medical Diagnostics II – Wójcik, Pavlov & Kalimoldayev (Eds)
© 2019 Taylor & Francis Group, London, ISBN 978-0-367-17769-0

Automation equipped working place of the neurologist of a perinatal centre

S.V. Kostishyn, S.M. Zlepko & M.V. Moskovko
Vinnytsia National Technical University, Vinnytsia, Ukraine

V.V. Bychkov
Department of Healthcare of Kyiv, Ministry of Healthcare, Kyiv, Ukraine

H.S. Lepekhina
Skadovsk Central District Hospital, Skadovs'k, Ukraine

D. Sawicki
Lublin University of Technology, Lublin, Poland

A. Kalizhanova
Institute Information and Computational Technologies, Almaty, Kazakhstan

ABSTRACT: The structure and features of the software development process for the neurologist of a perinatal centre is discussed in this article. This automation equipped working place is intended for the diagnosis and treatment of new-born's neurological disorders. It is based on a review card by the neurologist of a perinatal centre, which is also presented in this paper. The purpose of the application of this software tool, structure of its constituent blocks and their purpose is determined. Examples of the interface in the form of program windows are presented.

1 INTRODUCTION

Recent years of perinatal medicine development are characterized by significant improvements in the medical-technical and diagnostic provision of health care facilities, including perinatal centers. However, there are a great number of unresolved problems that are needed complex and urgent solutions (Petruk et al. 2012, Zlepko et al. 2016, Petruk et al. 2016, Kovalenko et al. 2017, Serkova et al. 2017). Among them, we will define two main, which associated with perinatal lesions of the central nervous system:

- The problem of reliable diagnosis of neurological disorders of the newborns's central nervous system and adequate methods and means of their treatment;
- Creation of methods, systems and devices for automated adaptive correction of motor disorders in such children.

It is clear that the doctor continues to play a major role in the medical process, but there is a problem of providing the doctor with all possible tools that would help him in his work and perform auxiliary operations. A specialized hardware-software—automated workstations of the doctor assumes these tasks.

The automation equipped working place can be a complete program module that works with a local or remote database. They can be integrated into the general structure of the medical information system of a medical institution or work autonomously (Arkhipova & Semenova 2008, Pavlov et al. 2013), but the main task of their work is to help the doctor to choose an effective and efficient medical strategy and accompany it to the recovery

Материал, защищенный авторским правом

of the patient (Kostishyn et al. 2016, Zlepko et al. 2016, Selivanova et al. 2016, Serkova et al. 2017).

2 AIM OF THE RESEARCH

The purpose of this work is to develop a software tool that is intended for the neurologist of a perinatal center, which provides increased informativeness, reliability and speed of diagnosis of motor disorders in newborn of the life's perinatal period (Zlepko & Pavlov 2013). This product should be implemented in the form of an automated workplace of a neurologist, that installed on his personal computer and provide work with information.

3 SOLUTION

An important aspect of the therapeutic process organization by the neurologist of the perinatal center is the use of an automated equipped working place (AEWP) in his work, which is a software tool that is installed on the personal computer of the doctor and serves for save of current information, its processing and definition of the treatment strategy.

The AEWP of the neurologist consists of the functional blocks, that are has some interrelationships, which are presented in Fig. 1.

In accordance with this structure, AEWP is a means of managing the medical process, since it includes both the elements of the medical examination and the blocks of forming diagnosis and purpose of treatment. At the same time, it should be noted that the doctor can at any time make adjustments to the proposed treatment tactics or agree with it. Each component of the ARM will be considered separately.

This AEWP consists of the following blocks:

– The User Interface is intended for organization of medical information input-output with which this AEWP works. The standard window interface has fields for typing text, buttons for downloading files, executing calculations, exporting data and other control elements.

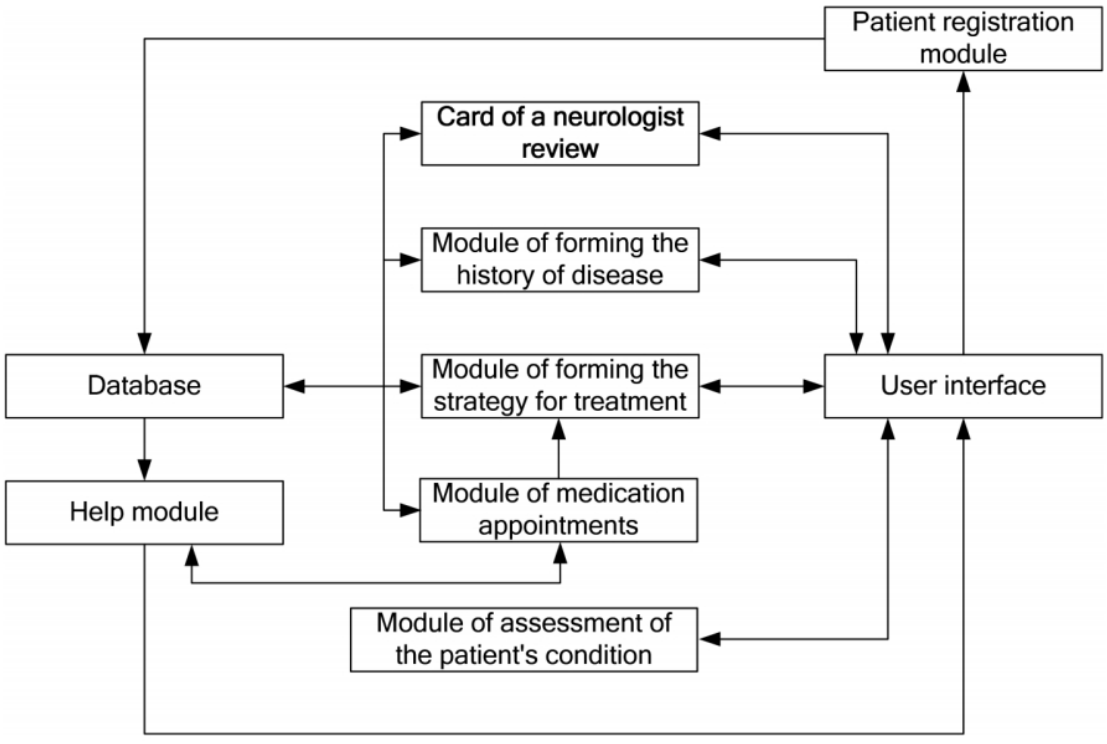

Figure 1. Structure of automated equipped working place of the neurologist of a perinatal center.

Материал, защищенный авторским правом

– The Card of a Neurologist's Review is a collection of weighty information parameters that are evaluated by the doctor-neurologist of the perinatal center when the patient arrives. In the process of filling the card, the doctor enters the information in corresponding fields. While not all fields are obligatory, so the doctor may vary the degree of filling the card at his own discretion, thereby reducing the length of the reception. The structure of the card of the neurologist's review of the perinatal center is shown in Fig. 2. For the convenience of perceiving information, the entire card is divided into separate blocks, which are physically spaced out on different tabs of the graphical software interface.
– The Patient Registration Module registers and records new patients in the system. The functions of this module include the introduction of general medical data about new patients of the system, their main medical parameters, as well as the time of their registration.
– The Module of Forming the History of Disease is intended to review the medical status of newborns for a certain period of time. This block provides the operation with information about previous medical surveys (data of review cards), and also allows us to track the change in the value of a particular informative parameter from the card. For convenience, this value is applied to the time axis. Thus, review of the patient's disease is provided and a visualization of the treatment progress is implemented.
– The Module of Forming the Strategy for Treatment is intended for automation of diagnosis and the appointment of medical, diagnostic, rehabilitee and physiotherapeutic measures. This process occurs in accordance with the rules that are formed in the module of medication appointment. Simplified algorithm of forming a treatment strategy is presented in Fig. 3. According to him, the doctor has the opportunity to choose an appropriate strategy from the existing and saved in the database (with the possibility of correction and resave) or to construct his own. In addition, there is an opportunity to review the history of treatment strategies in the database of medical diagnoses and appointments and get a set of similar strategies based on partial matches of other strategies with an indication of the identity percentage. This allows to the neurologist to decide on the strategy himself, and make a decision, which based on the partial diagnoses offered by this module of AEWP.
– The module of medication appointments contains standard connections between typical anamnestic combinations and prescribed medications. This block is edited by the physician, and the obtained logical connections are stored in the database by form of logical rules for further use in the work of the AEWP.

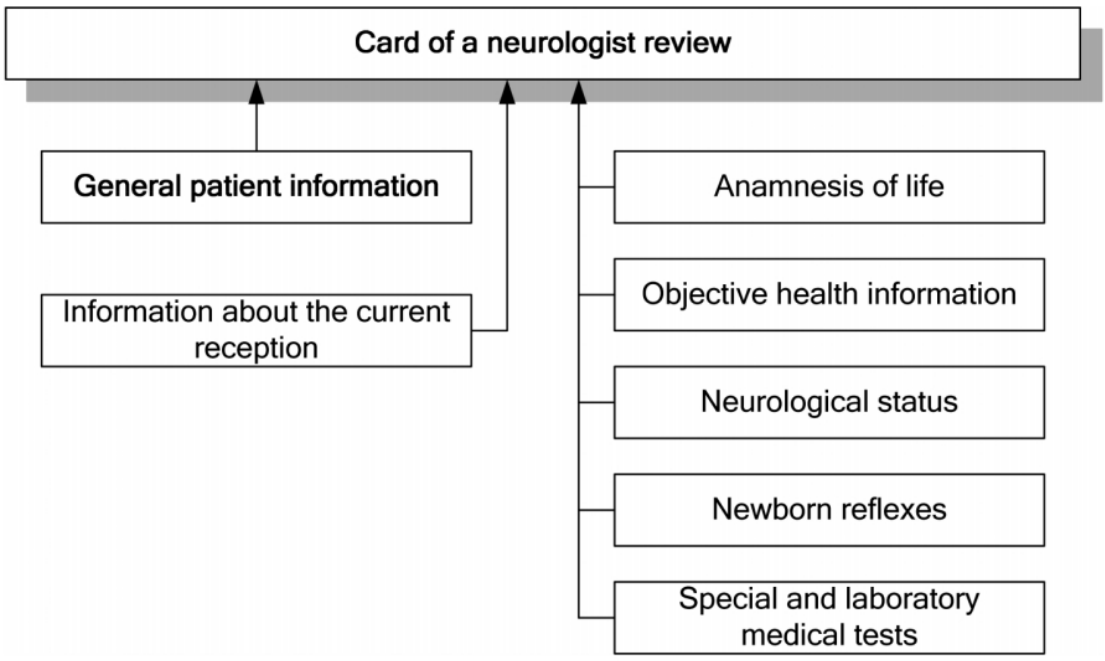

Figure 2. Structure of review card of the neurologist of a perinatal center.

Материал, защищенный авторским правом

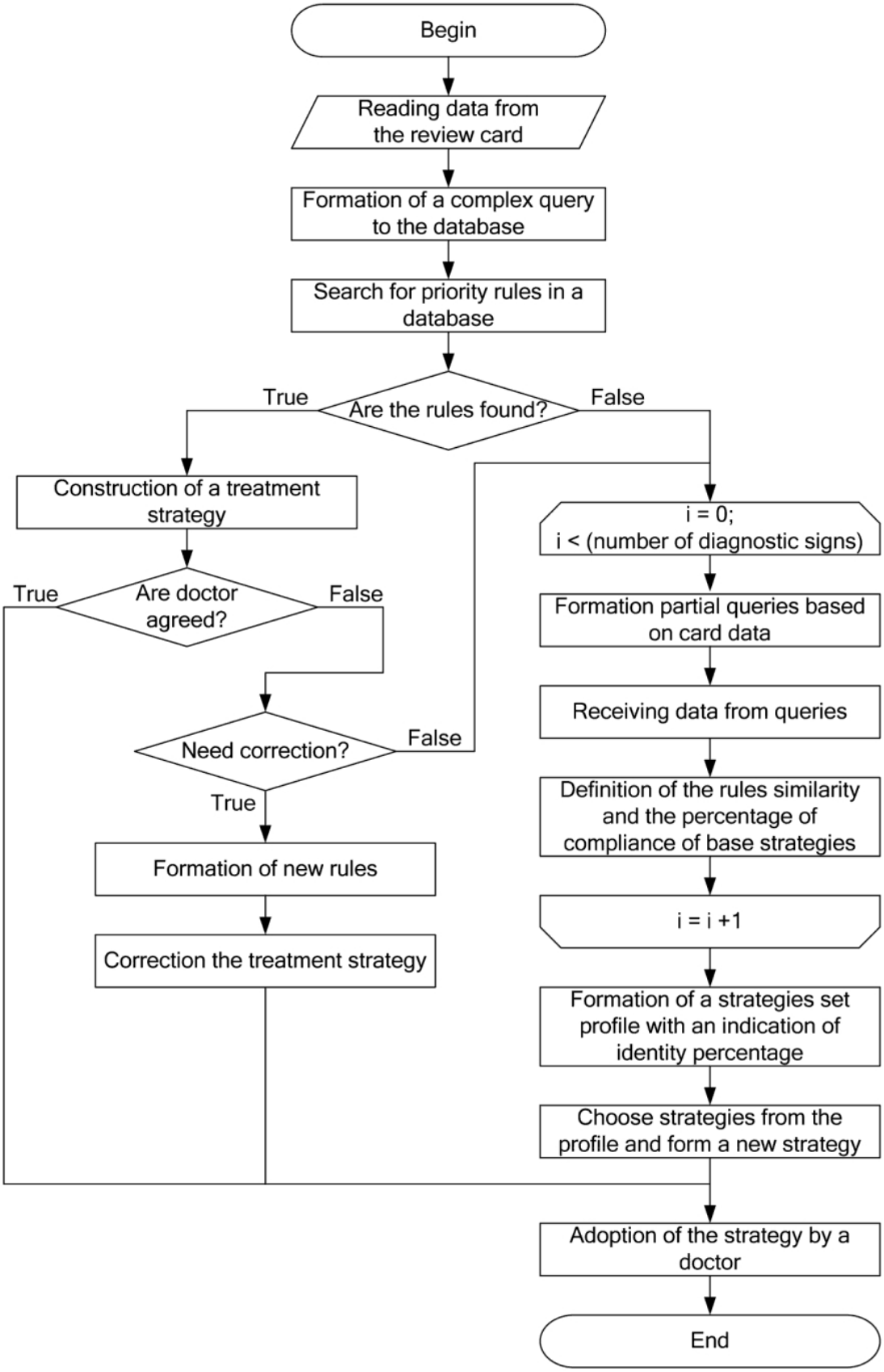

Figure 3. Simplified algorithm for the formation of a treatment strategy.

– The Module of assessment of the patient's condition is designed to diagnose the patient's functional state and is based on the registration of the ECG and EMG parameters, since these parameters are necessary for the developed method of bioadaptive correction of newborns motor disorders (Taranov A. 2012).

Материал, защищенный авторским правом

– The Help Module is intended for receiving of reference information about drugs, diagnoses, symptoms of diseases, etc.

This necessitates the use of various software-algorithmic constructions. Thus, an automation equipped working place is a set of modules (or blocks) and is a software tool that operates within the Windows family of operating systems, has an appropriate graphical interface and maintains a MySQL database.

The user interface is intended for the organization of user and algorithmic-software constructions interaction, which implemented in the developed system. This AEWP is a set of interconnected modules, each of which is designed to address their own specific functions. All of they are solves the problems that arise before the neurologist of the perinatal center.

The developed AEWP of neurologist is a multi-windows program, the interface tabs of which is presented in screenshots, as shown in Figs. 4–7.

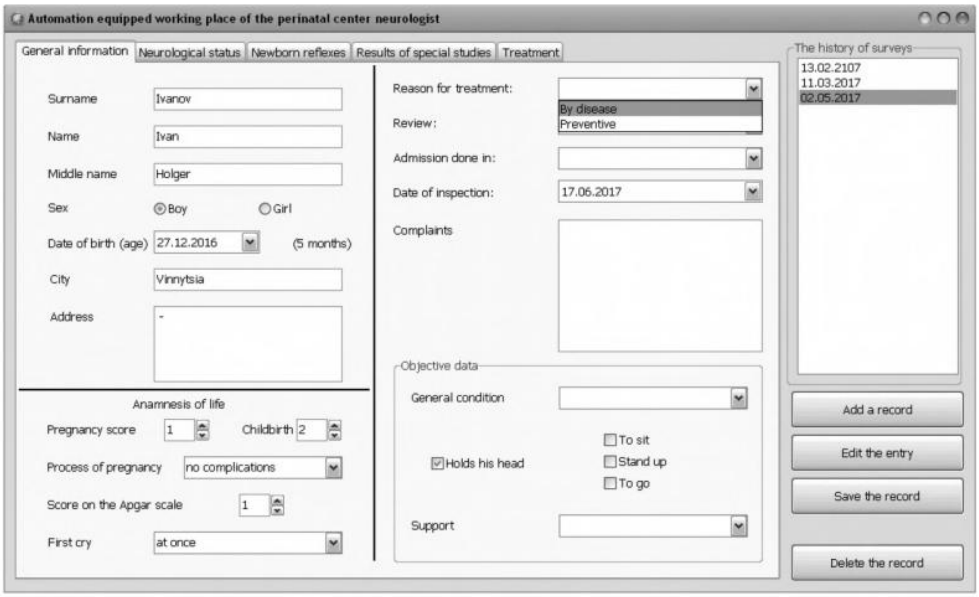

Figure 4. AEWP of the neurologist. Tab "General Information".

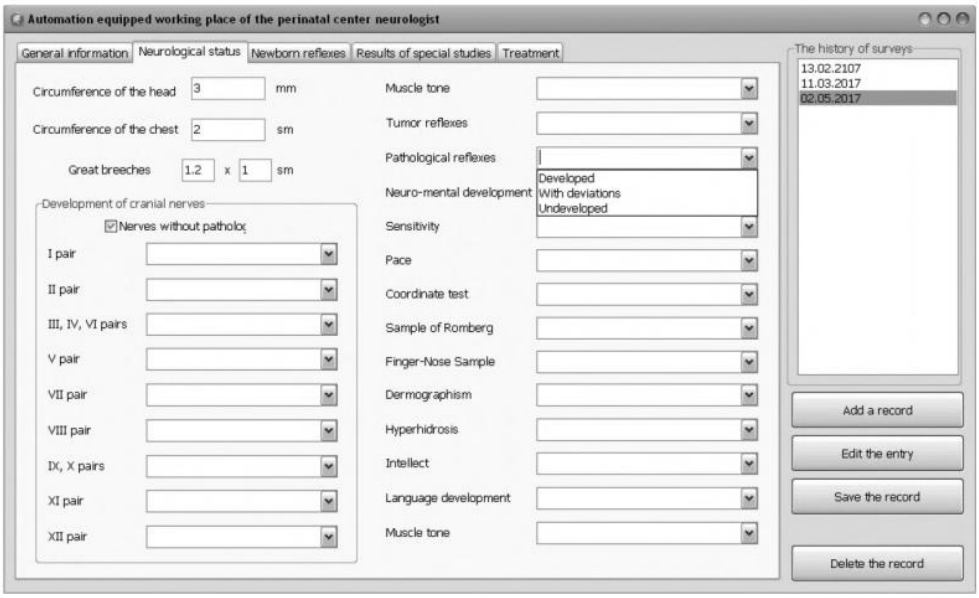

Figure 5. AEWP of the neurologist. Tab "Neurological Status".

Материал, защищенный авторским правом

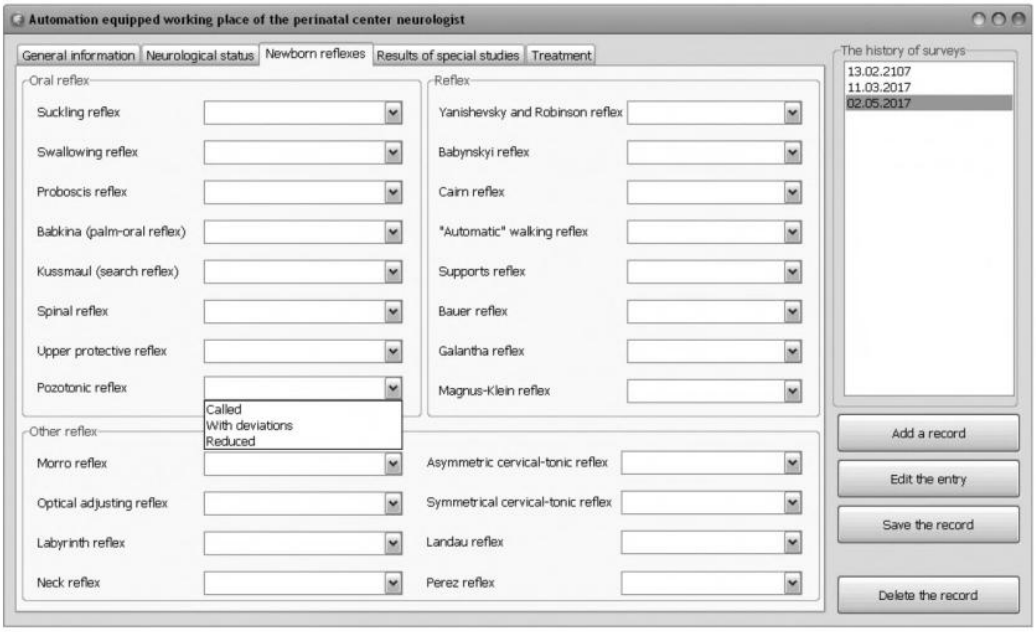

Figure 6. AEWP of the neurologist. Tab "Newborn Reflexes".

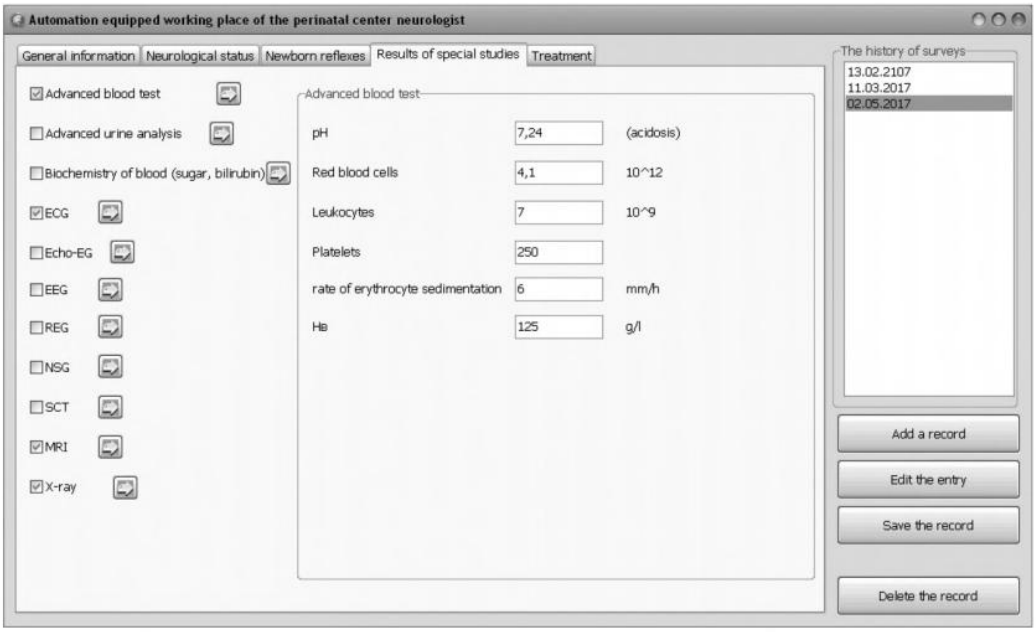

Figure 7. AEWP of the neurologist. Tab "Results of special research. Advanced Blood Analysis".

This AEWP is implemented as a database client with a set of automated computing functions, query constructor for the database, and a medical reference book.

Work with the AEWP of the neurologist begins from the search for the required patient who arrived at the reception. The search is carried out according to the criteria: surname, name, date of birth and other. After identifying the patient, it is possible to see his medical history and view the information from the stored review cards, diagnoses and appointments. In the case of a new patient, his registration is carried out in the system, which provides the introduction of biographical data, which base on the metric and words of mother.

The interface of the neurologist's review card is divided into several tabs for ease of perception and work with information. The first tab is "General information", which is shown in Fig. 4. It is intended for viewing the patient data, as well as general data on his history of life.

Материал, защищенный авторским правом

In case of making a new card, the doctor must fill in the fields about the cause of treatment, the nature of the reception and complaints of the patient. By double-clicking on the form, a software window appears in which you can select and add standard template phrases to reduce the time of filling the card. Also, the doctor estimates the general condition of the newborn.

It should be noted that the transition between the tabs is accompanied by the automatic saving of information in the database, therefore, the doctor does not necessarily constantly click on the "Save record" button.

The next tab "Neurological status" is intended for a more detailed examination by a doctor. In the process of medical examination, the doctor performs an examination of the necessary parameters of the newborn body based on anamnesis of life and complaints, namely, anthropometric parameters, development of the cranial nerves, state of consciousness, muscle tone, required tests, sensitivity, linguistic development, intelligence, etc.

The doctor can select the parameter value for each item from the drop-down menu, which also reduces the time of filling the tab.

The next tab is "Newborn Reflexes". Filling in this tab is based on simple experiments that are performed over the newborn. But it should be noted that not all reflexes are checked quickly and painlessly, so it is necessary to regulate the number of these inspections, missing secondary and unnecessary. As in the previous case, the corresponding fields are filled with values from the corresponding lists.

The tab "Special Investigations" is designed to save and review information about specific laboratory studies, such as blood and urine tests, biochemical blood tests, ECG, EMG, etc. In this case, the software does not integrate with the appropriate laboratory equipment, but only saves the entered values of the received data in the database.

The software supports graphic medical images in digital and analog form in used medical formats, such as simple (Bmp, Jpg, Tiff), and specialized (Dicom) (Schulman et al. 2005).

Image downloading is carried out manually by clicking on the corresponding buttons. The image is saved automatically, on condition of successful loading. It is also possible to enlarge a piece of the loaded image or print it.

Another feature of the system is its differentiation into two levels. The first level determines the current state of newborn's health, after which the initial treatment program is formed. At the second level, the initial program is adjusted according to the results of treatment. At each of these levels, data is stored that is saved in the database and reviewed by the doctor at the right time [1, 5].

4 CONCLUSIONS

The designed AEWP of the neurologist is a software package, in which all its modules are functionally-oriented in support of decision-making. The basis of AEWP is an expert system that helps analyze data. It gives the doctor a comment (or explanation) to each decision, taking into account intermediate conclusions. The reliability of data processing and obtained results is achieved by preliminary verification of the data to the internal consistency, completeness and adequacy of the actual state of the patient. Specialized databases and data obtained from the patient's electronic medical card are used for this.

AEWP provides (in analogy with (Kostishyn et al. 2016)) an individual algorithm for diagnosing a functional state for each patient. This allows:

- to determine the values of physiological indicators that are evaluated as appropriate ranges of norm, permissible values and limit values of these indicators;
- to refine the symptom complexes and syndrome complexes, that characteristic of certain diseases.

The established diagnosis is formed according to a single standard format: the etiology and clinical variant (portrait) of the disease; phase of the disease (exacerbation, cure); possible complications.

Материал, защищенный авторским правом

Thus, AEWP of the neurologist supports three levels of work function automation with medical information:

– at the data entry level;
– at the level of their processing using the appropriate databases;
– at the decision-making level.

This gives the doctor the opportunity to optimize the choice of patients, which at the moment, need the most attention and ensure the effectiveness of the entire medical process.

REFERENCES

Arkhipova, E.F. & Semenova K.A. 2008. Restorative treatment of children with perinatal defeat of the nervous system and infantile cerebral palsy. *Law and Order*.

Kostishyn, S., Tymchyk, S.V. & Vyrozyb, R.M. 2016. Design features of automated diagnostic systems for family medicine. *Modern Problems of Radio Engineering. Telecommunications and Computer Science (TCSET); 2016 13th International Conference on. – IEEE, Slavske, 23–26 February 2016*: 774–776.

Kovalenko, A.S., Tymchyk, S.V., Kostyshyn, S.V., Zlepko, S.M., Wójcik, W. et al. 2017. Concept of information technology of monitoring and decision-making support. *Photonics Applications in Astronomy, Communications, Industry, and High Energy Physics Experiments; Proc. SPIE 10445(104452D), Wilga, 27 May – 5 June 2017.*

Pavlov, S.V., Sander, S.V., Kozlovska, T.I., Kaminsky, A.S., Wójcik, W. et al. 2013. Laser photoplethysmography in integrated evaluation of collateral circulation of lower extremities. *Optical Fibers and Their Applications 2012; Proc. SPIE 8698 (869808), Lublin and Naleczow, 10–13 October 2012.*

Petruk, V.G., Kvanternyuk, S.M., Bolyuh, D.B. et al. 2012. Research of the spectral diffuse reflectance of melanoma in vivo *Optical Fibers and Their Applications 2012; Proc. SPIE 8698 (86980F), Lublin and Naleczow, 10–13 October 2012.*

Petruk, V.G., Kvanternyuk, S.M., Bolyuh, D.B. et al. 2016. The optical diagnostics of parameters of biological tissues of human intact skin in near-infrared range. *Photonics Applications in Astronomy, Communications, Industry, and High-Energy Physics Experiments 2016; Proc. SPIE 10031 (100313C), Wilga, 29 May – 6 June 2016.*

Schulman, E.I., Mikshin, A.G., Pshenichnikov, D.Y., Glazatov, M.V. & Mouth, G.Z. 2005. Information support of the healing process using dynamic multilayer. *Autometry 41* (5): 99–107.

Selivanova, K.G., Avrunin, O.G., Zlepko, S.M. et al. 2016. Quality improvement of diagnosis of the electromyography data based on statistical characteristics of the measured signals. *Photonics Applications in Astronomy, Communications, Industry, and High-Energy Physics Experiments 2016; Proc. SPIE 10031 (100312R), Wilga, 29 May – 6 June 2016.*

Serkova, V.K., Pavlov, S.V. et al. 2017. Medical expert system for assessment of coronary heart disease destabilization based on the analysis of the level of soluble vascular adhesion molecules. *Photonics Applications in Astronomy, Communications, Industry, and High Energy Physics Experiments 2017; Proc. SPIE 10445 (104453O), Wilga, 27 May – 5 June 2017.*

Taranov Yu. A. 2012. Development of a modular information and analytical system for perinatal centers. Internet resource. *http://sibac.info/2009-07-01-10-21-16/50-2011-12-21-06-47-18/2011-12-21-06-47-43/5113-2012-12-04-16-18-52*.

Zlepko, S.M. & Pavlov, S.V. (eds). 2013. *Modern information technologies in the management of sanatorium and resort institutions.* Vinnitsa: VNTU.

Zlepko, S.M., Lepokhina, N.S., Shevchuk, O.O., Kostishyn, S.V., Azarkhov, O.Y. & Vyrozyb, R.M. 2016. Peculiarities of construction of information provision of computer systems for the appointment of drugs in perinatal medicine. *Topical Issues pediatrics, obstetrics and gynecology* (1): 63–65.

Zlepko, S.M., Tymchyk, S.V., Novikova A.O. et al. 2016. An informational model of sportsman's competitive activities. *Photonics Applications in Astronomy, Communications, Industry, and High-Energy Physics Experiments; Proc. SPIE 10031 (100312N), Wilga, 29 May – 6 June 2016.*

Материал, защищенный авторским правом

For many centuries, mankind has tried to learn about his health. Initially, during the pre-technological period, he could only rely on his senses. Then there were simple tools to help the senses. The breakthrough was turned out to be the discovery of X-rays, which gave insight into the human body. Contemporary medical diagnostics are increasingly supported by information technology, which for example offers a very thorough analysis of the tissue image or the pathology differentiation. It also offers possibilities for very early preventive diagnosis. Under the influence of information technology, 'traditional' diagnostic techniques and new ones are changing. More and more often the same methods can be used for both medical and technical diagnostics. In addition, methodologies are developed that are inspired by the functioning of living organisms.

Information Technology in Medical Diagnostics II is the second volume in a series showing the latest advances in information technologies directly or indirectly applied to medical diagnostics. Unlike the previous book, this volume does not contain closed chapters, but rather extended versions of presentations made during two conferences: XLVIII International Scientific and Practical Conference 'Application of Lasers in Medicine and Biology' (Kharkov, Ukraine) and the International Scientific Internet conference 'Computer graphics and image processing' (Vinnitsa, Ukriane), both held in May 2018.

Information Technology in Medical Diagnostics II links technological to medical and biological issues, and will be valuable to academics and professionals interested in medical diagnostics and IT.

CRC Press
Taylor & Francis Group
an informa business
www.crcpress.com

6000 Broken Sound Parkway, NW
Suite 300, Boca Raton, FL 33487
Schipholweg 107C
2316 XC Leiden, NL
2 Park Square, Milton Park
Abingdon, Oxon OX14 4RN, UK

ISBN 978-0-367-17769-0

an informa business

View publication stats