ISSN: 0975-8585

Research Journal of Pharmaceutical, Biological and Chemical Sciences

The Use of Medical Expert Systems in Prosthetic Dentistry.

Sergey Vasilievich Chuykin*, Sergey Anatolievich Lazarev, Oleg Sergeevich Chuykin, Vitaliy Vasilevich Viktorov , and Marsel Maratovich Tuigunov.

Federal State Budgetary Educational Institution of Higher Education "Bashkir State Medical University" of the Russian Ministry of Health, Russia, Republic of Bashkortostan, 450008 3, Lenina Str., Ufa

ABSTRACT

The importance of the data support for medical technology is currently generally accepted. Expert systems enabling the doctor to assess both his own diagnostic assumptions and to use their abilities for consultation in difficult diagnostic cases are increasingly used in many areas of medicine. Development of modern medicine sets a lot of tasks on the optimal stage of diagnosis by using computer technology. Self-learning intelligent systems (SIS) take a special place among medical expert systems. Planning of orthopedic treatment by using artificial intelligence programs takes a special place. We have created a program of prediction of bone density after tooth replacement by using different types of dentures in order to select an optimal design for complex examination of patients and identify an influence of various factors on each other. The program can be used during orthopedic visits for physicians with little practical experience and during resident training for the formation of clinical thinking.

Keywords: prediction, neural networks, medical expert systems, orthopedic stomatology, bone density.

**Corresponding author*

INTRODUCTION

The importance of the data support for medical technology is currently generally accepted. Expert systems are increasingly used in many fields of medicine. This allows doctors to assess both their own diagnostic assumptions, and to use their abilities for consultation in difficult diagnostic cases [2, 7].

Possibilities for the use of diagnostic systems include differential diagnosis of various diseases, and thus represent a great interest for practical medicine. At the same time, various “input” data are often used to develop a specific solution: data of the patient history, clinical findings, laboratory test results, and complex functional methods.

Self-learning intelligent systems (SIS) take a special place among medical expert systems. Their use is based on various methods of automatic classification of situations that arise in actual practice - that is, learning by examples. Artificial neural networks (ANN) are among the most striking examples of SIS. ANN are nonlinear systems, which allow to classify data more efficiently as compared to conventional linear methods. With regard to medical diagnostics, ANN contribute substantially to an increase in specificity of diagnostic methods. They also do not decrease their sensitivity.

ANN are based on simple elements (typically the same type of elements - cells) that mimic brain’s neuron activity. A certain current state similar to the cells of the cerebral cortex (a stronger excitation or inhibition) is typical for each neuron. At this time, an artificial neuron also has a group of synapses. In this case these are unidirectional input connections linked to the output of other neurons. Also, these neurons have axons providing an output link, through which the signal (excitation or inhibition) is transferred to other synapses of neurons.

The principle of parallel processing of the signal is typical for ANN. This is provided for by arrangement of a large number of neurons in the so-called “layers”, and further binding of different neuronal layers. The number of layers and neurons in this layer may vary. In practice it is limited by computer capacity. As a rule, more complex ANN systems can solve larger problems. At the same time, possibilities of synaptic connections are modified in the process of extracting information from the so-called training data set. Subsequently these possibilities are used to obtain the result on the basis of the available data.

An essential difference of ANN from other prediction methods is the ability to design expert systems by the specialist that transmits individual or collective experience to the neural network. And thus neural network is trained based on the real information obtained through observations.

ANN are able to make decisions based on the detected hidden regularities by analyzing information provided to them, that is, on the basis of multidimensional data. An important distinctive feature of ANN is the lack of programming, i.e. these systems do not use clear output rules to solve the problem (e.g., diagnosis). They rather train to carry out this task by using examples. This is a key feature why neural networks differ from expert systems, the use of which is based on the principles of memory modeling and pattern recognition technology. Functioning of the latter is based on the results of the study of the neural organization of the brain.

In some cases, ANN can exhibit properties inherent to the human brain. In particular, they are able to open patterns in complex unstructured data volumes. Another feature of neural networks is their ability to train based on systematization of the information received.

Diagnosis is a special case of events classification. The highest value belongs to classification of those events that are not in the set used for neural network training. This includes advantage of neural network technologies, which are able to implement such classification on the basis of generalization of previous experience and applying of the results in new cases [1].

There is a whole class of tasks that do not require clear rules for solutions, but rather the experience and knowledge of the previous situations. The experience provides correct possible decisions even if this situation has never met before. An experienced doctor will make a correct diagnosis even in case of incorrect information about symptoms of the disease, which he has not seen previously.

Making algorithms for medical diagnostics tasks rests on the difficulty or even impossibility of accounting of all possible input data and finding patterns that associate the task conditions with the result. Despite high-speed performance of modern computers, they are inferior to the man in dealing with such “simple” tasks as learning objects in the differential diagnosis [3, 6].

The neural network which takes a specific input signal is able to give a definite output answer (decision) after its processing by neurons. In turn, the answer depends on the neuronal weighting patterns included in the network. Neural network training is nothing else but “setting up” of the weighting patterns. As a result, a particular output signal corresponds to the particular input signal.

Neuroinformatics is a knowledge field related to the creation of information processing devices based on the principles of natural neural systems. Neuroinformatics involves an area which is based on the development of methods for the creation of neural networks that are able to solve various problems.

At the same time, the neuron is considered to be a simple device such as an amplifier with a large number of inputs and one output. Neuroprocessors are characterized by neural memory distributed between very simple processors resulting in the fact that the main burden of the processor for performing system functions lies on the architecture. Its features are defined by characteristics of interneuron connections.

Thus, the quality of the expert system work is always stable, the neural network is able to extract and apply the knowledge that is unknown to the modern medicine. Therefore, there is every reason to expect that imperfection of the modern medicine will be eliminated to a large extent in the future due to the use of artificial intelligence.

Studies involving various algorithms have shown that some problems of medical practice (particularly those that have an “implicit character”) can be solved by obvious methods with the standards of accuracy that are not satisfactory from the point of view of their practical use in diagnosing diseases and pathological conditions, making prognoses and taking proper decisions. Possible neural network medical expert systems have the following advantages:

1. The system is able to make decisions based on its own accumulated experience. In this case, it means that that the creator of an expert system does not need to establish relationships between input parameters and the desired solution. Thus, it is not necessary to spend time on statistical analysis, choose mathematical apparatus, or perform calculation and long-term verification of mathematical models.
2. Neural network does not make a categorical decision, the decision is made together with information on the degree of confidence. This allows the user to evaluate the result critically.
3. Neural network is able to modulate its decision, making it possible to see “what happens if..”.
4. Neural network allows to get an answer quickly. This makes it possible to use it in dynamic systems, with the rapid decision-making being is a precondition for their functioning.
5. Ability to solve problems that cannot be processed by using any algorithms.

During the establishment and operation of the above-noted systems we have found principles of indistinct logic based on incorporated idea that elements with one common feature comprising a set may possess these properties in varying degrees. Therefore, these elements may belong to another set with varying degrees of severity. Thus, when the expert system processes information built on the basis of reasoning according to the rules of indistinct logic, then, for example, during the solution of the clinical problem, the specialist receives a list of diagnoses which relate to the degree of belonging to the described case of the request. That is during the analysis of the available information the doctor receives a list with all possible diagnoses, which are established in the presence of the symptoms available for the study.

Predicting outcomes of orthopedic treatment is most important regarding improving the patient's quality of life, and in particular bone density in the abutment teeth, retaining prosthesis construction. Factors that affect bone density include load and, as a consequence, change in the microcirculation of abutment teeth [4, 5].

METHODS OF THE STUDY

The study of changes in bone density was carried out by using various types of dentures (overdenture abutments, clasp dentures, partial dentures, prosthetic restoration on dental implants). In order to create an expert system for predicting bone density, we used the data obtained during dopplerography. The survey was conducted using the device "Minimax-Doppler-K" (certificate of conformity No. 3695564 as of 26.11.1999, registration certificate No. 9/03061297/0052-00 as of 06/03/2000), being unique in its class as it is equipped with probes 20, 10 and 5 MHz, which allow you to diagnose both macro- and microvessels that are used in dentistry at the same time at once.

The following patients were examined in order to create the data array: 43 patients (102 teeth - dentures), 88 patients (352 teeth - clasp dentures), 94 patients (312 teeth – bridge dentures), and the control group included 121 patients (484 teeth).

The study of optical density of the bone tissue in the area of the abutment teeth was carried out by using radiological examination in dentistry during RVG, orthopantomography and cone beam X-rays. Program database included the survey data prior to the prosthetic procedure, then 6 months and 1 year after the procedure. The data were continuously updated at the end of the treatment.

The following method was used in order to determine an optical density comparable to the mineral one. A profile form made of aluminum was used as a template with uniformly varying thickness of the strip. On the X-ray image treads are depicted as follows: the most thick (first one) is the darkest, while the most thick (last one) is the lightest. Accordingly, the lighter the analyzed area of the image is, the higher the bone mineral density of the studied tissue site is. The brightness is determined as a percentage of the plate in shades of gray. The minimum is taken as a one, and the maximum - as 100%. Further, in the range of 1-100% the brightness is defined in percentages at the any other image areas.

In order to match the jawbone density, we have compared the X-ray density of the jaw with the density of other human bones, as they have different blood supply, innervation, are not included in dentoalveolar complex, are not subjected to generalized lesions of dentoalveolar system, and included in zonografic slice. All these requirements are met by the body of cervical vertebrae, which are depicted on the orthopantomogram. An aluminum plate was used in all kinds of radiological studies in the same patients. (Patent (RU (11) 2280406 Authors: V.N. Trezubov et al.) Thus, we examined 43 patients (102 teeth - dentures), 88 patients (352 teeth - clasp dentures), and 94 patients (312 teeth – bridge dentures).

DISCUSSION AND RESULTS

The result of the study included the creation of an expert system "Predicting changes in bone density in the abutment teeth" (patent number 2013618906 as of 20.09.2013 Authors: Lazarev S.A., Lazarev V.A.) based on artificial intelligence programs.

The program database included the findings obtained during the study prior to the prosthesis, then after 6 months and 1 year. The data were constantly updated with increasing array of the studied subjects.

The program to predict bone density was based on the Windows shell as it is more convenient for computing. The program consists of three modules: prognosis, training, and input of a new data.

A training is carried out after the input of new data, and allows you to improve the quality of the prognoses. Improving of the prognosis is estimated by the numerical data displayed on the screen. The training can be carried out repeatedly and without updating the database. At the same time, it is possible to maintain the best option in the memory. A training set consisting of examples is required for training the neural network. Each example represents a task of the same type with a single set of conditions (input parameters) and a known response.

Practical application of the medical expert system is possible due to the following factors.

1. This program is able to develop in dynamics during its use, thus accumulating experience of many professionals or training on real factual material.
2. It can work in a lack of information.
3. It can operate with any type of information, up to the subjective definitions.

The use of this software is carried out as follows.

At the first stage of forecasting the X-ray bone mineral density of the alveolar process of the jaws, we measure the input parameters values. Six main parameters were selected by us: regional blood flow according to the Doppler in the apex (2 parameters), bone mineral density of the alveolar bone in the area of the supporting apex prior to the prosthesis (1 parameter), tooth location (2 parameters), and type of the prosthesis (1 parameter).

The first output parameter (p=1) is bone density in six months after the prosthesis.

Then we input the parameters obtained during examination of the patients before and after the prosthetic procedure, according to their divisions. The prognostic module of the program produces an estimated result of changes in bone density for each option of possible dentures.

Workflow of the created program is presented by input of the patient's clinical examination data in the prognostic module. So, after the launch we get a prognosis of the parameters and an option of the preferred type of prosthesis. By the way, we enter data in the "new data input" module for its further use in the "training" module.

There are the following advantages of the use of neural network expert medical program.

1. Medical expert system makes decisions based on the experience accumulated on its own. This means that it is not required to establish the relationship between the input data and the necessary decision, spending time on various statistical processing.
2. Decisions taken by the medical expert system are not definitive. The program gives a solution with a degree of confidence in it. It gives the user the ability for critical evaluation of its response.
3. The medical expert system allows you to simulate a situation of decision-making.
4. The medical expert system provides an answer very quickly, so you can use them in various dynamic systems.

CONCLUSION

An expert system proposed by us is able to predict changes in bone density after prosthetic procedures, and make a conclusion about whether to use a particular type of prosthesis and the safety of its use. In a broader sense, the use of artificial intelligence in dentistry during diagnosis, choice of treatment methods and predicting the results have a great practical value. By using this algorithm one can create expert systems in all areas of dentistry and in the separate nosological groups.

REFERENCES

[1] Galushkin, A.I. and S.N. Sidorov, 2011. Neyrosetevyye tekhnologii v Rossii (1982-2010) [Neural Network Technologies in Russia (1982-2010)]. Moscow: Goryachaya Liniya – Telecom, pp: 316.

[2] Glybochko, P.V., Yu.G. Alyaev, L.M. Rapoport L.M. et al., 2014. Virtual'nyye tekhnologii v sovremennoy khirurgii [Virtual Technologies in Modern Surgery]. Russian Medical News, 19 (1): 4-16.

[3] Pohodenko-Chudakova, I.O. and Yu.V. Karsyuk, 2014. Obosnovaniye issledovaniya po razrabotke sistemy prognozirovaniya iskhodov dental'noy implantatsii. Analiticheskiy obzor literatury [Rationale for the Study on the Development of the System for Dental Implantation Outcomes. Analytical Review of the Literature]. Bulletin of the Vitebsk State Medical University, 13 (1): 6-12.

[4] Ryakhovskiy, A.N. and V.V. Levitsky, 2008. Novyye vozmozhnosti planirovaniya esteticheskogo rezul'tata ortopedicheskogo lecheniya [New Features for Aesthetic Results Planning of Orthopedic Treatment]. Clinical Dentistry, 4: 32-36.

[5] Semenyuk, V.M. and D.V. Tytar, 2010. Mineral'naya nasyshchennost' nizhney chelyusti okolo korney opornykh zubov u lits, pol'zuyushchikhsya dlitel'no nes"yemnymi mostovidnymi

metallokeramicheskimi protezami [Mineral Richness of the Mandible around the Roots of Abutment Teeth in Patients Using Long-term Fixed Metal-ceramic Bridge Dentures]. Institute of Dentistry, 2: 32-33.

[6] Chumachenko, E.N., I.V. Logashina and I.Yu. Lebedenco, 2014. Teoreticheskiye osnovy komp'yuternogo modelirovaniya biomekhanicheskikh zubochelyustnykh system [Theoretical Basis of Computer Modeling of Biomechanical Dentoalveolar Systems]. Bulletin of Natural Sciences, 1: 98-105.

[7] Beretta, M., P. Poli and C.Maiorana, 2014. Accuracy of Computer-aided Template-guided Oral Implant Placement: a Prospective Clinical Study. J. Periodontal Implant Sci, 44 (4): 184-193.