ARTIFICIAL INTELLIGENCE APPROACH TO DIABETES DIAGNOSTICS

**Galina Setlak, Mariusz Dąbrowski, Wioletta Szajnar,
Monika Piróg-Mazur, Tomasz Kożak**

***Abstract**: In this paper a concept of designing and building intelligent system in diabetes diagnostic is introduced. The way of the expert, classifying the input data system (symptoms) for four types of diabetes (classes) has been shown in that article.*

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Introduction

The concept of the artificial intelligence was started up together with the beginnings and developing of the computer era. The possibility of adopting one of the basic features distinguishing a man, that is an intellect were concerned. Computers outdid and outdo people in mathematical calculations speed, but they lack the basic element, thanks to which they cannot match the human beings. It is the consciousness.

However, the artificial intelligence, defined as the intelligence hallmarks, is the science sphere that is developing quite fast and in the course of time one can count on new achievements.

The artificial intelligence has been defined in many different ways. According to Minsky, the artificial intelligence is science about the machines realizing the tasks that need the intelligence when they are done by a human being [Kowalczuk, Wiszniewski, 2007], [Kwaśnicka, 2005].

Figenbaum defined intelligence as the computer science field concerning methods and techniques of symbolic deduction by a computer and the symbolic representation of knowledge applied during that deduction [Kowalczuk, Wiszniewski, 2007].

Whereas Turing proposed the following definition: if the unbiased, external observer is not able to differentiate the machine answer from the human answer, we can talk about the intelligence of that machine [Kowalczuk, Wiszniewski, 2007].

Expert systems

An expert system is the information system which as its name suggests performs tasks as the expert in that sphere of the science or knowledge. This system, on the basis of particular knowledge, rules basis, draws conclusions, takes decisions, and its activity is similar to the human activity in that sphere.

Expert systems can be classified from different points of view. It can be the advisory systems, the ones that suggest the direction; systems taking decisions without the help and human interference; criticizing systems the ones which on the basis of a particular problem and the predicted solution by a man, analyze and comment the particular reasoning and action way.

Forming a system based on the knowledge background needs the expert knowledge who often finds a solution on the basis of the information about the problem and on the basis of his own experience. The expert system, having a written expert knowledge from a chosen field, can use it many times in an economic and effective way

because it does not need the presence of the expert. At the same time, it allows the expert not to repeat the analogous reports and take up more creative tasks. The special advantage of such systems is the possibility of solving the particular tasks without the direct expert's participation, and also the possibility of knowledge aggregation in one system of the numerous experts team [Mulawka, 1996].

Neural networks

The concept of neural networks has its own background in the biological nervous system. It is a very complicated structure consisting of neurons (nerve cells) and connections between them. Not delving into strictly biological background, let us look how the neural networks are formed (because our model should be treated like that) [Witkowska, 2002].

Artificial neural networks, as it is easily predicted, consist of artificial neurons. From the technical point of view, is the element of which the features match the chosen features of the biological neuron. The artificial neuron is not a faithful copy of the biological neuron, but the element that should fulfil particular functions in the artificial neural network. Such an artificial neuron is in a sense a transducer with the signal at the entrance, and it is then multiplied by the particular for each transducer, weighting kit and summed up. We receive the new signal at the way out, which defines the neuron activity.

Neural networks can be divided according to the build into:

- feed forward networks:
    - one-layer,
    - multi-layer,
- recurrent networks,
- cellular networks.

The most important feature of the neural networks is their ability to learn that is the ability to independent adjusts the weighting factors. Learning is done in particular cycles, so each task to solve for the neural networks is at the same time a new stimulus, causing the increase of “knowledge” of a particular network. Thanks to such a phenomena, the neural networks represent the sphere of the artificial intelligence [Rutkowska, Piliński, Rutkowski, 1997].

Hybrid systems

A hybrid system is a new category of systems based on the artificial intelligence. They rely on connection of the best features of such systems as: expert systems, learning systems, neural networks, and genetic algorithms. Thanks to that, the particular system is able to solve the most difficult problem, the single system which is the part of the hybrid system could not cope with. It is obvious that implementing such system is connected with the additional difficulties resulting from the necessity of connection of these elements [Białko, 2000].

Hybrid expert systems, as others classical expert systems, are built upon fundamental components:

- a knowledge base,
- an inference engine (interpreting knowledge stored in the knowledge base and making deductions),
- knowledge engineering system,
- automatic knowledge acquisition,
- explanation subsystem,

- user interface – one for accessing the knowledge base through the knowledge acquisition module, and another one for system users accessing the system in the consultation mode or in the explanation (tutor) mode and
- additional component part – the neural network.

In this context the cooperation between systems usually follows by data interchange. Each of the subsystems realizes specifying purposes. It works by autonomous way and transmits results of its activity to the other system. Especially spectacular and also practically useful are results of expert system and neural network integration. We can describe following examples of their cooperation:

- the neural network realizes numeric data processing for the expert system ;
- expert system controls the learning process of neural network;
- the neural network is made for building knowledge base of the expert system;
- the expert system transforms the output neural network data in order to show there suitable for people interpretation.

Expert system outlined in this paper uses PC-Shell 4.2. – domain independent expert system shell, having strong hybrid properties. The PC-Shell has been implemented in Artificial Intelligence Laboratory (AITECH, Katowice). The PC-Shell 4.2 system integrates the expert systems shell using blackboard architecture elements and the simulator of the neural network. It assures the knowledge representation as declarative expressed rules, facts and distributing knowledge in the neural network. The expert knowledge can contain in some knowledge sources. This system enables procedural knowledge representation too.

The knowledge representation language SPHINX is a mean for building intelligent applications. It is the way of integration of particular artificial intelligence systems. We can find a quota on this subject in paper [Bubnicki, 1990], here we will discuss only selected aspects of knowledge representation. The knowledge base structure of the PC-Shell 4.2 system is distributed following:

The block sources and control will be the most important for this paper. They are means of integration of the expert system and the neural network.

The source block: The PC-Shell is a hybrid system with elements of blackboard architecture. This determines that we can use a lot of heterogenic knowledge sources for problem solving. The declaration of ource in sources block consists of symbolic name and account of properties. One of properties is source type, we can declare sources for following types:

♦ kb – expert knowledge base,

♦ neural_net – neural networks,

♦ metaphors and what_is_file – the data base containing explanations.

The source has properties file describing a file name for source, which is, creates in the Neuronix subsystem.

The control block: The PC-Shell 4.2 system makes possible an integration of the declarative knowledge representation

```
knowledge base name
        sources
                sources description
        end;
        facets
                facets description
        end;
        rules
                rules description
        end;
        facts
                facts description
        end;
        control
                program
        end;
end;
```

Figure 1.The knowledge base structure of the PC-Shell 4.2

with procedural knowledge representation language, which enables programming of the system activity. The program in the PC-Shell system consists of instruction set included in the control block. The subset of language instruction enables the integration of neural network and the expert system. The instructions are following:

- initNetwork(X) – induces generating of neural network. X (the parameter) – defines the name of the knowledge source.
- DelNetwork(X) – induces mowing of neural network pointed by parameter X, where X is name of source declared in source block.
- RunNetwork(X,Y) – induces running the neural network, earlier inducted by initNetwork instruction. The parameter X defines the input vector of data and Y defines the output vector. Input and output vectors make possible passing the input data for neural network and also taking of results.

The example the realization of hybrid application in the PC-Shell

The realization of application in the PC-Shell system is following:

- Creating by the NEURONIX subsystem one or some neural application.
- Elaborating knowledge base in form of knowledge sources.
- Integration of the elaborated knowledge sources on the level of knowledge representation language.

Expert system of diabetes diagnostic

Expert systems or generally the artificial intelligence, are useful where the expert's knowledge is used. One of the spheres is medicine. As it is commonly known, in such an important aspect of everyday life there is no place for half measures – a doctor can not be an expert in one field only at the certain level, be not educated enough, can not count that in case of the mistake, something can be turned back. Obviously, such assumptions should be binding in all spheres of life, but let us leave divagation on that aside. Therefore a doctor is the biggest authority concerning the particular problem, he is the expert. He has to use his knowledge, knowledge of the expert each time when he intervenes (and he does it every day-quite often). But it happens very often, that the problem diagnosed by him is quite trivial, and diagnosis identical, so he has to devote lots of time to mechanical deduction. But it does not have to be that way, if instead the expert system -properly construed, can be “employed” instead of that [Bizoń, 2008].

One of such systems can be the system diagnosing the types of diabetes. Let us have a look at the characterization of the expert system operation, diagnosing this disease. Its results can be the following types (classes) [WHO, 1999]:

- Type 1 diabetes (immunologically conditioned or idiopathic),
- Type 2 diabetes (with obesity or without obesity),
- Other defined types of diabetes,
- Diabetes mellitus in pregnancy.

To start diagnosis, one should gather the proper number of data. The source of the data can be the following: a patient himself, patient's record, primary physician, specialist, biochemical lab, specialist tests.

The system gathers data by the tests: subjective and objective, laboratory and additional tests.

a) Subjective tests – history taking

- the system takes data such: name, surname, age, occupation, place of work, life style (diet, addictions (smoking), alcohol), general condition, dietary habits, nutritional status (obesity, emaciation), history of the body mass, family interview (did the family members suffer similar diseases), beginning of the

disease (when, how many years ago) course of disease, ailments from other organs and systems, past diseases and operations, present and previous infections, diabetes education, course of the treatment (in case of previously treated due to the diabetes) medicines used [PTD, cukrzyca info].

b) Objective tests

- height and body mass measurement (BMI), counting the proper body mass and comparing with the real mass, personal development phase evaluation, (sexual - bodily phase, old age phase), arterial pressure evaluation in a lying position and standing position (with the measurement of the orthostatic reaction), ophthalmoscopes tests of fondues (with papillary dilation), thyroid test, heart test, taking pulse and testing all peripheral arteries accessible when fingering and auscultating, feet test, neurology test, teeth and gums test, skin test and mucosa tests [WHO, 1999], [PTD, cukrzyca info].

c) Laboratory tests:

- glycaemia (blood glucose level) test on an empty stomach and the daily glycaemia profile,
- notation of the glycated haemoglobin and fructosamine,
- notation of the lipid profile on an empty stomach: total cholesterol and cholesterol in lipoproteins of high density (HDL – high density lipoproteins), cholesterol in lipoproteins of low density (LDL – low density lipoproteins) and trigliceryde,
- urine test (apart from glucosuria) ketone bodies and protein presence (macro- and micro-albuminuria) and microscope test of the sediment,
- bacteriological test (urine cultures and antibiotic gram),
- euthyroidism test and morphological status of the thyroid test (concentration evaluation T3, T4 and TSH, scintigraphy of the thyroid),
- peripheral arteries tests (potency and rush of blood),
- electrocardiogram, echocardiography, ergo meter test,
- neurological tests, especially the electromyography test,
- ophthalmic review (general test of the organ of sight) [WHO, 1999].

d) Additional tests

- fundus test

Conclusion

After gaining all information about the patient, symptoms and disease and after basic tests, we are at the phase when our expert system draws conclusions on their background. Diagnosing is done on the rule of moving on the decision tree. As it was mentioned before, the system that has been defined recognizes 4 classes of the disease: type I diabetes, type II diabetes, secondary diabetes, diabetes mellitus in pregnancy. In order to present the way of activity there is no need to show the conclusions scheme for each class in details – let us have a look only on one of them, the rest, of course is similar.

Diagnosis Scheme is quite simple and in a way obvious. One direction means the natural course of the disease and the possibility of the pharmacological treatment, the other one show abnormalities or alarming course of the disease and its symptoms. The final result can be the statement that the patient was (is) diabetic of the particular type, and the recommended remedy is just the proper diet and the pharmacological treatment.

That way we are approaching the diagnosis. If we analyzed one of the possible ways in details, we would notice that the particular phases do not differ from the doctor's way of proceedings. Our expert system has a task to achieve the appropriate conclusion, behaving like an expert in that field that is a doctor.

It is important that there is a close cooperation between a system engineer and experts on those interest fields when constructing the appropriate expert system. Nothing can replace the knowledge and doctor's experience.

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Authors' Information

Galina Setlak, D.Sc, Ph.D., Eng., Associate Professor, Rzeszow University of Technology, Department of Computer Science , W. Pola 2 Rzeszow 35-959, Poland, and The State Professional High School, Czarnieckiego 16, 37-500 Jarosław, Poland, e-mail: gsetlak@prz.edu.pl

Mariusz Dąbrowski *- Dr. of medical science, specialist diabetolog; e-mail: madab@esculap.pl*

Wioletta Szajnar - *M.A. The State Professional High School, Czarnieckiego 16, 37-500 Jarosław, Poland: e- mail:* wiola@pwszjar.edu.pl

Monika Piróg Mazur - *M.A. The State Professional High School, Czarnieckiego 16, 37-500 Jarosław, Poland: e-mail:* m_pirog@pwszjar.edu.pl

Tomasz Kożak - *M.A. The State Professional High School, Czarnieckiego 16, 37-500 Jarosław, Poland: e-mail:* tomasz@pwszjar.edu.pl