PRESUMPTIONS OF DECISION SUPPORT SYSTEM ON EXAMPLE OF INTRACRANIAL ANEURYSM

Kasper Tomczak

Institute of Control Engineering, Szczecin University of Technology
Szczecin, Poland

kaspert@wp.pl

Abstract: The paper is focused on both basis and assumptions of a medical decision support system, which is expected to play an important role in indicating a solution in case of intracranial aneurysm. The work presents the existing expert systems and methods being an objective of the system to be created and developed in the future. The primary problems of developing such a system are also mentioned.

Introduction

A brain aneurysm is characterized as a weak bulging spot on the wall of a brain artery very much like a thin balloon or a weak spot on an inner tube. This abnormality of vain is deemed to be very dangerous especially in case of rupture of aneurysm, which may result in people disability or even death.

The aim of this paper is to discuss assumptions of medical decision support system (MDSS) which will also incorporate a module of automatic aneurysm finding. The system will be based on an expert knowledge and acquisited tomography images. The type of the aneurysm to be taken into consideration in the future studies is depicted in Fig.1.

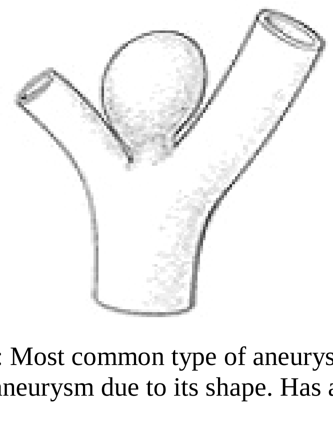

Figure 1: Most common type of aneurysm, known as a "berry" aneurysm due to its shape. Has a neck and a stem.

Increasingly, imaging and computing is being applied in minimally invasive surgery to provide two-dimensional (2-D) and three-dimensional (3-D) visualization of vascular structures to assist clinicians in preoperational planning, real-time operating room decision making, and postoperation monitoring. One emerging area of interest is in quantitative image processing techniques that can aid in the development of new and safer methods of endovascular treatment for intracranial saccular aneurysms, whereby tiny platinum coils are used to prevent blood flow within cerebral aneurysms. Hence, it is crucial to elaborate MDSS in this subject and it has been decided to give simple foundations of such a system.

Materials and methods

One may distinguish the following methods which can be employed in order to create a functional and helpful expert system [1, 11]:

- rule based methods,
- fuzzy logic,
- neural networks.

Before giving the detail description of the model, a brief review of the available modern and fully practical models is presented. In [7] a rule-based knowledge system for diagnosis of mental retardation was proposed, which is related to knowledge provided by experts in the field of mental retardation. It contains three major elements: a knowledge base, an inference engine and user interface. The knowledge base is supported by the knowledge of experts and translated into symbolic expressions. The inference engine is used for automatic extraction of consequences from information contained in the knowledge base and to verify their consistency.

The diagnosis is a result of a combination of the outputs of three equal subsystems. The first subsystem consists of prenatal factors, second perinatal and second postnatal factors. The combinations of these parameters have three possible values in each subsystem: high, medium or null. Each rule can be expressed similarly to the following formulation:

$$-x[1] \wedge x[2] \rightarrow a[2]$$

using typical mathematical symbols such as „no", „and", „or", „implies". The whole system bases on 223 rules, while the diagnosis section on 128. Although the approach shows its effectiveness, the only remaining problem of such a kind of systems is to form straight questions to an expert and to obtain precise answers.

Since the aneurysm is not a well known issue and the experts` answers cannot be exact, a more complex expert system was tested. According to [8], such a process can be performed as in Fig. 2.

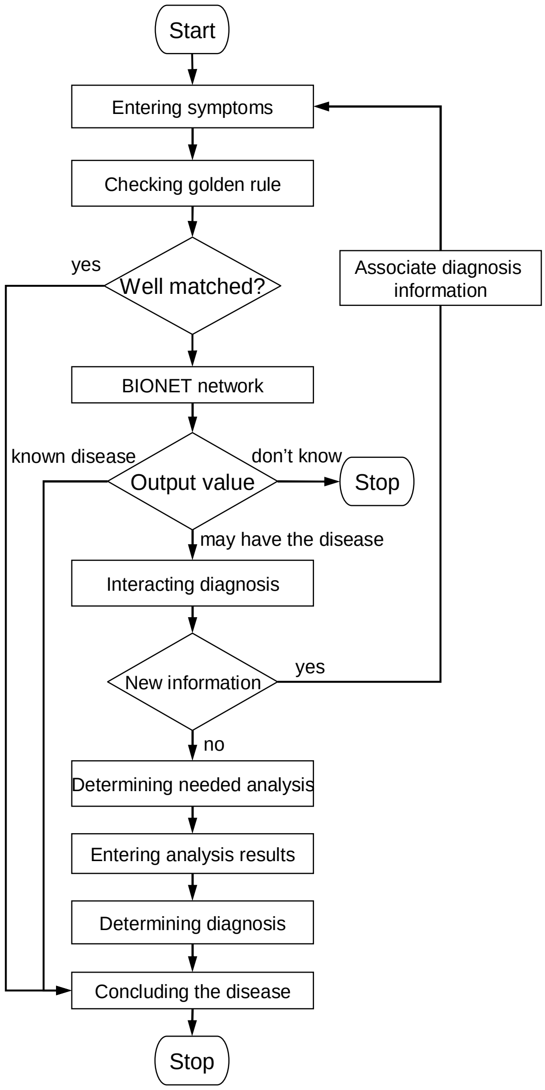

Figure 2: Exemplary process of disease diagnosis [8]

There are six main parts of the system:

- data input – entering symptoms – sequence of questions,
- checking the golden rule part – symptoms are compared with golden criteria of each disease. If it is not appropriate, the symptoms will be then used as input in a neural network,
- neural network,
- interacting diagnosis – when the data are compared to taining set (case-based reasoning)
- determining diagnosis,
- concluding the disease – final diagnosis.

The main benefit of this system is its multidimensional character. Data, which could not be simply used to precise diagnosis, are transmitted to the neural network. After that, if the system still cannot figure out the disease, it will utilize doctors' experiences to contact the patient interactively. The interacting process uses bound criteria that are a rule set extracted from a training data set. The training set is obtained from experts knowledge and employed in uncertain cases.

As it was mentioned above, the main problem of construction such a system is to specify the best methods of preparation of the knowledge base and good governing criteria. In [10] an application of a fuzzy expert system to diagnosis and treatment of male impotence was considered. The nature of the problem is very similar to the described model, namely in complication of making a simple decision. Additionally, it was decided to put our rules on fuzzy logic [1, 9, 10].
The rule of the fuzzy logic can be exemplarily formulated: if the aneurysm wall is thinner and bulge is yes and smoking is high and high blood pressure is yes and age is middle, then the aneurysm rupture is highly possible. The reasoning stage could be organized as follow:

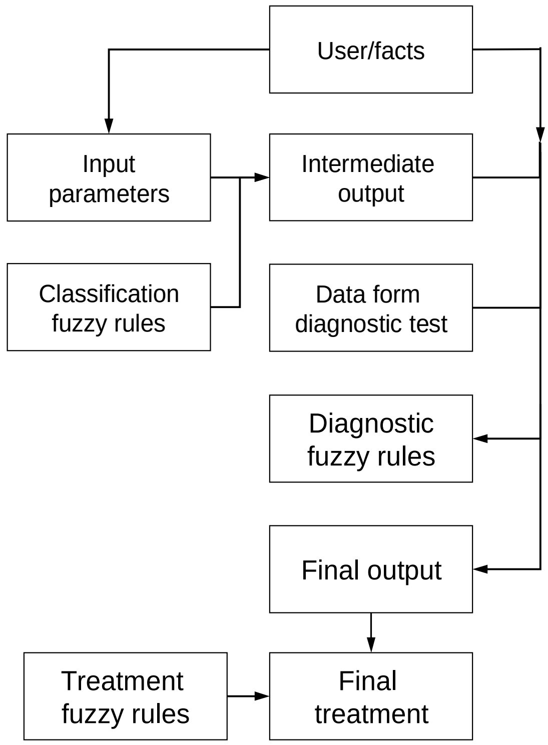

Figure 3: Reasoning flow in fuzzy logic [10]

The following factors should be incorporated in such a decision support system:

- medical knowledge about types, ways of finding and cure of the intracranial aneurysm (saccular),
- image processing – segmentation – which provides data of aneurysm for further use [2],
- mathematical model – including medical data and factors which are the result of image processing and also computational fluid dynamics.

These four modules generate enough data to design the MDSS.

Creation of the expert system to assist non-expert doctors making an initial diagnosis would be very desirable. As it is known, the real world of the medical knowledge is often characterized by inaccuracy. In the studied example medical terms do not have a clear-cut interpretation.

The developed fuzzy system should have the structure of the shown in Fig. 4.

ISSN: 1727-1983 © 2005 IFMBE

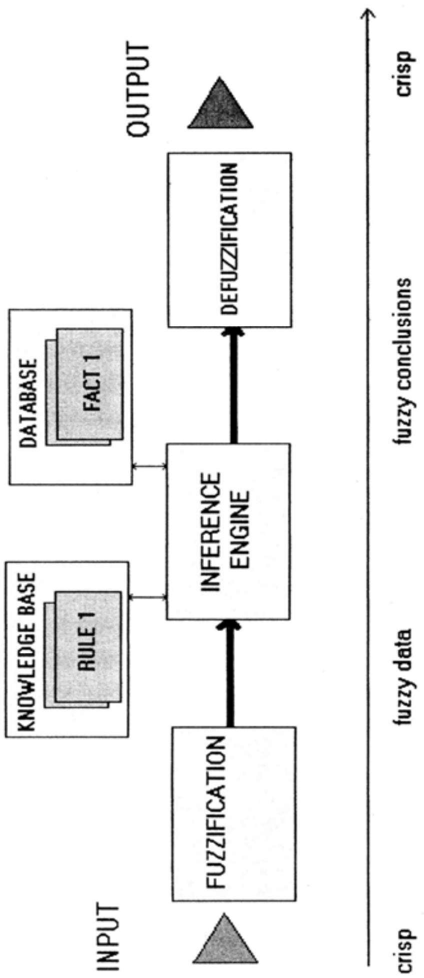

Figure 4: General structure of fuzzy expert system [9]

It is crucial to specify a set of parameters that play an important role in diagnosis for each patient's data. Following to the experts it could be:

- age as a higher risk of the rupture,
- aneurysm volume, diameter etc,
- health condition,
- other not well known factors.

The basic problem lies in obtaining data of essential aneurysm factors such as: volume, diameter, aorta condition as well as potential rupture places where the aorta wall is thinner.

Moreover, it is important to extract the aneurysm from tissue, which sometimes resembles aorta. The image, obtained from a tomograph, cannot provide clear-cut information about aneurysm structure in all cases. This fact depends mainly on a flow in aorta, since the construction both of aneurysm and aorta usually prevents contrast fluid from reaching each part of the aneurysm.

In general, there are three ways of detecting artery defects:

- manual segmentation – time–consuming,
- automated segmentation – methods presented in [3, 4],
- semi–automated segmentation like proposed in [5].

For our purposes, the second and the third technique are regarded as the most appropriate for MDSS. Obviously, the automated methods are believed to be worse about 10% than the manual counterparts, what was stated in [3]. However, the system should be as much automated as it is possible, so that use one of the aforementioned methods will establish the base in the fully automated system.

The solution for the problem of not always accurate automated segmentation method is the guidelines mentioned in [5]. According to [5], this technique consists of a selected region of interest on a few computer tomography (CT) slices. This process belongs to doctor's competence, nevertheless the rest of the slices are simulated automatically, basing on an active contour approach.

Undoubtedly, this method enables to avoid the listed below [5] problems met in case of CT scans:

- aorta does not have the same optical density within the whole volume,
- sometimes tissue has the same colour and looks very similar to aorta,
- small vessels, which branch from aorta can be neglected in a fully automated segmentation.

Modern automated medical imaging techniques followed by appropriate image analysis methods [6] have proved to be very useful for measurements of the aneurysm. In general, these methods base on a level set algorithm. In addition, they perform a 3–D segmentation of CT images and extract a 3–D aorta aneurysm model, which is practical to select an appropriate healing method.

The MDSS can be created on the base of the abovementioned recommendations, yet there is still necessity to classify the aneurysms. They can be determined by both selecting specific data from an image and comparison with an expert knowledge. The proposed system should be organized like in Fig. 5.

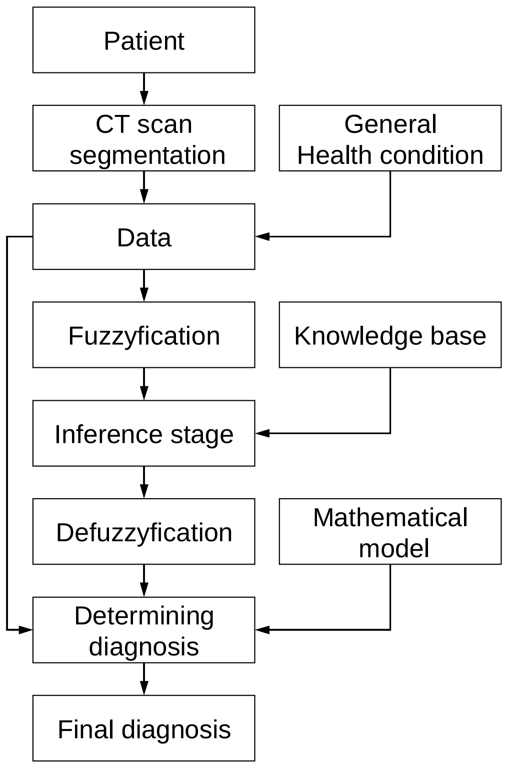

Figure 5: Proposed structure of MDSS

Results

The presented paper is first of the papers relating to a project conducted by the Szczecin University of Technology, which delineates the primary assumptions of the research project. We decided to write this article to delineate the main ideas. Since the project is in the preliminary stage only the assumptions, objectives and the main problems which have been faced when exploring this subject were disscused.

Conclusion

The mentioned methods are concerned as a basic presumption of a broad topic of medical decision support systems. The next step is to present the final equations to assess of the risk of the aneurysm rupture and providing a potential patient with possible cure methods as well as certain advice how to live with the aneurysm.

References

[1] J.P. MARQUES DE SA (2001) : 'Pattern Recognition, Concept, Methods and Applications', Springer Verlag

[2] D. A.STEINMANN, J. MILNER, CH. NORLEY, S. P. LOWNIE, D. W. HOLDSWORTH (2003): 'Image–based computational simulation of flow dynamics in a giant intracranial aneurysm', Amer. J. Neuroradiology 24, pp. 559–566

[3] M. DE BRUIJNE, B. VAN GINNEKEN, M. VIERGEVER, W. NIESSEN (2003): 'Adapting active shape models for 3D segmentation of tubular structures in medical images', Information Processing in Medical Imaging

[4] K. SUBRAMANYAN, M. STEINMILLER, D. SIFRI, D. BOLL (2003): 'Automatic aortic vessel tree extraction and thrombus detection in multi–slice CT', Medical Imaging: Image Processing (M. Sonka, M. Fitzpatrick, eds.), Proceedings of SPIE, Vol. 5032

[5] S. LONCARIC, D. KOVACEVIC, E. SORANTIN (2000): 'Semi–automatic active contour approach to segmentation of computed tomography volumes', Proceedings of SPIE Medical Imaging, Vol. 3979

[6] A. P. DHAWAN, S. JUVVADI (1990): 'Knowledge-based analysis and understanding of medical images', Computer Methods and Programs in Biomedicine, Vol. 33, pp. 221–239

[7] R. SANCHEZ-MORGADO, L. M. LAITA, E. ROANES-LOZANO, L. DE LEDESMA, L. LAITA (2004): 'A Rule-Based Knowledge System for Diagnosis of Mental Retardation', Biological And Medical Data Analysis, pp. 67-78, Springer Verlag

[8] J. VICENTE, J. M. GARCIA-GOMEZ, C. VIDAL, L. MARTI-BONMATI, A. DEL ARCO, M. ROBLES (2004): 'SOC: A Distributed Decision Support Architecture for Clinical Diagnosis', Biological And Medical Data Analysis, pp. 96-104, Springer Verlag

[9] LE HOAI BAC, NGUYEN THANH NGHI (2004): 'Disease Diagnosis Support System Using Rules, Neural Network and Fuzzy Logic', Knowledge-Based Intelligent Information and Engineering Systems p. II, pp. 1114-1120, Springer Verlag

[10] C. KOUTSOJANNIS, I. HATZILYGEROUDIS (2004): 'FESMI: Expert System for Diagnosis and Treatment of Male Impotence', Knowledge-Based Intelligent Information and Engineering Systems p. II, pp. 1106-1113, Springer Verlag

[11] N. LAVRAC (1999): 'Machine Learning for Data Mining in Medicine', Proceedings of the Joint European Conference on Artificial Intelligence in Medicine and Medical Decision Making, pp. 47-62. Springer Verlag

ISSN: 1727-1983 © 2005 IFMBE