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THE SPECIALIZED MEASURE-INFORMATIVE TRANSFORMER

In this paper the simple model of measure-informative transformer is presented. It is destinated to discriminating of two causes of symptoms in low urinary tracts: benign prostatic hyperplasia (BPH) and prostate cancer (PC). The inputs of this transformer are results of physical investigations (laboratory investigations, measurements of pressures, flow, etc.) as well as information about patient in digital form (subordinated suitable numerical scales). Outputs are described in the form of studied symptoms. Probability of occurrence of given cause is the result of processing.

the specialized measure-informative transformer, urinary tracts

Introduction

According to one from definition the measurement is an experiment executed by suitable methods, behind help of suitable tools, being organized into suitable system. Measurement can be and from rule it is process, in which it gains over information about measured object. Information is derived by signals, which are the guilds of object or physical phenomena, which create knowledge about object. In literature the notion of signal is very diverse in dependence from its source, content and code, that is a way of subordinating the information to symptoms guild of carrier [1].

In every case met in our reality information is the content of signal. It can be quantitative, e.g. the tension is 10V, or qualitative, e.g. the pain of head is small. In qualitative option one is coding signal in such a way that it express his content in form of numbers (in medicine – e.g. scales of ailment, in economy – e.g. degree of satisfaction of customer, etc).

Processing of signals is the basic operation aiming to getting, transmitting and using of information. It is done by transformers. In a simple transformer this operation is executed by forming of output signal, which content stays in definite relationship with content of input signal. This relationship is called as the equation of processing.

This subject is provided by existing rich literature. Transformers can be categorized respecting to the physical nature of input and output signals, or the way of processing. The problem appears when input signals have different nature. That is so often e.g. in medicine. During the estimation of degree of threat fall we get following information of (input values): testifying of electrocardiogram signal about abnormal work of heart + information such as a smoking history (40 cigarettes/day) + information that patient works in continuous stress (8. degree of stress in scale of 10 pts.). In result of processing of this information it was established, that probability of pronouncement of fall is even 85%. Definition of measurement describes such case when the mezurand is multidimensional, and object of measurement is described by many output values [2]. There are the difficulty to connect the signals of physical and "computer" nature. Also the way of processing using the knowledge and experience can be described only in few cases in form of equation or characteristics. The aim of this work is to present the transformer with input signals of both natures. Among accessible tools (e.g. neural networks, elements of fuzzy logic [6]) the Bayesian network has been used to process and convert the signals mentioned above.

There is still one essential aspect which can not be neglected. In metrology, the model of measured object should be always constructed. Parameters of this model or relationships among them are the objects of measurement. In described problem the human organism is the object of measurement. Considering its complexity and insufficient knowledge, the metrological model is very simplified and it contains only the most important attributes from the point of view of the aim of measurement [3].

1. The Aim and Object of Measurement

The Benign Prostatic Hyperplasia (BPH) and the Prostate Cancer (PC) are the diseases occurred at men in older age. Medicine possesses elaborated through years and constantly modernized methods and tools permitting the detection and even total healing in many cases. In last decade the possibilities of treatment in BPH enlarged considerably: from new synthetic's pharmacological drugs up to more and more perfect operating cure. Annually all over the world there are about million's operations executed from reason of BPH but about 20% of them do not cause satisfying improvement [4]. On the base of American data the sick rate by the reason of PC among the men below 50 years old is 20, and in age of 80 years it approaches to 90! In Western Europe and USA he is the frequent malicious tumour at men and happens 20% of all tumours! In 1999 the 179 300 new cases of PC were registered in USA, from

which as much as 37 000 finished by the decease of patient. In Poland, the prostate cancer is on third place, after cancer of lungs and stomach, and states about 5% of all deceases from the reason of tumours at men. How is to see, in near years the ills connected into prostate will be one from most important medical and social problems [5].

Therefore the correct diagnose which make the difference in the causes of low urinary tracts symptoms is so important. Investigations of prostate should be done in every man in the age over 50 at minimum once per year.

Man is an object of measurement, but its metrological model contains only characters significant for diagnosis of mentioned cases. They are gathered in the set of recommended (standard) investigations, which should be effected at patient with described affections.

2. Model of Transformer

In presented transformer (Fig. 1) there are only 5 inputs, because only 5-dimensional model of object will be considered. Each from input variable (symbol x_i) is the result of specific investigation (Tabl. 1).

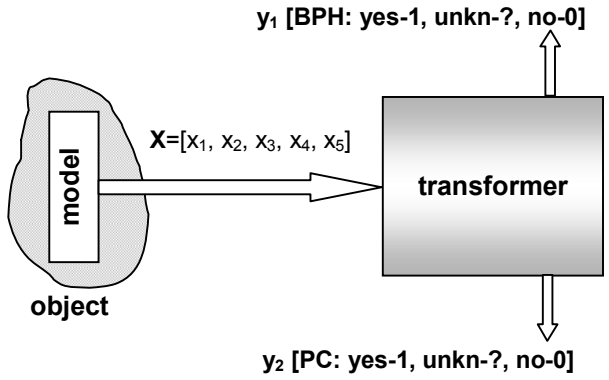

Fig. 1. Transformer with the model of measured object

Table 1

Description of input variables

Input variable	Description	The scale of value
x_1	The I-PSS test (the intensity of affections)	0 – 35 score
x_2	Examination *per rectum* (DRE) of prostate consistence	proper, boost, hard
x_3	Examination *per rectum* (DRE) of prostate volume	normal, lightly enlarged, enlarged
x_4	Concentration of prostate specific antigen (PSA)	0 – 15 ng/ml (or more)
x_5	The maximum urinary flow (uroflowmetry)	0– 20 ml/s (or more)

In this transformer there are two outputs with three permissible states on each one: 1 (*yes*), ? (*unknown*), 0 (*no*). It is assumed that only state *yes-yes* is excluded but the others combinations are not inconsistent.

The equation of processing may be written in conventional notation

$$\begin{bmatrix} y_1 \\ y_2 \end{bmatrix} = P \begin{bmatrix} x_1 \\ x_2 \\ \dots \\ x_5 \end{bmatrix}, \qquad (1)$$

where P is the transform operator for realize dependences:

$$\begin{aligned} y_1 = 1 &\Leftrightarrow f_1(x_1, x_2 ..., x_5) > 0{,}9; \\ y_1 = 0 &\Leftrightarrow f_1(x_1, x_2 ..., x_5) < 0{,}1; \\ y_1 = N &\Leftrightarrow 0{,}9 \ge f_1(x_1, x_2 ..., x_5) \ge 0{,}1 \end{aligned} \qquad (2)$$

and

$$\begin{aligned} y_2 = 1 &\Leftrightarrow f_2(x_1, x_2 ..., x_5) > 0{,}9; \\ y_2 = 0 &\Leftrightarrow f_2(x_1, x_2 ..., x_5) < 0{,}1; \\ y_2 = N &\Leftrightarrow 0{,}9 \ge f_2(x_1, x_2 ..., x_5) \ge 0{,}1. \end{aligned} \qquad (3)$$

The determination of functions f_1 and f_2 is not a simple problem. It belongs to domain so-called artificial intelligence [6]. In described problem the diagnostic graph created on the base of Bayesian network is utilized [7]. It enables to joint the expert's knowledge (urologists) with literature data and allows to find the connections between inputs x_i and outputs y_1 and y_2 .

3. Principle of operation

The settlement of transformer structure (Fig. 2) as well its parameterization are the most difficult task. The node is a basic element of structure, for which the distribution of probability a priori is defined on the basis of data from medical literatures and knowledge of expert. The values of parameters established a priori [9] for each of node corresponding to input variables are presented in Tabl. 2.

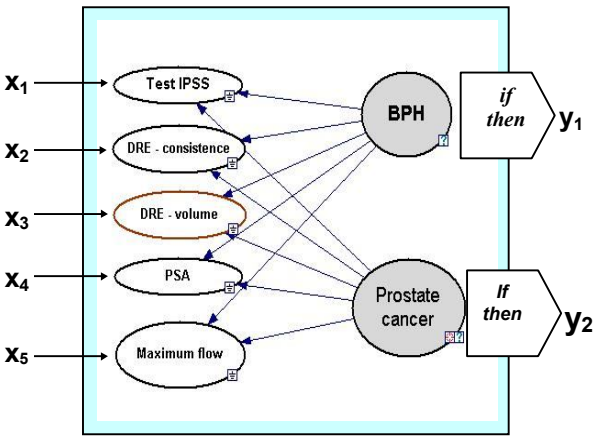

Fig. 2. View of the internal structure of transformer

The Bayesian network is realized in specialized software GENIE [8]. It should be modified as the increase of knowledge about studied symptoms. The actual results of examinations and observations are introduced into transformer's input. Then, the process of inference is executed in the Bayesian model. The result of operation is given as a number from range of 0 to 1, which determines the probability that BPH or PC is occurred in patient. A simple logical system assures the realization of equations (2) and (3).

Table 2

Values of internal parameters of transformer nodes

Value of input variable	*BPH*		*PC*	
	Yes	No	Yes	No
	Test IPSS			
from 0 to 7 points	0,05	0,994	0,40	0,40
from 8 to 19 points	0,20	0,005	0,35	0,35
from 20 to 35 points	0,75	0,001	0,25	0,25
	DRE consistence			
proper	0,60	0,05	0,01	0,80
boost	0,25	0,35	0,25	0,15
hard	0,15	0,60	0,74	0,05
	DRE volume			
normal	0,001	0,850	0,33	0,34
lightly enlarged	0,195	0,145	0,33	0,33
enlarged	0,804	0,005	0,34	0,33
	PSA			
0 – 4 ng/ml	0,45	0,15	0,001	0,85
from 4 to 10 ng/ml	0,45	0,15	0,200	0,14
over 10 ng/ml	0,10	0,70	0,799	0,01
	Maximum urinary flow			
more than 15 ml/s	0,05	0,85	0,25	0,05
from 10 to 15 ml/s	0,15	0,10	0,55	0,30
less than 10 ml/s	0,80	0,05	0,20	0,65

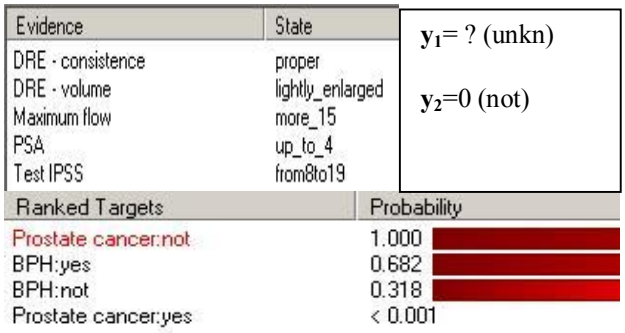

Fig. 3. The result of transformer work

4. Results

The results of transformer work is showed on Fig. 3. Patient came with small symptoms (result of test IPSS is 12 points). The uroflowmetry investigation gave good result (16 ml/s) which testifies about lack of obstruction in urinary truck. The prostate consistencies (by DRE investigation) is normal, and its volume is determined by urologist as a little bigger than normal. The PSA test is also good (0,4 ng/ml). For this values of input variables the Bayesian network demonstrates the probability of occurring the particular output states (*yes* or *not*). On basis of delivered data the possibility of prostate cancer is excluded (y2 = 0), however the unequivocal diagnosis of BPH is not clear (y1 = unkn). In such a situation doctor can look for new information by ordering additional investigations, that may change the output state *unkn* on *0* or *1*. He can also propose for patient to renew visit in two - three months or when affects will increase. This transformer is working in situation of lack of few input values, too.

Conclusions

The results of transformer operation are verified by the urologist. On the basis of results of patients investigations he placed the series of diagnoses, which corresponded with the output values. In practice the number of inputs is much higher, therefore the state *unkn-unkn* has been received most often. This way of processing input variables has been implemented earlier at study of model with 24 inputs and one output [10]. It was a result of common work with urologists from Provincial Hospital in Bialystok. This model is developed and improved now. Its final version will contain tens of inputs and at least several outputs corresponding to the reasons of low urinary tract symptoms.

In this paper the intuitive approach is presented so the sources of inaccuracy of processing and even uncertainty of received results were not mentioned.

Measurements of information and its uncertainty involve to applying quite different mathematical description [11] and it will be the aim of future work.

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Literature

1. Jaworski J., Morawski R., Oledzki J.: Introduction to metrology and technique of experiment. WNT, Warszawa 1992.

2. Guide to the Expression of Uncertainty in Measurement. ISO Geneva 1995.

3. Makal J.: Medical Diagnosis as the Result of Multiparameter Indirect Measurement, 4th International Conference on Measurement (by IMEKO TC-7 & TC-13), June 15-19, 2003 Smolenice Castle, Slovakia, (P. 260-263).

4. Leveillee R.J., Patel V.: Prostate Hyperplasia, Benign, November 18, 2004, Emedicine: (www.emedicine.com).

5. Recognition and treatment of BPH. The actual guidelines of American Urological Association. The Practical Surgery Medicine, nr 5-6/2003.

6. Henrion M., Breese J.S., Horwitz EJ,: Decision analysis and expert systems, AI Magazine, 12(4): (P. 64-91), 1991.

7. Wetter T.: Application of expert systems in medicine. Acta Clin Belg, 55,2 (P. 55-67), 2000.

8. Orzechowski P., Makal J., Oniśko A.: Bayesian networks and statistical analysis application to analyze the diagnostic test accuracy, Proc. of SPIE, Vol. 5775 (p.400-405), Bellingham 2005.

9. http://www.sis.pitt.edu/~genie.

10. Orzechowski P., Makal J.: Acquisition of Medical Data in the Diagnosis of Benign Prostatic Hyperplasia (BPH), In: Proceedings of the 6th School-Conference on Computer Aided Metrology, 2003 Waniewo, Poland; (P. 275-280).

11. Arndt C.: Information Measures. Information and its Description in Science and Engineering. Springer-Verlag Berlin 2004.

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