DIAGNOSTICS IN HOMEOPATHIC SYSTEM USING NEURO-FUZZY NETWORKS

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Abstract

The principle of Homeopathic system is to select a single medicine by priority of the symptoms not by the diseases for any patient. Neuro-Fuzzy logic networks can solves the problem of the diagnostic in Homeopath System. Homeopathic software we suppose the neural networks for solution the problem of the diagnostic in Homeopath System and consider the algorithms of the training. Neural networks will adjust the wet value as symptoms.   Using intuitionistic fuzzy set theory medical diagnosis has been applied to the problem of selection of single remedy from homeopathic repertorization. Two types of compositions of IFRs and three types of selection indices have been discussed. We also propose a new repertory exploiting the benefits of sof-intelligence.

Keywords: *artificial intelligence; Intutionistic fuzzy set; Intutionistic fuzzy relation; repertorization; Automated decision making; neural networks, training of neural networks, information granules.*

1. Introduction

Homeopathy has often been called the third-most commonly used system of healing on the globe. For that reason alone it deserves serious attention from the modern scientific community. In homeopathic practice, use of repertory is inevitable for a successful application. This very tedious process of repertorization of a patient's case has now been facilitated by the commercially available software like CARA and RADAR. But such software, instead of suggesting a single remedy, leave the practitioner with about ten to fifteen drugs, from which she has to decide for the single one. As a rule, as a consequence of the cerebrum study and mechanisms of its

functioning there have been created new computer models, namely artificial neural networks (NN). The tasks of the office automation processes based upon the research in the sphere of the artificial intelligence (AI) are of current importance to present day. NN permit to solve applications such as pattern recognition, modeling, fast data conversion (parallel computational processes), identifications, management, and expert systems creation .Theoretically, NN can solve a wide frame of tasks in the specific data domain. (as it is the human brain model prototype), but it is still not practically possible to create the integrated universal NN for the specific data domain at present, since there is no integrated construction algorithm (functioning) of the NN. The moment to date the specific structure NN and with the defined learning algorithms are used for the solution of the concrete group of tasks out of the fixed data domain.

As it is well-known, each neuron has a number of qualitative characteristics, such as condition (excited or dormant), input and output connections. The one-way only connections, mated with the inputs of the other neurons are called synapses and the output connection of the given neuron from which the signal (actuating or dormancy) comes on the synapses of the other neurons are called axon. The neuron overview is presented on figure 1. Per se, the functioning of every neuron is relatively simple. As a rule, the set of the $X=[x_1, x_2,, \ldots x_n]$ signals come to the neuron input.
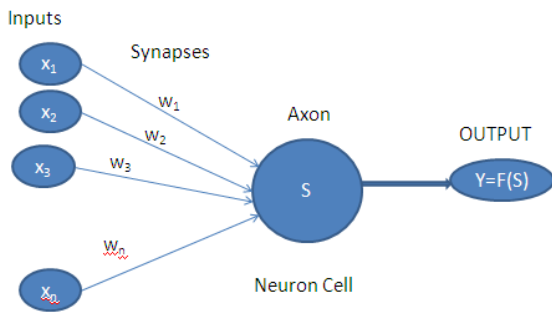
Figure 1. General view of neuron

Each of the signals may be the output of the other neuron or source. Every input signal is multiplied on the corresponding angular coefficient W=[w1,w2,w3,…wn]. It complies with the force of the synapse of the biological neuron. The products of the wi*xi are summarized and come on the adding element. To initialize the networks, the input x0 (x0=+1) and the weighting factors of the synaptic ties w0 are specially entered. The neuron condition in the current moment is defined as the weighted total of its inputs:

$$SS = \sum_{i=1}^{n} X_i \, W_i + X_0 W_0$$

The neuron output is the output of its condition: Y=F(S) . The F function is the function of activation. It is monotonous, contiguously differentiable on the interval either (-1,1), or (0,+1). In the multilayer neuronal networks (MNN) the basic elements outputs of each layer come to the inputs of all the basic elements of the next layer. The activation function F(S) is chosen as being the same for all the neurons of the network. In [1] the MNN it is determined in such a symbol form $N^K_{n1,n2,\dots,nk}$ where K – the number of the layers in the network, n_0 the number of the network inputs; n_i (i= 1, k-1) the number of the basic elements in the i-x interlayers, n_k the number of the basic elements in the output K layer and simultaneously the number of the outputs q_1 …. q_{nk} of the MNN. The intermediary a layer has a n_a neurons. There are no connections between the basic elements in the layer. The layer basic elements outputs come to the neurons inputs of only the next

(a+1) layer. The output for any neuron is determined as being

$$q_i^a = f\left(\sum_{j=1}^{n a-1} W_{i,j}^a \, q_i^{a-1} + W_{i,o}^a \, q_o^{a-1} = f\left(s_i^a\right.\right.$$

2.Specilized NN in Homeopathy System

The scientists have been into the development of the mathematical methods solutions of medicinal tasks for many years already. The effectiveness of the similar mathematical methods may be followed by the set of the medical diagnostics systems, developed in the last time. The general trait of these systems is their dependence on the specific methods of the group data processing, poorly applied to the unit objects and, also, on the features of the medical information .

The neuronal networks (NN) are easy-to-use instruments of the information models presentation. In the general case, the network receives some input signal from the outer world and passes it through itself with the conversion in each of the neurons. Hence, the signal processing is being made in the process of its passage through the network connections, the result of which is the specific output signal. For the purposes of the neuronal network designing in the system of HOMEOPATH there has been chosen the mostly spread structure of the neuronal networks – multilayer one. This structure imports that every neuron of the arbitrary layer is connected with all the outputs and inputs (axons) of the preceding layer or with all the NN inputs in the case of the first layer. In other words, the network has the following structure of the layers: the input, the intermediate (latent) and output. Such neuronal networks are also called fully connected .

For the solution of the diagnostics task in the system of HOMEOPATH the NN of the following architecture is being used (Figure 2). The task of the habituation of the MNN in classical form could be presented as following. Let there is specified some series of x* input data. It is requested to find such solution x , with which it is possible to classify the

newly presented input data. The criterion R (x, x*) determines the quality of solution. The variety of solutions x is determined by the choice of the weighting factors $w_i^{(a)}$ adjustment algorithm. Under such problem definition, the training process is comes to the receipt of the best solution out of the series of possible ones. In other words, the MNN training – is the process of data x* accumulation and, concurrently, the process of the solution x choice.
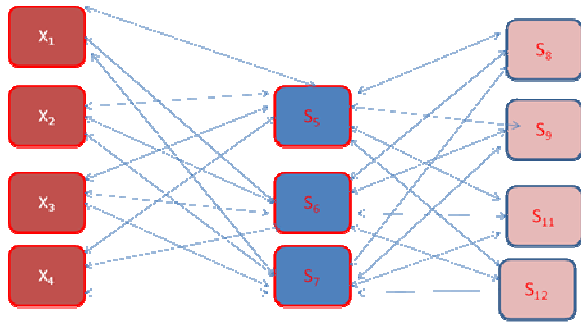

Figure 2. Architecture neuron network

3. The Algorithm of Training

The NN of the HOMEOPATH system uses the algorithm of the inverse distribution the gist of which is in the distribution of the error signals from the NN outputs to its inputs in the direction, back to the direct signals distribution in the usual mode of operation (identification regime). In other words, we use the technologies of the series tuning of neurons starting with the last output layer and finishing with the tuning of the first layer elements.

The NN habituation may be done the necessary number of times. For the habituation the so called δ - rule is used, which lies in the realization of the training strategy with the "teacher". Let us label as y* the required neuron output, y – the real output. The error of the training is calculated according to the following formula $\delta = y *-y$ in the algorithm of the gradient descent (the weighted factor)

$W_i (k+1) = W_i (k) + \gamma \delta x_i$, $\gamma > 0$

where   γ -is the "strengthening of the algorithm" factor, x_i - the i input of the neuron synaptic

connection. The algorithm of the NN training for the determination of the diagnostics   tasks in the HOMEOPATH system is in the following order of steps:

3.1 Algorithm

1. In the context of the data domain the input signals vector is made: $x = (x_1, x_2 ------x_n)$ where x_1, x_2 ------x_n are the patient symptoms.

2. The vector corresponding to the correct definitions (required) $y* = (y_1, y_2 ------y_n)$, formed by an expert in the data domain.

3. The algorithm of the direct spread of the signal x through the network is executed. As a result of the algorithm execution the weighted sums S_{jn} are determined and the activators for each cell.

4. The algorithm of the inverse signal distribution through the cells of the output and intermediary layer is executed. The errors δ_o calculation is performed for the output cell and δ_i for the encapsulated cells.

5. The neurons weights renovation is performed in the network, where S_{in} – is the weighted sum of the output signals of the n layer n (the activation function argument).

The NN habituation is in the presentation of the training examples out of the little group of the desired actions. This is performed by the way of the algorithm of the inverse distribution performance with the account of the desired result and real result.

The network functions in two regimes: in the regime of habituation and in the regime of identification. In the regime of habituation the so called logical chains formation is made. In the regime of identification according to the specific input signals with the high range of validity the NN determines, which actions to undertake.

The habituation of the neuronal network is performed upon the limited number of examples, then, they permit it to independently generate the behavior in other situations. The ability to generate correct

reaction on various symptoms, which are not in the training set, is the key factor in the creation of the NN. The data for testing is some scenarios with the set of possible actions. In the result, the network has to calculate the reaction on the inputs and perform an action, which will be similar to the training scenarios. For the network habituation the following examples were used (Table 1).

In order to test the NN, the networks should be presented with the new examples. This allows determining how the network will react upon the

Table-1 Input Data

Ssmpt-1	Ssmpt-2	Ssmpt-3	Ssmpt-4	Preparetion
1	1	0	1	P1
1	1	0	1	P2
0	0	1	0	P3
1	0	1	1	P4
0	0	1	1	P5

scenarios, of which nothing is known. The similar tests permit to know hoe qualitatively the NN can react on the unforeseen situations and perform the necessary actions. To test the NN it is necessary to present new examples (Table 2).

Table-1 Output Data

Ssmpt-1	Ssmpt-2	Ssmpt-3	Ssmpt-4	Preparetion
1	1	0	1	P1
1	2	0	1	P2
0	0	1	1	P3
1	1	0	1	P4
0	1	0	1	P5

The distinguishing property of the HOMEOPAT system is it's possibility to follow the strategy of construction (and following check of differentiated diagnosis), used by a clinicist. Such a diagnostic model includes the two-level procedure, which builds hypothesis of illness, based on input patient data, and processes the data estimation based on additional

symptoms, which should be common for the possible illnesses. The search for the needed information to form the image of illness is performed through the knowledge base using the mentioned specialized NN

4. Features of NN in the Homeopathy System

The processes of defining, extraction and structurization of information are known to be the most important in artificial intelligence system building. Implementation of each process has a great distinction, depending on the information storage environment, organization of information and the concepts of NN design for searching and analyzing the required data. In HOMEOPAT system main informational blocks consist of general patient's state, symptoms and recommended drugs. Taking into consideration the fact that system uses the concept of granular NN design [Bargiela, 2003], based on the information granules creation process with their following processing. Information granules are defined as the map

$$A : X \rightarrow \delta$$

where A - illness, X – the space on possible symptoms, δ – the space of homeopathic drugs.

The detail level of artificial information granules is defined be the number of elements in the granule. The level of precision is defined through the integral

$$Card\,(A) = \int_X A(X)\,dx$$

where – A – examined granule. The more powerful granule is, the more precise will be the result of illness distinction using the given symptoms and less specific.

Let $A = (A_1, A_2 \ldots\ldots A_C)$ - where "c" is the precision level in naturally common illnesses in the form of granule set.

The initial data can have a different level of precision. For example, $B = (B_1\,B_2\,\ldots\ldots B_P)$, where "p" is the level of precision, which is much higher, then of a granule with level "c. Such a transition from

the granule of the selected level of precision to the granule with another level of precision brings up the mechanism of dealing with so-called dynamical information granules, or the mechanism of new granular space building.

For example, the evolution of granular space <X, G, A'> into < A G X"> where A" is more precise than A' , in the HOMEOPAT system can mean the gathering of some new information about the illness, and consequently a dynamic change of corresponding information granule. Depending on the problem, granules in the system are grouped into layers. The given information network in the basis for the NN design in the HOMEOPAT system. In addition we should point out that hidden layers of NN in such a case represent the agents of granular environment, responsible for interaction between different objects. Formally the granular environment with the interaction layer can be defined the following

way G = < X, G, A, C> Let's examine the general structure of data-model in terms of information granulation on example of simplified model of NN functioning. The upper generalized level of granular space could be represented in the form of the following information granules: structure of input data for the NN, which is represented as an array of illnesses symptoms, is the first element of informational granulation, which has a corresponding array of drugs, which could be used to cure the current symptoms, which is the second element of informational granulation. Formally this can be described so $G_{net} = \{ X_{net} , G_A ,In_{G1} , In_{G2} .... \}$ where G_{net} neural network of granulation, G_A – agent of granulated environment, net X_{net} - artificially represented space of informational granules, In_{G1} informational granule containing an array of symptoms, In_{G2} - informational granule containing an array of drugs.

5. Sanchezis Scheme in terms of IFS

By using IFSs we first generalize and adapt Sanchezís scheme for medical diagnosis ([9],[10]) to the problem of selection of homeopathic similum. In a given homeopathic case, suppose S is the set of symptoms, D set of drugs, and P the set of patients. Analogous to Sanchezís notion of "Medical Knowledge" we define Intuitionistic Homeopathic Knowledge(IHK for short) as an intuitionistic fuzzy relation K from the set of symptoms S to the set of drugs D (i.e., on S X D) which reveals the degree of association and the degree of non-association between symptoms and drugs.

3.1. Method. The methodology of intuitionistic fuzzy drug selection comprises following main steps:

1. Determination of symptoms of the patient and their associations/non-association to his/her by routine case-taking. Thus mathematically, a patient is an IFS, say A; on the set of symptoms S: This IFS would help to construct an IFR CPS; relating patient to symptoms. It is customary to underline symptoms reported by patients with more underlining indicating stronger symptoms. It must be noted that assigning association and non-association degrees to each symptom is a generalization of the underlining practice.

For example if a practitioner wants to use only traditional underlining, then he may fix association degree of one underline as 0:3, double underline as 0:6 and three underlines as 1. But the provision of discerning more grades of symptoms than the traditional three, allows for a finer analysis and thus gives an edge to this method over the classical one.

Being part of a generalized method association and non-association degrees may be interpreted variously. For example first number of a pair is the degree to which a patient thinks the symptom to be important and the second is the degree of importance attached to it by the practitioner. Patient may attach a great value to his aching knee but for practitioner it is just a particular physical symptom and not a generality or modality. The generality of method includes the classical case as a special one as follows: it is clear that

$$\mu(x) + \gamma(x) = \le 1;$$

$$\forall_x \in X$$

allows us to select non-association
$\gamma (x)$ as $\gamma (x) \leq 1 - \mu (x)$;

This implies that if only the traditional analysis is to be adhered to, one should use the mechanical formula for the non-association i.e.
$$\gamma (x) = 1 - \mu (x) \qquad (1)$$

Clearly, in this case one deals with a subclass of IFS's i.e. fuzzy sets and, in fact, would be under-utilizing this method. While using (1), this should also be kept in mind that it is bit debatable if an association of (say) 33% marks mechanically implies a two-third non-association.

2. Codification of homeopathic knowledge as an intuitionistic fuzzy relation. It would be achieved by the help of an expert homeopath or some other dependable source of homeopathic knowledge, for example as the one pr posed in [8]. If the 3 or 5 grade system used by different repertories is required to be carried along, it may be handled as was done in case of patient-symptom underlining in step 1 above. This IFR from S to D of homeopathic knowledge is denoted as $K_{S\,D}$:

3. Determination of patient-drug relational strength through composition of intuitionistic fuzzy relations. The max-min-max or max-average composition RPD of CPS with the IFR $K_{S\,D}$ denoted by $R = KoC$ (may interestingly be read as, Result = Knowledge applied to Case) signifies the patient-drug relation as an IFS on D with the membership and non-membership functions, respectively, given by

$$\mu_R (d) = V_{s \in S}[\mu_A (s) \wedge \mu_R (s, d)] \qquad (2)$$

And $$\gamma_R (d) = \wedge_{s \in S}[\gamma_A (s) \vee \gamma_R (s, d)] \qquad (3)$$

$$\forall_x \in X$$

The choice of composition method lies with the user. If user's knowledge of homeopathic case is to be considered, then Definition 2.4 should be employed. If one decides to depend upon the knowledge of expert solely, then choice of Definition 2.5 is logically more correct.

4. Computation of selection index S_K for final decision. Any one of the following selection indices may be used:

$$S_K^1 = \mu_K - \gamma_K \, \P_K.$$

$$S_K^2 = \mu_K - \frac{\gamma_K + \P_K}{2}$$

$$S_K^3 = \frac{\mu_K + \gamma_K}{2} - \pi_K \qquad (4)$$

S_K^2 is more discriminatory as compared to S_K^1: Whereas S_K^3 is firmer on giving judgment and seldom comes up with a tie decision. Hence rare, if ever, use of hesitations is made in S_K^3:

5. In case of a tie decision in step 4, hesitations are called in to get final judgment and the drug with least hesitation is selected.

As conclusion we note that the simultaneous usage of main terms of informational granulation and neural networks gives a bunch of new possibilities in designing of the mentioned specialized neural network. Exactly: more precisely design the architecture of the network, number of hidden layers and the method of representation of learning set and the following work with the real data.

6. Conclusion

In order to establish Homeopathy as a true science at par with others, systematization and standardization are prerequisites. simultaneous usage of main terms of informational granulation and neural networks gives a bunch of new possibilities in designing of the mentioned specialized neural network. A repertory of homeopathic symptoms-drugs is one of the most important sources of the practice and research in this science. Hence one reads now and then calls to develop new repertories based upon modern scientific practices e.g. likelihood ratio [8] based repertory. Complementary to a new repertory is a method of repertorization which may use the full benefit of the new repertory.

References

[1] K. Atanassov, Intuitionistic fuzzy sets, Fuzzy Sets and Systems 20(1986) 87-96.

[2] K. Atanassov, G. Georgeiv, Intuitionistic fuzzy prolog, Fuzzy Sets and Systems 53(1993) 121-128.

[3] Aleksander, I., & Morton, H. (1990). An Introduction to Neural Computing. Chapman & Hall. [4] R. Biswas, Intutionistic fuzzy relations, Bull. Sous. Ens. Flous. Appl. (BUSEFAL) 70(1997) 22-29.

[5] H. Bustince, P. Burillo, Structures on intutionistic fuzzy relations, Fuzzy Sets and Systems 78(1996) 293-303.

[6] W. L. Gau, D. J. Buehrer, Vague Sets, IEEE Trans. Sys. Man Cyber. 23(2)(1993) 610-614.

[7] J. T. Kent, Use of the repertory, in Repertory of the Homeopathic Materia Medica, B. Jain Publishers India (1993).

[8] A. Rutten, C. Stolper, R. Lugten and R. Barthels, Repertory and likelyhood ratio:time for structural changes, Homeopathy 93(2004) 120-124.

[9] E. Sanchez, Resolution of composition of fuzzy relation equations, Information and Control 30 (1976) 38-48.

[10] E. Sanchez, Solutions in composite fuzzy relation equation. Application to Medical diagnosis in Brouwerian Logic, in: M.M. Gupta, G.N. Saridis, B.R. Gaines (Eds.),

Fuzzy Automata and Decision Process, Elsevier, North-Holland, 1977.

[11] M. H. Shu, C. H. Cheng, J. R. Chang, Using intuitionistic fuzzy sets for fault-tree analysis on printed circuit board assembly, Microelectronics Reliability (Article in press, doi:10.1016/j.microrel.2006.01.007).

[12] A. Steinsbekk and Data Colloection Group, Data collection in homeopathic practice: A suggestion for an international standard, British Homeopathic Journal 89(2000).

[13] Anthony, D., Hines, E., Barham, J., & Taylor, D. (1990). A Comparison of Image Compression by Neural Networks and Principal Component Analysis. In International Joint Conference on Neural Networks, Vol. 1, pp. 339--344.

[14] Baxt, W. G. (1995). Application of Artificial Neural Networks to Clinical Medicine. Lancet, 346, 1135-1138.

[15] Burke, H., Rosen, D., & Goodman, P. (1995). Comparing the Prediction Accuracy of Artificial Neural Networks and Other Statistical Models for Breast Cancer Survival. In Tesauro, G., Touretzky, D., & Leen, T. (Eds.), Advances in Neural Information Processing Systems, Vol. 7, pp. 1063--1067. The MIT Press.