INTELLIGENCE PSYCHO-DIAGNOSTIC FORECASTING SYSTEM

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The article considers a problem of efficiency of psychotherapy. We have offered a method of assessing and forecasting of efficiency of therapeutic influence. The principle of creating intelligence diagnostic forecasting system is described.

Keywords: decision support systems, neural networks, fuzzy logic, efficiency of psychotherapy.

Introduction

The main goal of any psychotherapeutic treatment consists of helping patients to make necessary changes to their lives. Success or efficiency of psychotherapy is estimated depending on how resistant and, in a broad sense salutary, are these changes for the patient. Today the psychotherapeutic measures which provide long-lasting positive effect are considered as optimum. In other words, overall performance of a psychotherapist is estimated by the result which is not a subject of reliable forecasting.

The problem of efficiency forecast of psychotherapy at the initial stage of treatment has not been solved yet. The choice of a method which would be adequate to a patient's condition and their personal characteristics is carried out by psychotherapists intuitively or on the basis of their professional experience. This aspect of psychotherapeutic treatment has a subjective character. As for forecasting results, the majority of psychotherapeutic models do not even include the aspects of measuring of dynamics of the patient's condition and treatment efficiency assessment.

Method of efficiency predictive assessment of psychotherapeutic influence

We believe that efficiency predictive estimation of psychotherapeutic influence can be based on a series of measurements of indicators of mental and, first of all, emotional condition of the patient. If we exclude the methods of diagnostics of a functional state by removal of psychophysiological indicators, perhaps, the questionnaires, directed on a self-assessment of the mental state of examinees, we will arrive at the most widespread method of forecasting.

One of the diagnostic methods, which would meet the requirements of serial measurement of indicators is the color test of M. Lyusher. This method was chosen by us because it is not bound to lexical or graphic questions and terms which result in the so-called "effect of learning" at repeated tests and seriously distort the results of testing. Long-term experience of applying Lyusher's test, the essence of which is the detection of the examinee's choice of the preferred and non-preferred colors out of eight shown color standards show that color preferences depend on a set of basic personal characteristics as well as on the actual state caused by a particular situation.

The offered method of assessment and forecast of a condition of the examinee, the psychotherapist's patient are based on the calculation of the described criteria. Since the procedure of testing is brief and simple and its contents have unconscious character for the patient, it can be repeated several times, with short time intervals, without the loss of results reliability. It gives the opportunity of forecasting patient's condition dynamics by means of methods of trends creation.

Intelligence system of dynamics forecasting an emotional condition of a personality

In order to perform forecasting the change in the emotional state of the patient in the nearer future we apply the indistinct neural production network of Vanga-Mendel. Let us examine the forecast task in more details in the example below.

Throughout the psychotherapeutic course the patient takes tests with a certain frequency which corresponds to the frequency of carrying out psychotherapeutic sessions (usually not more often than once a week). As a result, the data file with indicators of an emotional condition of this patient is being collected. Carrying out each testing is the result of the value of seven indicators of an emotional state. These indicators form a complex assessment of an emotional state. For the purpose of maximum saving of information on the examinee we have decided to consider these indicators independently without carrying out regression generalization. In this regard, the forecast for each indicator becomes irrespective of its own neural network. The forecast of one of the indicators will be described further in this paper.

For the actual forecast to be successful it is necessary to have knowledge of the values of at least the same number of results of testing, as the number of the entrances into the neural network. The values of last testing are used for the forecast below. At implementation of the forecast, the predicted values are used instead of the missing values. Therefore, the process of forecasting becomes interactive.

For implementing the forecast function in indistinct neural networks, we have applied indistinct neural production network of Vanga-Mendel. It implements the indistinct production model based on rules of the following type:

$$\begin{gathered} If\ x_1\ there\ is\ A_{i1}\ \& \ldots \&\ x_j\ there\ is\ A_{ij}\ \& \ldots \&\ x_m\ there\ is\ A_{im}, \\ THEN\ y\ there\ is\ B_i,\ i = 1, \ldots, n \end{gathered}$$

Besides, the algorithm of an indistinct conclusion which is carried out by this indistinct neural production network is based on the following provisions:

− The accessory functions of all indistinct sets are represented by Gauss function;

− Indistinct implication - indistinct work;

− T-norm - indistinct work;

− Accumulation of the active conclusions of rules are not carried out;

− The defusification method - the average center.

Thus, the indistinct production model and the mechanism of an indistinct conclusion for this indistinct neural production network can be displayed by the following expression:

$$\mu_{B'_i}(y) = \mu_{B_i}(y)\prod_{j=1}^{m}\mu_{A_{ij}}(x'_j) \tag{1}$$

As accumulations of rules are not carried out and the method of a defusification is the method of the average center, a defusified value is determined by the output change in the formula:

$$y' = \frac{\sum_{i=1}^{n}\left(\arg\max_{y} \mu_{B'_i}(y)\prod_{j=1}^{m}\mu_{A_{ij}}\left(x'_j\right)\right)}{\sum_{i=1}^{n}\prod_{j=1}^{m}\mu_{A_{ij}}\left(x'_j\right)} \tag{2}$$

In our case the accessory functions of all indistinct sets are represented by the function of Gauss. Therefore, the expression (2) is re-written as following:

$$y' = \frac{\sum_{i=1}^{n}\left(\arg\max_{y}\left(\exp\left[-\frac{y-c_i}{d_i}\right]\right)\cdot\prod_{j=1}^{m}\exp\left[-\left(\frac{x'_j-a_{ij}}{b_{ij}}\right)^2\right]\right)}{\sum_{i=1}^{n}\prod_{j=1}^{m}\exp\left[-\left(\frac{x'_j-a_{ij}}{b_{ij}}\right)^2\right]} \tag{3}$$

Where c_i and d_i - respectively are the centers and the width of the Gaussian functions representing the function of accessory indistinct sets B_i of the conclusions of rules;

a_i and b_i - respectively are the centers and the width of the Gaussian functions representing the function of accessory indistinct sets A_i of the prerequisites of rules.

In the final equation:

$$y' = \frac{\sum_{i=1}^{n}\left(c_i\cdot\prod_{j=1}^{m}\exp\left[-\left(\frac{x'_j-a_{ij}}{b_{ij}}\right)^2\right]\right)_{y}}{\sum_{i=1}^{n}\prod_{j=1}^{m}\exp\left[-\left(\frac{x'_j-a_{ij}}{b_{ij}}\right)^2\right]} \tag{4}$$

Expression (4) fully describes the procedure of an indistinct conclusion proceeding from the above provisions. In figure 1 the multi-layered structure of an indistinct network which elements of layers realize the corresponding components of this expression is presented.

The structure of this indistinct network consists of four layers.

The layer 1 carries out a fusification of the variables $x'_j\,(j=1,\ldots,n)$. Elements of this layer calculate values of the accessory functions $\mu_{A_{ij}}(x'_j)$ set by Gaussian functions with parameters a_{ij} and b_{ij}.

Layer 2 in which the number of the elements is equal to the number of rules in the base carries out the aggregation of degrees of prerequisites validity of the corresponding rules.

In layer 3 the first element serves as a layer for activation of the conclusions of rules, c_i according to the values of the degrees of the prerequisites of rules aggregated in the previous layer. The second element of the layer carries out auxiliary calculations for the subsequent defusification of the result.

The layer 4 which consists of one element, carries out a defusification of an output variable.

Parametrical layers of a network are the first and the third layers where the adjusted parameters are a_{ij}, b_{ij} and c_i.

The indistinct neural production network of Vanga-Mendel has a multi-layered structure with direct distribution of a signal, the ouput value which can be changed, by correcting parameters of the elements of the layers that allow to use the algorithm of the return distribution of a mistake for teaching this network.

In the set training selection $(x_1^{(k)}, x_2^{(k)}, \ldots, x_m^{(k)}, y^{(k)}), k = 1, \ldots, K$, $x_1^{(k)}, x_2^{(k)}, x_m^{(k)}$ - values of entrance variables $x_1, x_2, \ldots, x_m$, $y^{(k)}$ - reference value of an output variable y in k.

We will consider procedure of the correction of values, c_i, a_{ij} and b_{ij}.

Stage 1. For each example of the training selection of values of input variables $(x_1^{(k)}, x_2^{(k)}, \ldots, x_m^{(k)}, y^{(k)}), k = 1, \ldots, K$ values of an output variable, $y'^{(k)}$, are calculated.

Stage 2. Function of a mistake for all examples of the training selection is calculated:

$$E^{(k)} = \frac{1}{2}\left(y'^{(k)} - y^{(k)}\right)^2, k = 1, \ldots, K \qquad (5)$$

Stage 3. Values c_i, a_{ij} and b_{ij} are corrected for every i provided that every example k of the training selection, proceeds from ratios:

$$c_i(t+1) = c_i(t) - \eta \cdot \frac{(y'^{(k)} - y^{(k)}) \prod_{j=1}^{m} \exp\left[-\left(\frac{x'^{(k)}_j - a_{ij}}{b_{ij}}\right)^2\right]}{\sum_{i=1}^{n} \prod_{j=1}^{m} \exp\left[-\left(\frac{x'^{(k)}_j - a_{ij}}{b_{ij}}\right)^2\right]} \qquad (6)$$

$$a_{ij}(t+1) = a_{ij}(t) - \eta \cdot \frac{2 \cdot \left(x'^{(k)}_j - a_{ij}\right) \cdot \left(y'^{(k)} - y^{(k)}\right) \cdot \left(c_i - y'^{(k)}\right) \cdot \prod_{j=1}^{m} \exp\left[-\left(\frac{x'^{(k)}_j - a_{ij}}{b}\right)^2\right]}{b_{ij}^2 \cdot \sum_{i=1}^{n} \prod_{j=1}^{m} \exp\left[-\left(\frac{x'^{(k)}_j - a_{ij}}{b_{ij}}\right)^2\right]} \qquad (7)$$

$$b_{ij}(t+1) = b_{ij}(t) - \eta \cdot \frac{2 \cdot \left(x'^{(k)}_j - a_{ij}\right)^2 \cdot \left(y'^{(k)} - y^{(k)}\right) \cdot \left(c_i - y'^{(k)}\right) \cdot \prod_{j=1}^{m} \exp\left[-\left(\frac{x'^{(k)}_j - a_{ij}}{b}\right)^2\right]}{b_{ij}^2 \cdot \sum_{i=1}^{n} \prod_{j=1}^{m} \exp\left[-\left(\frac{x'^{(k)}_j - a_{ij}}{b_{ij}}\right)^2\right]} \qquad (8)$$

Where t is the number of the iteration of training; $\eta \in [0,1]$ - training speed coefficient.

Stage 4. Values of an output variable for each example of selection $y'^{(k)}$ are repeatedly calculated and the average total error, taking into account all examples of the training selection, is calculated and compared to some established threshold:

$$E = \frac{1}{K}\sum_{k=1}^{K}\left(y'^{(k)} - y^{(k)}\right)^2 < \varepsilon \quad (9)$$

In case of successful performance of a condition, the network is considered to be correctly trained. Otherwise, transition to stage 3 is carried out and adjustment repeats.

Functionality of the automated system of the forecast of dynamics of an emotional condition of the personality includes the function of forecasting of the indicators of an emotional condition of the personality. For the comprehension of this function the indistinct neural-production network of Vanga-Mendel is used.

Effective functioning of a neural network requires empirical selection of some parameters, defining structure and networks, and parameters of the algorithm of its training. The forecast window (i.e. quantity of entrances of a neural network) is defined in a task for the system development. The parameters of a neural network available for control are a training coefficient.

To check the working capacity and the selection of necessary parameters the function below is used:

$$f(x) = 0.1\cdot\sin(0.02\cdot\pi x) + 0.2\cdot\sin(0.03\cdot\pi x) + 0.6\cdot\sin(0.9\cdot\pi x) + +1.11\cdot\sin(0.19\cdot\pi x) + 2.3\cdot\sin(0.37\cdot\pi x) \quad (10)$$

Its schedule and results of the forecast of a neural network are represented in figure 1.

In the function highlighted in blue, on the basis of which training was made, the red color corresponds to the values predicted by a neural network after training. Highlighted green portion of the area of the function was also used for training. Other area was used as test selection for determining quality of the forecast on the unknown data. Training was made before achieving the average total error training (formula 4) of 0.01.

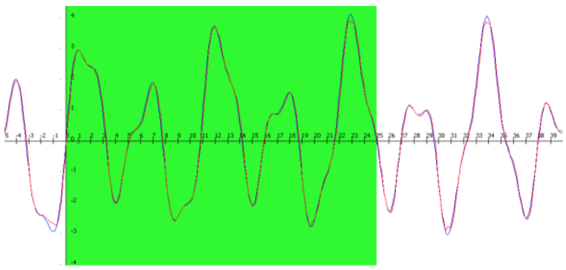

Fig. 1. Function graph of testing and results of the forecast

For the selection of the coefficient value of training, research of dependence of the number of iterations it is necessary to achieve an error of training units (training speed) and errors on test selection from value of coefficient of training was conducted at 0.01. Results are given in table 1.

Table 1. Selection of coefficient of training

Training coefficient	Number of iterations	Error
0.1	319	0.0126977
0.2	154	0.0115617
0.3	113	0.0122632
0.4	87	0.0126165
0.5	73	0.0120938
0.6	63	0.0117784
0.7	61	0.0116801
0.8	60	0.0134587
0.9	56	0.0122873

The graph on which the value of an error on test has reached 10,000 for descriptive reasons is given in figure 2.

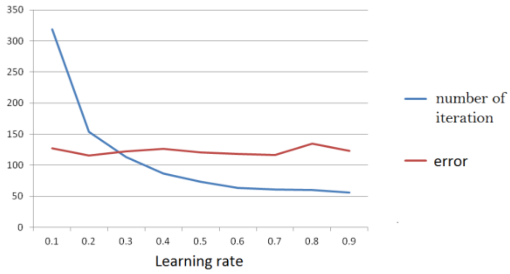

Fig. 2. Selection of coefficient of training

It is evident from the graph that the number of iterations considerably decreases as the coefficient value of training increases. Thus, the error slightly increases at great coefficient values of training. Also if the values of the coefficient of training are too large the instability of work of the algorithm of training is possible. Therefore, it is expedient to choose coefficient of training equal 0.7.

For research of the quality of the forecast for some steps forward, research of dependence of an error on test selection from number of steps of the forecast was conducted. Results are presented in table 2.

Table 2. Selection of coefficient of training

Number of steps of the forecast	Error
1	0.004398821
2	0.017341442
3	0.059260252

Training was conducted until an error of 0.02 was achieved on the training selection. It is evident from the table that the transition from the forecast for step one to the forecast for step two the error increases 4 times, upon transition to step three – 14 times. Taking into account that the network was trained for the forecast for one step and the main objective is the forecast for one step, these results can be considered satisfactory, since an error even at the forecast for step 3 keeps the same order as at the forecast for step 1.

A control variable

For a control variable tests of several people were held to collect data for training a neural network. The structure of a control variable included taking the test, viewing the results of the testing and analyzing the graph of change of indicators of an emotional state with the forecast.

The testee is offered to choose the color which is mostly preferred by them by pressing on the desired selection. After the next choice is made, the chosen color is removed from the choice panel. After all colors ar eslected, a message on a successful completion of testing is shown to the testee.

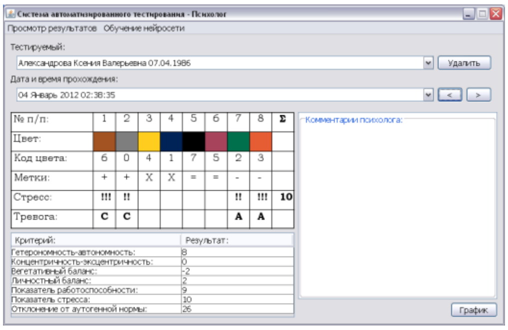

Fig. 3. Main window of the psychologist, browse mode of results

The graph below displays the results of choices one after another, a standard color, a code of a standard color, the appropriate tags, stress and alarm tags. In a separate field, the psychologist can leave comments to this test in the form of a saved text.

In order to view the graph of dynamics of emotional indicators, it is necessary to press ‘Graph’ button. Then there will be the corresponding window (figure 5). In the left part of the schedule the history of change of the chosen indicator is represented. In the right part, green color indicates the forecast of change of this indicator for three steps.

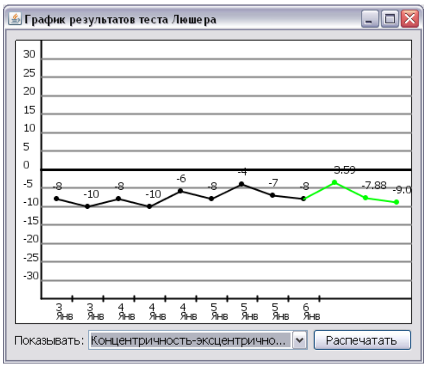

Fig. 4. Graph of changes of emotional indicators

For passing a control test, basic education of a neural network on the given held tests of three testees has been provided. The total number of tests was 19, 16 of them had other testees in the training selection, 3 – in the test mode.

Conclusion

The proposed method shows the real possibility of designing an intelligence system to estimate and to predict the psychotherapeutic influence at early stages of interaction between psychotherapist and patient. The method based on the classical psycho-diagnostic procedures is easy to use by the patients and therapists. Therefore, the development of an automated support instruments for psychotherapeutic process is crucial in the information technologies field.

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