Neuro-Genetic Hybrid System for Management of Organizational Development Measures

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Abstract. Current practical experience in measuring the effectiveness of organizational development activities is largely based on the evaluation of surveys. In this paper we present an approach based on an artificial neural network with elements of a fuzzy approach and a genetic algorithm to control organizational development. Based on genetic algorithms, the organizational development measures are initiated, selected, combined or mutated with the goal of finding the best possible solution for each concrete case. Since many variables have the uncertain set of their values, the use of a hybrid neuro-fuzzy mechanism makes it possible to analyze the behavioral components up to the combinations of needs and thereby select the appropriate organizational development measures. The system is designed to ensure the long-term effectiveness of organizational development measures. We supplement the previously known measures of organizational development with technology-based in order to increase the degree of automation in practice. This article is intended as an orientation for other scientists who are researching the same topic and are interested in the current state of the art, as well as for companies who want to ensure compliance with internal company rules using digital tools.

Keywords: neuro-genetic hybrid system, organizational development, fuzzy logic.

1 Introduction

Organizational development is a long-term continuous, planned process of optimizing attitudes and behaviors of organization members to achieve organizational goals. This process requires tremendous methodological knowledge of the participants and the commitment to change. Since changes in the state of the object of organizational development are often not clearly measurable over time, the genetic application with elements of fuzzy logic is particularly beneficial. Several already published studies offer approaches for management organizational change in general [1, 6, 8, 16, 18], employee performance [4], behavior [2, 15] using the technologies of artificial intelligence. These indicate high-quality approaches, some of which could also be applied to goals defined by us, but do not cover the entire range of the problem. Based on artificial intelligence, we have developed a model with three modules for organizational development. The first module is used to diagnose and record the current state of the organization, analyze the received data, and determine long-term measures for organizational development. The second module gradually monitors the results of the implemented measures, introduces and implements corrections. The third module has the main function of managing the system. The functions of the first two modules were realized through hybrid neural networks, partly with fuzzy weights. We apply the genetic algorithm to determine the behavior of individual (especially immaterial) multi-level variables. The reason for using the neurofuzzy system is on the one hand partially non-linear dependencies of the variables (their weighting), and on the other hand we implement the genetic approach to reach the system's ability for learning and adaptation. Although organizational development is primarily concerned with the behavior of organization members, the variables we measure are more than directly related to people. In this article, we limit our scope to the neuro-genetic hybrid system and present an example of just one functionality of the system that serves as the basis for in-depth behavioral correction.

2 Methodology

Neuro-genetic hybrid systems are mainly used for complex systems that, for example, map human behavior (subsystem investigated by us). These have a multilevel approach to capture, analyze and predict various processes or to offer a solution for a specific case [10-12, 14, 17, 19]. In our system for management of organizational development, we consider several subsystems, ranging from corporate performance and standards system to group behavior or individual motivation. In general, the neuro-genetic hybrid system works according to the following principle (**Fig. 1**):

- Genetic algorithm: the current element population receives three types of sequential rules of genetic operations to form the next generation of elements. A distinction is made between selection, crossover and mutation (**Fig. 2**). According to the first rule, a parent element from which the child elements follow is defined. The second rule defines the parent pairs that will create the respective children. The third rule determines the random changes to each parent element for the later creation of the child elements. Artificial neural network: The child elements enter the artificial neural network model as an input variable. In the artificial neural network model, the input data is analyzed and the option is outputted.
- Decoded strings from the current population enter the fitness calculation with the prediction results.
- The optimum variables are determined from the fitness evaluation.
- In case of non-conformity (data no longer correct or sufficient), the procedure is repeated.

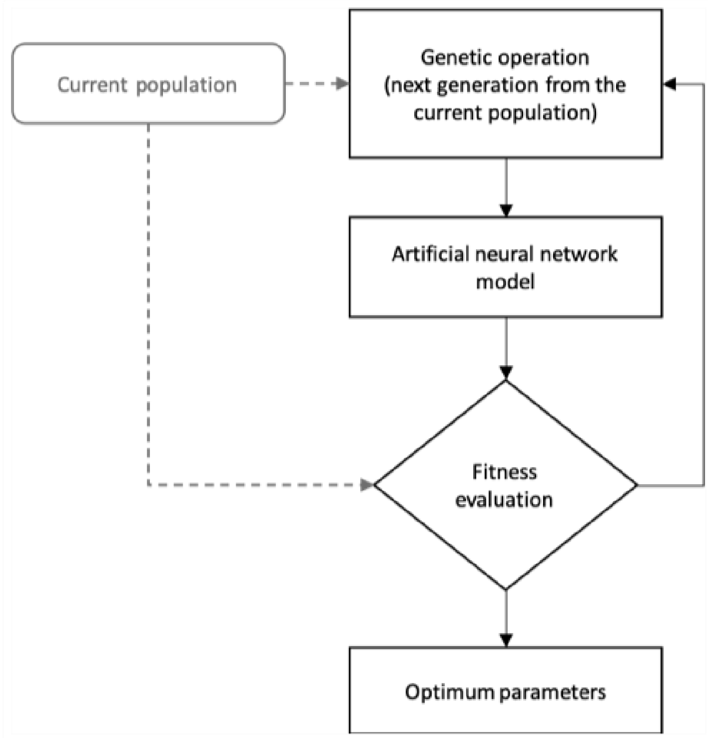

Fig. 1. General functional principle of neuro-genetic hybrid system

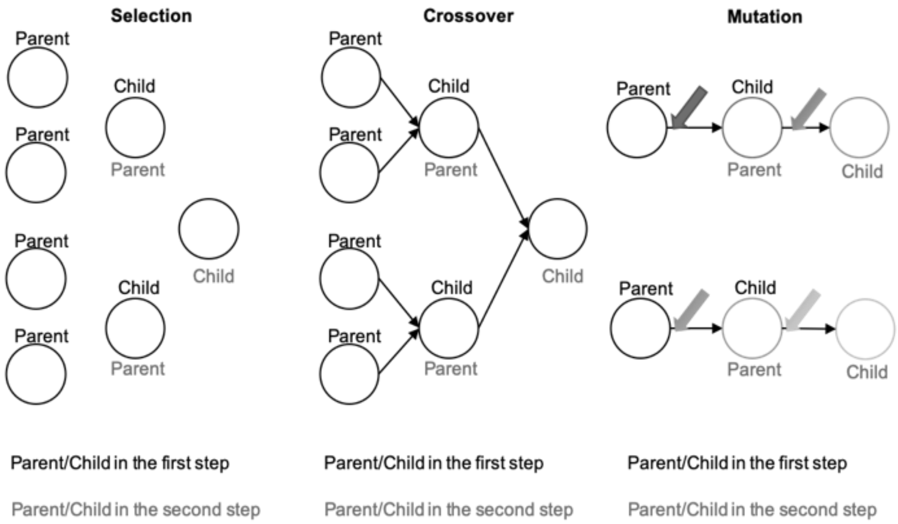

Fig. 2. Types of rules for the definition of next generation from current population

Since the majority of the variables are linguistic variables with multiple meanings, we use fuzzy logic to describe the relations in the system.

3 Results

The primary goal of organizational development is to ensure the long-term evolutionary improvement of the human factor as an organizational component to achieve organizational goals i. a. by influencing behavior. The individual is a member of a group within an organization and is therefore considered in connection with other group members (the individual is the lowest level in the organizational chain). At the same time, the group is a part of the department/area/the whole organization (the middle level in the organization chain). Thus, within the development of the organization, the group is also considered a member of the organization with all its connections. Since the form of the organization and the number of levels vary, we break the chain of organization after the third, the highest level - the organization itself (the departments, units and divisions are excluded, as they are considered as organizations within organizations). Consequently, the organizational development measures are focused on the single elements of the organizational system, their internal and external relationships, and the organization as a whole. Since the planned improvements are intended to be irreversible, the organizational development measures per se have the learning character. Most known methods of organizational development are limited to such motivation and behavior controls, that influence employees and groups directly or indirectly live, from print or digital media (meetings, workshops, employee information, leaflets, intranet contributions, etc.). Our approach refers to the control of motivation and behavior by providing timely actual information and assistance, where wrong behavior or work performance is excluded. This can be achieved through the digital assistant systems.

Since our organizational system is very complex, we have established several subsystems with complex structures [9, 18]. The neuro-genetic hybrid system, which is designed as a heuristic algorithm for searching the solution for optimization and modeling by selecting and combining of variables. In this case the neural network searches the potential solutions of multi-level fuzzy sets for further use by the genetic algorithm. The genetic algorithm consists of initialization, selection, cross-over and mutation. **Fig. 3** shows the principle of the system. In the context of organizational development, certain measures are performed, for example, informing employees about the new corporate values. After a certain period of time, the employee or group of employees shows behavior that does not correspond to the expected behavior. In the system, the behavior is split up into corresponding components. These are analyzed in steps and new corrective measures are offered. The employee or group of employees executes the measures. If the second measure is better than the first one, it is selected as one of the most effective measures in the measure pool. The next step is to improve the behavior of the employee or group of employees. To do so, the measures from the measure pool are combined or modified. If the behavior is not successful after the implementation of new measures, the process starts again.

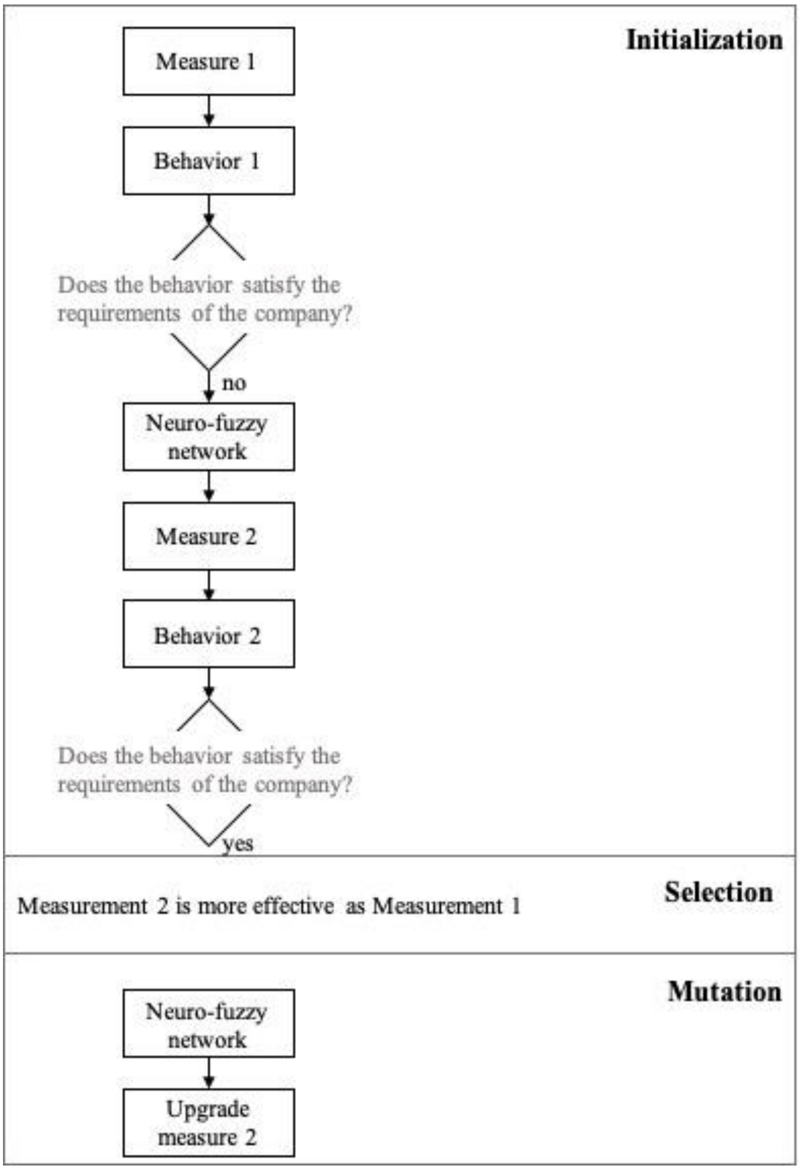

Fig. 3. Basic principle of the developed neuro-genetic hybrid system (example - mutation)

Input variables are collected in two ways: through video, audio or text recording mechanisms (self-developed, based on Microsoft tools) and from the connected performance measurement systems. In the first way e.g., emotions and modus operandi are recorded, in the second way e.g. work productivity and error rate are measured. The incoming information is analyzed in a fragmented way. For example, facial expressions with different voice positions or gestures are interpreted differently.

Furthermore, an example for the application of the neuro-genetic hybrid subsystem is presented.

The company is positioning itself as diversity-oriented. Cosmopolitanism and acceptability belong to the organizational values. During a conversation between employees in a working group, our system several times detects racist context (unacceptable words) that is offensive to human dignity. This resists one of the organizational goals, the stabilization of organization-compliant behavior of employees (in this case focused on behavior with colleagues and superiors, employee as part of the company, individual performance for overall goal).

The conversation is recognized as an emotional act. The variables of the act are the type of activity (conversation, by voice recognition), quality (in this case unsatisfactory, because of the recognized context), duration (in this case medium ($2 < x < 30$ minutes)), and iterations (in this case multiple), see **Table 1**. In this case, certain context components (unacceptable words) are recognized as hints. The hints serve as markers for variable values and indicate the allowed limits. The captured emotion is analyzed as happiness (through few iterations of smiles by face and voice recognition). Such behavior is declared as neutral conversation with unacceptable words.

Table 1. Act variables

type of activity	**quality**	**duration**	**iterations**
conversation	exemplary	brief	one
monitoring activity	desirable	medium	few
writing activity	good	long	multiple
manual activity	satisfying	very long	combination
coordinating activity	unsatisfying		
specific activity	bad		

In the case described, we refer to a certain type of activity. In other cases, for example, when the performance data of the person (speed and quality of the assembly, skill level of a working step) is collected externally, other variables will be input into the system. The goal of our system is to evolutionize the activity in small steps and to achieve the learning effects by applying appropriate measures. In other words, we intend the gradual implementation of the measures, not only to avoid unacceptable activities, but also to direct the underlying motives and needs to the benefit of the company. Here the fitness value correlates with the desired state of the act. Therefore, the first population refers to the quality, duration, iterations on the one hand, and emotion on the other hand.

The variables of the current acts flow into the neural network. This is necessary to select the optimal measures in the neural network by defining the corresponding motives and needs. The motivation and accordingly the needs are mainly derived from the type of activity, its quality and the hints. Kotlyarov [7], Petrenko and Tabaharnyuk [13] in their model of motivational space for organizational education, guided by Draker's theory, propose a three-dimensional vector space (expediency, result, effect) to describe the motivational strategy of an organization, group and individual. We have partially adopted and expanded their approaches.

Special attention should be given to the phases of the motivation need cycle, as these are directly related to the motivation optimum and therefore activate the motivation behavior subsystem [5, 20]. In the described scenario, the person is in the phase of actualization of the need, which is combined with an increase in emotional tension, a feeling of lack, a desire to do something, a desire for activity that is not directed. In this case, the measures proposed and applied by our system must correct the behavior of the person according to the organizational values and change the phase from the need-motivational cycle, either in the direction of the search phase or in the direction of the latent phase.

Thanks to the neural network, the system learns to manage special complex problems. The main layers refer to behavior components, motivation and needs.

- The behavior in our model is represented as a set of activities with defined vectors of acts and emotions. The act, in turn, is defined by the function of weighted motives. As a result, scalars of actions can acquire positive and negative integer and fractional values:

$$p \in \mathbb{Q};\ \underline{P} = \{p_1 \dots p_n\};\ p_n = \sum_{j=1}^{\infty} \sum_{n=0}^{1} m_j\, g_n \qquad (1)$$

- Weighting G is a complex function of dependence of key indicators, such as the value of expected result, target density, resources spent, external oppressive or binding factors, opportunities, etc. on their correlation ratio. These determinants reflect the views of H. Heckhausen's theories as well as those of J. V. Brem and E. Heckhausen. A. Self [3] and depend on activity type (are defined individually). Since this model investigates not only personal but also environmental factors, they are considered as an indicator of the influence on the force of the motive. Weighting takes the form of a vector of positive scalars of integers or fractional numbers:

$$g \in \mathbb{Q};\ G = \{g_1 \dots g_n\};\ g_n = \frac{\sum_{l=0}^{1} \sum_{i=1}^{\infty} b_l\, w_i}{\sum_{i=1}^{\infty} w_i} \qquad (2)$$

- Motive M is a function of need: the total number of appropriately prioritized needs reproduces the motive vector. Since a motive is not always positive, its individual scalars can be negative fractional numbers (c is a need dimension function). The mathematical content of a motif is expressed as follows:

$$M \in \mathbb{Q};\ \underline{M} = \{m_1 \dots m_n\};\ m_n = \pm \sum_{n=1}^{\infty} c_n a_n \qquad (3)$$

- Need a in mathematical context is a positive integer. Needs that define a motive are represented as vector A:

$$a \in \mathbb{N};\ A = \{a_1 \dots a_n\} \qquad (4)$$

Our system is based on the combined approach of motives and needs. Selection of needs for motivation combinations is based on the theories of Maslow, McClelland, Alderfer and Herzberg. In the described case, the act is based on the motivations of identification, authority, prosocial motivation and consequently the fundamental needs of self-affirmation, acknowledgment, authority and security with corresponding degree of involvement. The degree of involvement shows how deeply the need is present in the motivation.

The concrete IF THEN rules for the motivation-need relationship are shown in **Table 2** (IF "need 1" = "degree of influence x" AND "need n" = "degree of influence y" THEN "motivation 1" AND "motivation n"). In most cases, the behaviour is due to the combination of several motivations and therefore depends on multiple needs.

Table 2. Overview of dependencies in motivation-need relation on employee level

	motivation							
need	identification	self-affirmation	prosocial	authority	achievements	self-development	pprocedurally sub-stantive	affiliation
self-affirmation	●●●●●	●●●	●●	●●●●	●●●●	●●●●	●●●●●	●
acknowl-edgment	●●●	●●●●●	●●●●	●●●●●	●●●	●●	●	●●●●
respect	●●●	●●●●	●●●●	●●●●●	●●	●●	●	●●●
identification	●●●●	●●	●●●●	●●●	●●●●●	●●	●●●●	●●
affiliation	●	●●●●	●●●●●	●●	●●	●●	●	●●●●●
development	●●	●	●	●●●●	●●●●●	●●●●●	●●●●	●
authority	●	●●●	●●●	●●●●●	●	●	●	●
achievement	●●●●	●	●	●●●●	●●●●●	●●●●●	●●●●	●
involvement	●	●●●	●●●●	●●	●●	●	●	●●●●●
security	●	●	●●	●●●●	●●●	●●●	●	●●
physiologi-cal	●	●	●	●●●	●●	●●	●	●

● - no or very weak involvement
●● - weak involvement
●●● - medium involvement
●●●● - strong involvement
●●●●● - very strong involvement (dominant need)

Each level of neural network has its componets, with the generalized form (**Помилка! Джерело посилання не знайдено.**.):

- The abstract element E (in our case need/motivation/act etc.) has the following form:

$$E(x) = \frac{1}{1+e^{(\pm a(x-b))}} \tag{5}$$

- Therefore, the rule β becomes the general form:

$$\beta = E_1 \wedge E_2 \wedge E_3 \tag{6}$$

- and the output is accordingly:

$$O = E_1^{-1}(\beta) \tag{7}$$

- The total system output is expressed by the formula:

$$o_0 = \frac{\sum_{n=1}^{\infty} \sum_{k=1}^{\infty} \beta_n o_k}{\sum_{n=1}^{\infty} \beta_n} \tag{8}$$

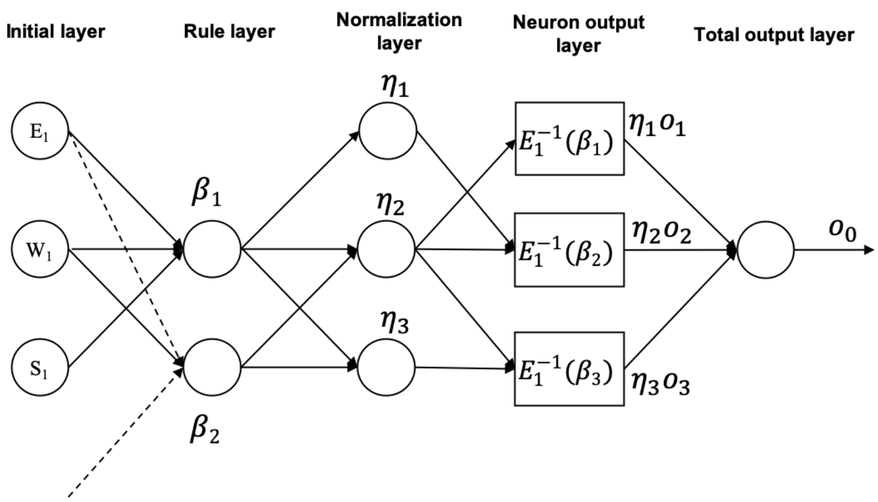

Fig. 4. Part of the artificial neural fuzzy network for an element level (e.g. motivation)

In general, individual layers can be described as follows:

1. Initial layer: The outputs of the nodes are degrees in which the given inputs satisfy the functions associated with these nodes.
2. Rule layer: Each node calculates the intensity of the rule. All nodes are marked with T and can be selected to simulate logical AND.
3. Normalization layer: Each node normalizes the intensity of the rule:

$$\eta_j = \frac{\beta_j}{\sum_{n=1}^{\infty} \beta_n} \tag{9}$$

4. Neuron output layer: Neuron output is the product of normalized rule intensity and individual rule output:

$$\eta_n O_n = \eta_n E_3^{-1}(\beta_n) \tag{10}$$

5. Total output layer: Single output neuron calculate the network output:

$$o_0 = \sum_{n=1}^{\infty} \eta_n O_n \tag{11}$$

The neural network consists of such elements, where the output of one level corresponds to the input of the other level. In case one of the variables does not occur, it is still recorded with minimum value.

In the case of usage of unacceptable words, different measures are implemented one after the other, in the order of information - warning - sanction. In this case, the first step is general information (as a voice reminder or on the display screen): "In this company such phrases are not being used". Next is "Please use the following words instead of (unacceptable words)...". The employee is subsequently warned of the following "Any unacceptable words will be punished by (certain measure)". If these measures do not work, the sanction will follow. At the same time, measures are being taken to adopt new behavior patterns in order to achieve the organizational goal of long-term stabilization of employee behavior.

The following system can not only be applied to commercial and public organizations, but can also be used for integration projects of diverse groups.

4 Conclusion and Discussion

The system we describe should only be seen as part of the overall organizational development system, which cannot be described within an article because of its complexity. The whole system offers the monitoring of organizational development at all levels of the company and therefore provides continuous improvement.

The main strength of neuro-genetic hybrid systems with fuzzy neurons and rules is that they are universal approximators. Nevertheless, this method also has disadvantages in the implementation of organizational development, such as very long processing time and uncertain convergence. Furthermore, the limitations of the system proposed by us include the complexity, high data volume and preparation effort on the organization side, as the system depth and organizational development measures have to be created individually by each company.

The main motivation for the use of such systems is the timely integration of appropriate measures in order to achieve the organizational goal in an optimal way.

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