

Evaluation and Selection of Personnel Based on Clear and Fuzzy Cognitive Models

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Abstract: The study solves one of the most important tasks of personnel policy, the problem of professional competency correspondence rate estimation and other characteristics of a claimant to the requirements and conditions of an employer. The possibility of cognitive model use is considered, both clear and fuzzy ones, at different stages of personnel selection. A fuzzy production model of a claimant cognitive competencies and a clear cognitive model of a vacancy are described including heterogeneous criteria of an applicant assessment; the technique for the collection and processing of expert estimations of connection weights between the concepts of a clear cognitive map. A properly built orgraph of competencies allows job seekers to take into account not only the basic competence (if an applicant do not own them completely) at the assessment of conformity but also the basic competences needed for the development of the basic ones. Thus, the potential of an applicant is estimated which he has to improve his skills. A cognitive vacancy map (at the estimation of an applicant correspondence to the vacancy requirements) allows to take into account different qualitative and quantitative characteristics, the presence of additional combinations of criteria, which allow to increase the resulting estimation of an applicant that reflect the personal preferences of an employer during the selection of candidates. The study contains a practical example of a clear cognitive vacancy map development. The estimates of eleven candidate compliance data are presented. The results are fully consistent with an employer preferences.

Key words: Personnel policy, personnel selection, Cognitive Model, fuzzy logic, cognitive map, competence assessment

INTRODUCTION

In modern world, the success of any company is directly related to an effectively organized personnel policy. The popular quality management systems consider staff as one of an enterprise key resources. At that the personnel selection is of great importance.

Indeed, within the terms of a current economic situation when the market has competing enterprises and sophisticated technologies are applied in their research, the problem of a qualified personnel selection is hard to overestimate. On the other hand, when an employee is assigned to a vacant position, an employer, in addition to high professional qualities would like to see in a future employee those psychological and personality traits that will increase the value of an employee as a team member. It should also be noted that a set of an applicant characteristics relating to professional competences and to the personal qualities are considered usually from the standpoint of a person preferences who takes the decision (a supervisor, an employer).

This study studies the current issues of staff evaluation and selection in accordance with the requirements of a particular employer when an employee is hired.

MATERIALS AND METHODS

The problem of an expert selection may be attributed to a linear ordering of alternatives (candidates) through a set of criteria (the requirements for applicants) under uncertainty by involving expert knowledge.

The involvement of experts to get a general and all intermediate assessments of applicants, the number of which may be quite large, is hardly appropriate. In order to evaluate the alternatives at general and interim evaluations the applicants may use the methods of fuzzy logic and the apparatus of cognitive maps.

The most important task is to assess the degree of compliance with professional competencies and other characteristics of an applicant to the requirements and conditions of an employer (Tarhov, 2012). In this study,

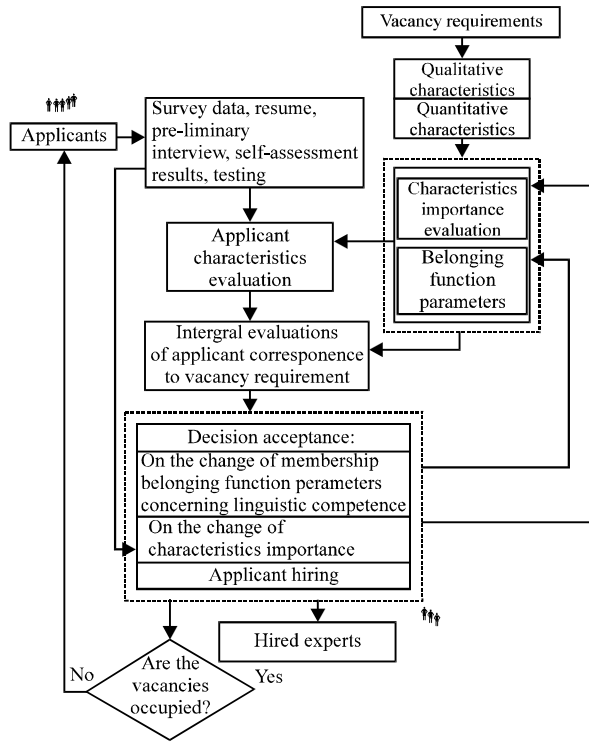


Fig. 1: Applicant selection scheme

the problem of quantitative evaluation compliance is solved concerning disparate parameters and characteristics of an applicant for a position/workplace to the requirements and conditions of an employer, based on accurate quantitative and qualitative expert assessments and cognitive map apparatus. The obtained quantitative estimates of applicants allow to perform their ranking and determine the candidates who mainly meet the requirements of an employer. The general scheme of staff selection is shown on Fig. 1.

The development of personnel selection algorithm requires the processing of large amounts of information, includes the accounting of a large number of heterogeneous objects of interaction (Tarhov, 2012) with different goals and resources, with varying degrees of interdependences from each other and so on (for example, universities, businesses, free applicants, employment centers, etc.).

One of the tasks for a carried out study is the building of an expert model, allowing to present its competences with regard to their relationships and the stages of formation.

Most part of existing approaches to the assessment of competencies do not allow to get this estimate for the professionals who require additional training (professional development) but have considerable potential for the professional development.

On the other hand, the data concerning existing expert competencies allow us to have a chance to determine the estimation of possibilities of an applicant's "missing" competency replenishment. The consideration of such data makes the assessment of an expert compliance with to a certain position more adequate.

A cognitive Model (cognitive map) may be selected (Asanov, 2012) as an expert competence model, the concepts of which may be represented by the competences or their components Knowledge, Skills and Ownership (KSO) with regard to their detail. The relationship between the concepts are interpreted as relations in the sense of the relevant competencies or KSO continuity.

The selection of a cognitive model is conditioned by the possibility of competence interference consideration in terms of their continuity.

Formulation of the problem. Let $Z = \{Z_i\}, i = \overline{1, N}$ is the set of competencies (or KSO) defining the portrait of an expert occupying some position including basic competences (or KSO) which make the part of basics mastering. On the set Z the oriented graph $G = Z, E$ is developed where Z is the set of peaks, $E = \{e_{ij}\}, i = \overline{1, N}, j = \overline{1, N}$ is the set of arcs which reflect the relations between the peaks Z_i and Z_j . At that $e_{ij} = 1$, if the competence (or KSO) Z_i is the basis (foundation) for competence obtaining (or KSO) Z_j , in other words the presence of a link indicates the presence of continuity; e_{ij} if the relation between the peaks Z_i and Z_j is absent.

The problem in the following formulation was considered: on the basis of the developed graph as well as the information about the presence/absence or the assessments of an expert competences, the estimates of competence importance for the post to obtain conformity assessment of a job seeker. Fuzzy cognitive competence production model looks like (Fedulov, 2004a, b; Carvalho and Tome, 1999; Carvalho and Jose, 1999):

$$\Phi = G, X, W$$

Where, $G = G, E$ is an oriented graph, where V the set of nodes (concepts), at that $V = \{V_i\} = \{Z_i\} \cup \{S\}, i = \overline{1, N}, S = V_{N+1}$; the peak (the concept) of "compliance with vacancy requirements"; $E = \{e_{ij}\}, i, j = \overline{1, N+1}$, the set of arcs, at that $E_v = \{e_{i, N+1}\}$ the set of arcs which determines the competencies, necessary for a vacancy occupation (if M is the number of such arcs, then $M < N$). Thus, the model of an expert competences includes the basic competences (or KSO) necessary for the acquisition of core competencies (or KSO) required by a vacancy.

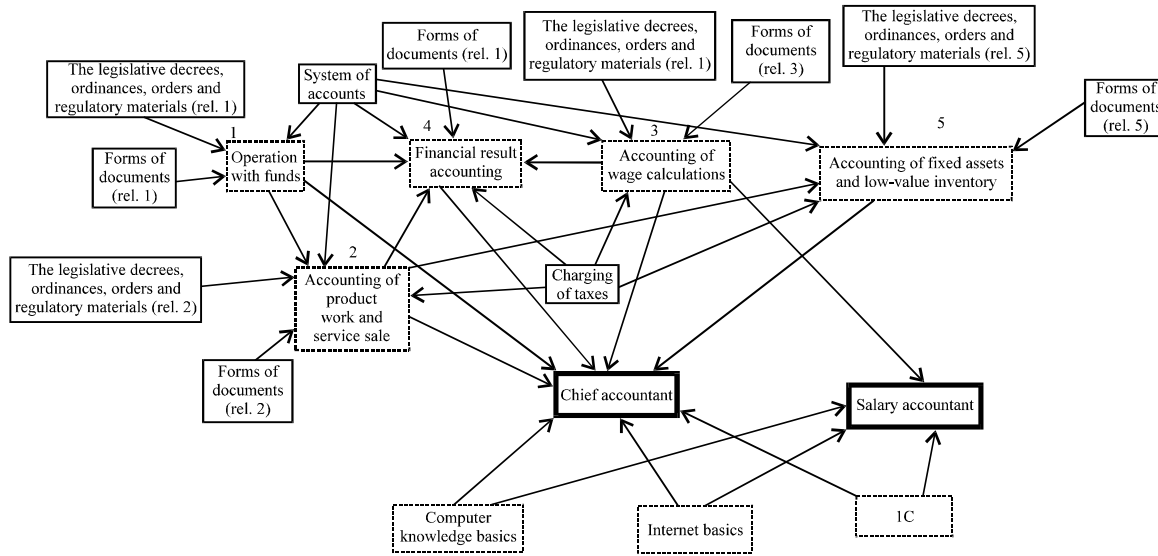


Fig. 2: Orgraph fragment of financial department employee competencies

With regard to the set task the causal relationships between concepts have some features. The products that specify the relations between the concepts and competences V_j and V_i ($i=\overline{1,N}$), mean the change of potential assessment (preparation level) to obtain the competence V_i on the value of the concept increment V_j basic competence.

The effects of the concepts and competences on the resulting concept V_{N+1} (requirement conformity assessment) mean the change in conformity assessment of a job seeker vacancy depending on the value of the concept-competence increment.

The $X = \{X^V\}$, $i=\overline{1,N+1}$, the set of peak parameters V (the value of concepts Z , Z the evaluation of a job seeker according to criteria (competencies), the value of the concept, S the evaluation of conformity to vacancy requirements). The values of the concepts competences, known at an early stage do not change in the process of modeling.

Figure 2 shows a fragment of competence orgraph among the financial department employees. The cognitive competency model is considered thoroughly in (Asanov, 2012). Then the possibility of clear cognitive maps use (Borisov, 2007) for an integrated applicant compliance assessment obtaining on the basis of diverse criteria accounting. Cognitive model of a vacancy:

$$\Phi = G, Y, W$$

Where $G = V, E$ oriented graph where V the set of peaks (concepts) at that $V = \{V_i\} = \{K_i\} \cup \{S\}$, $i=\overline{1,N}$, $S = V_{N+1}$, the peak (concept) "conformity to vacancy requirement"; $E \{e_{ij}\}$, $i, j=\overline{1,N+1}$ a set of arcs.

The $Y = \{Y_i^V\}$, $i=\overline{1,N+1}$, a set of peak parameters V (the value of concept K , the evaluation of an applicant according to a relevant criteria, the value of the concept S conformity assessment to vacancy requirements).

The weights of impacts $W = \{w_{ij}\}$, ($i=\overline{1,N+1}$, $j=\overline{1,N}$) between each pair of concepts take values from the interval $(0, 1)$.

Problem formulation to obtain the conformity assessment of an applicant to vacancy requirements on the basis of an applicant's evaluations according to selected criteria. The solution of this problem involves the following steps:

- Stage 1: the development of a vacancy cognitive model
- Stage 2: setting of concept criteria initial values
- Stage 4: Recalculation of all concept values. Model of calculation stages for a clear cognitive map:

$$Y_i(t+1) = Y_i(t) + \sum_{j=1}^N \Delta Y_j(t) \times w_{ij}$$

for the concepts representing the groups of criteria and the resulting concept (in a cognitive map presented on Fig. 3, these are the concepts with the numbers 1-6). The $\Delta Y_j(t)$ the increment (change) of the value for a j th concept in a moment of time (calculation step) t :

$$Y_i(t+1) = Y_i(t) + \sum_{j=1}^N \Delta Y_j(t) w_{ij} \times H(Y_i(0))$$

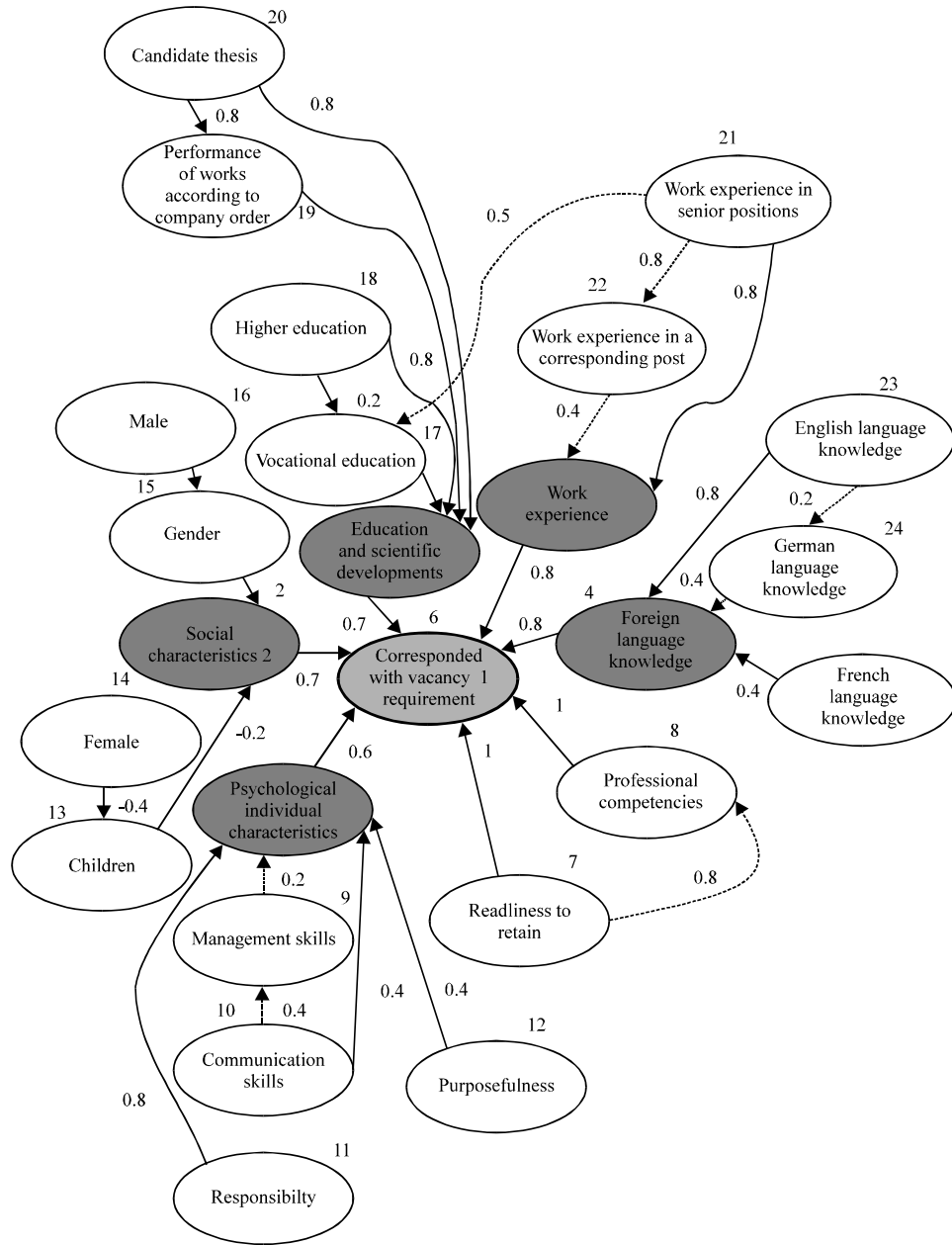


Fig. 3: Cognitive map for vacancy requirements

Where, $H(x) = 0$, if $x = 0$ and $H(x) = 1$, w if $x \neq 0$ for the concepts representing criteria. The restriction in this case is introduced in order to consider the combination of criteria during an applicant evaluation only if both related criteria have non-zero initial values.

The collection and processing of expert assessments during the determination of connection weights between the concepts involves the following steps:

- The experts determine the weights of relations between the concepts of cognitive maps (evaluation significance of applicant selection criteria) separately for the groups of criteria, the criteria for each group and the additional combination of criteria
- The mean arithmetic weights are determined
- The medians of weight gain are determined
- The average weights and their medians set some criteria ranking

Table 1: The example of expert evaluation result processing

Expert number	Impact level (importance) on the total estimation of an applicant (the values from 0-1)						
	Criterion 1	Criterion 2	Criterion 3	Criterion 4	Criterion 5	Criterion 6	Criterion 7
1	0.30	0.40	0.50	0.700	0.80	0.90	1.00
2	0.50	0.70	0.60	0.800	0.90	1.00	0.90
3	0.70	0.80	0.90	0.900	1.00	0.90	1.00
Average	0.50	0.63	0.67	0.800	0.90	0.93	0.97
Median	0.50	0.70	0.60	0.800	0.90	0.90	1.00
Average ranges	1.00	2.00	3.00	4.000	5.00	6.00	7.00
Median ranges	1.00	3.00	2.00	4.000	5.50	5.50	7.00

- The matching algorithm of two clustered rankings is used (Gorsky, 2000). If there are conflicting sets of criteria, the experts are offered to assess these criteria once again

As an example, let's consider the situation where three experts carry out the evaluations of 7 criteria. The possible results of the stages 1-4 for the collection and processing of expert estimates are presented in Table 1.

Based on the results, we obtain two rankings of criteria: based on average values $A = [1 < 2 < 3 < 4 < 5 < 6 < 7]$ on the basis of medians $B = [1 < 3 < 2 < 4 < \{5,6\} < 7]$. The set of contradictory criteria pairs $S = [(2,3), (5,6)]$. The result of clustered ranking matching: $f(A,B) = [1 < \{2,3\} < 4 < \{5,6\} < 7]$. Thus, only the criteria $\{2,3\}$ and $\{5,6\}$ require further study in order to streamline and obtain new estimates of significance.

In the case of a large number of criteria one may perform a preliminary check the opinion consistency from one expert that includes the following steps:

- An expert is proposed to divide criteria into clusters (groups) "low importance", "medium", "high", "very high"
- To rank the criteria within each group in order to increase significance
- A matching algorithm (Gorsky, 2000) of obtained ranking and the rankings of direct assessment criteria, given by an expert is used

If there are conflicting sets of criteria, the experts are invited to assess these criteria once again.

RESULTS AND DISCUSSION

Let's consider the example of a vacancy cognitive map development. Let's select the following combinations of an applicant two criteria evaluation which, according to an employer's opinion should increase the final evaluation of vacancy requirement compliance:

- The knowledge of English and German languages
- The availability of organizational skills and communication

- The availability of work experience in a senior position and in a considered vacancy position
- The availability of candidate thesis and the works under the contract with companies
- The availability and higher and secondary vocational education
- The willingness to retrain should raise the level of an applicant professional competence
- Vocational education and the work experience in a higher position
- The preference during hiring is provided to men

Besides, according to an employer's opinion the final grade is reduced by the fact that an applicant has children; the estimation is reduced even more if an applicant is a woman. The developed map is presented on Fig. 3.

As an example, let's define via a developed cognitive map of an applicant conformity assessment with different sets of characteristics for a considered vacancy using a developed cognitive map. Let the candidates have the following characteristics:

- A woman with children, the other characteristics have the maximum value
- A man with children, the other characteristics have the maximum value
- A woman without children, the other characteristics have the maximum value
- A man without children, the other characteristics have the maximum value
- A man without children has the experience in senior position, has no experience for the considered post, higher education, has no secondary vocational education, PhD, the other characteristics have the maximum value
- A man without children, vocational education, higher education and scientific degree are absent has the experience in the considered and higher position, the other characteristics have the maximum value
- A man without children has no secondary vocational education, higher education, has the experience for the considered vacancy, has no experience in senior positions, has no scientific degree, the other characteristics have the maximum value

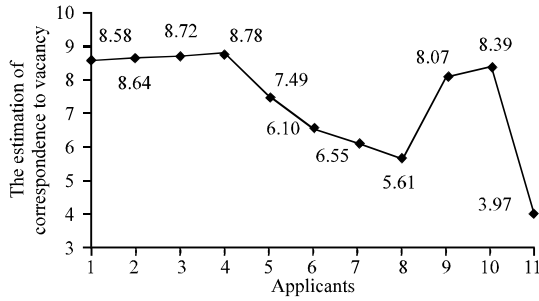


Fig. 4: Applicant vacancy conformity assessments with different sets of characteristic values, based on a cognitive map

- A man without children, only vocational education, has the experience for the considered vacancy, has no experience for higher positions did not execute any works commissioned by companies, the other characteristics have the maximum value
- A man without children does not know English, the other characteristics have the maximum value
- A man without children does not know the German language, the other characteristics have the maximum value

A man without children, professional competence 0.8, the willingness to retrain 0.5, work experience absent, knowledge of foreign languages English, organizational skills 1, purposefulness 0.9, communication skills 1, responsibility 0.7, education-higher education, academic degree-absent, the execution of works commissioned by companies-absent. The evaluations of vacancy conformity with these 11 candidates are shown on Fig. 4. The results are fully consistent with the preferences of the employer.

Summary: The proposed method of staff selection on the basis of clear and fuzzy cognitive models may be the basis for a computer support system of decision acceptance that allows to process a large amount of data, to reduce the terms and increase the quality of accepted personnel decisions.

The resulting assessment of compliance may be very widely used: during hiring, while addressing the need for training and retraining, at the assessment of a graduate training compliance to the requirements of a particular job, at the assessment of expert training quality in a educational institution and so on.

CONCLUSION

Thus, the possibility of cognitive model application to solve the problem of personnel selection was considered in the paper. A fuzzy production cognitive model of a job seeker competencies as well as a clear cognitive model of a vacancy are developed. The example shows the usefulness of a cognitive map application to calculate an estimation of an applicant conformity to the vacancy requirements, taking into account the personal preferences of an employer.

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