Available online at www.sciencedirect.com

ScienceDirect

Procedia Economics and Finance 24 (2015) 634 – 642

Procedia Economics and Finance

www.elsevier.com/locate/procedia

International Conference on Applied Economics, ICOAE 2015, 2-4 July 2015, Kazan, Russia

Modelling of conceptual space of the "regional social potential" term on the basis of fuzzy frames

Shikhalev[a] A.M., Panasyuk[b] M.V. [1], Ahmetova[c] I.A.

[a b c] *Kazan Federal University, Kazan, 420008, Russia*

Abstract

The article is devoted to problems of formal determining and modelling of the conceptual space of important socio-economic terms. A new approach for conceptual space modelling based on fuzzy frames is suggested. The results of "regional social potential" term modelling are discussed. They afford to come to the conclusion that the use of fuzzy frames allows to structure the investigated conceptual area and also to assess priorities and weights of its attributes with getting well interpretable results

Selection and/or peer-review under responsibility of the Organizing Committee of ICOAE 2015.

Keywords: conceptual space of term, fuzzy frames, conceptual space modelling, determination of regional social potential

1. Introduction

Despite the fact that quantitative methods are primarily used in analysis of socio-economic systems, disaffection with solved by their instrumentality problems and limitation of the analytical assumptions is evident. Therefore, in recent years, researchers are increasingly turning to the use of alternative, in particular, non-numerical methods of investigation of complex social systems. The study of non-numerical objects requires appropriate non-traditional forms of their formal representation. Therefore, representation of source data (problem area knowledge) is updated with growing complexity of the modeled domain area.

Weak structuring of the investigated domain area and lack of stable assessments of actual factors and their possible aggregations are main characteristic features of complex systems modelling in general, and regional socio-economic modelling in particular.

In solving problems of knowledge about regional socio-economic systems structuring the main questions are: what knowledge should be presented and in what is its form. The complexity and diversity of knowledge structures showed different ways of knowledge presentation, namely: logic models, frame and production semantic networks.

1

* Corresponding author. Tel.: +89196967191
E-mail address: mp3719@yandex.ru

Selection and/or peer-review under responsibility of the Organizing Committee of ICOAE 2015.
doi:10.1016/S2212-5671(15)00661-9

Each method has its own methodological strengths and weaknesses. It is therefore quite understandable attempts to use knowledge representation models that combines these methods. And if problem-solving procedures of fairly broad class of problems is based on the so-called "strict algorithms", the knowledge representation models are dealing with information obtained primarily from the experts, which in this case is not only of quantitative nature, but also has qualitative, sometimes contradictory, nature. Therefore there is an objective necessity for determining the degree of adequacy of knowledge representation on the main aspects of the modeled domain area that may be provided under special theoretical approaches, two of which are well defined at the present moment:

- cognitive approach – the direct knowledge representation based on production rules, frames and semantic networks;
- logical approach - based on first-order predicate logic, producing logical conclusions on a strictly formal, theoretical system, based on mathematical formalization and logical completeness.

Cognitive approach, in general, is based on the process of understanding of individual supervising (Lahlou 2008). It is based on the principles of organization of human memory. Therefore, the knowledge representation expressiveness rather than mathematical elegance and rigor is peculiar in this case. And if the exponents of logical approach choose for their research relatively simple problems, the researchers using cognitive approach solve real, relatively complex problems, requiring the introduction of new concepts and new methodologies. In this regard it is useful to recall briefly the existing periodization in development of the approach ideology (Baranov and Sergeev 1990) and the characteristic features of its each stage:

1. N. Wiener 's "Black box". The principle of simulation when modeling techniques do not correlate with the actual characteristics of a simulated object. The method has shown its effectiveness in modeling of some simple forms of intellectual processes. The main drawback of the method was formulated in the famous Neumann's conjecture about the " complexity threshold"; starting with a certain degree of complexity of the modeled object, the model becomes more complex the object itself.

2. The "black" and "white" boxes complex. The same principle but with the ideology of partial transparency, which proved to be more efficient than previous, stimulating in its establishment and development the elaboration of fuzzy criteria (Zimmermann 2010), frame and network methods of knowledge representation, etc.

3. " Knowledge machine" involves the atomistic principle of knowledge representation, on the basis of which a wide class of different (ES) generations with forward and reverse operation was created (and is created where there is a need). This techniques convincingly demonstrated the advantages and disadvantages of logical and cognitive directions in the ways of knowledge representation. At that, methodological limitations in the expert systems ideology were found only in the process of their testing and serial adaptation. It was found too that the fixation of the knowledge representation method fundamentally limits the class of situations in which they can be used in modeling of intellectual processes. In addition, there were cases when a designer used different knowledge to solve the same problem, and to solve different problems - the same knowledge were used.

4. The interpretive ideology, which in its capabilities not only overcame limitations of the atomistic approach. Particular interest in this case was generated by the models of understanding process, which were developed in hermeneutics as a scientific direction in the cognitive science.

2. Fuzzy frames as the approach for definition of conceptual space of the economic term

For achieving their goals the authors of this paper used the concept of frame as the mean of creating a frame (semantic) network. Despite the fact that in the area of artificial intellect there was a transformation of the meaning of the "frame" term, the classical M. Minsky model was used. He understand frame as the minimal description of object or phenomenon, which contains all important information about object or phenomenon and has the property that deletion of any part of the description leads to loss in essential information, without which the description of object or phenomenon may not be sufficient for its identification.

The proposed approach may be more productive if under the slots of each frame or set of frames as a means of description of the studied object or phenomenon we should understand some fuzzy subsets . In this respect, fuzzy frames may be the basis for structuring the investigated domain area in the form of decision tree (DT) and on its basis – the creation of a semantic network, which is the most general model of knowledge representation. The vertices of semantic network are information units, and arcs represent relations between them. The use of its capabilities can be illustrated by results of solving the research problem of this paper.

Conceptual (semantic) space of such nontrivial term as "regional social potential" was chosen as the target of research. It is necessary to define the place of this term in problems of regional systems research. The authors emphasize three main classes of research targets:

1) well-structured problems where existing dependencies between parameters are determined so clearly that they can be expressed in numbers or symbols, receiving numerical representations finally;

2) semistructured problems that include both qualitative and quantitative parameters and variables, and qualitative variables tend to dominate;

3) unstructured problems containing only description of the major resources, indicators and characteristics, quantitative relationships between them are unknown.

An example of unstructured problem description could be almost any conceptual-built analysis, for instance, the article by M. A. Nugaev and R. M. Nugaev (1995). In this paper the separation of "potential" and "potential carrier" concerns, the use of activity approach, logical division operations and some kinds of abstractions, in particular, the abstraction of identification when each predicate corresponds to a set and vice versa, and definitions through abstraction lead to situation when properties of the investigated domain area are not created by definitions, but are found themselves in investigated subjects.

The proposed approach gave the opportunity to highlight some of subpotentials characterizing social potential based on a combination of factors (attributes) that determine the social activity of personality. The main factors can be represented as the following list: 1) innovative-creative potential; 2) professional potential; 3) axiological (moral) potential; 4) intellectual potential.

This list of terms will be used later as the source text information about the study object study with the names of frames $\{F_j, j = 1,2, \ldots n\}$, where n = 4.

The modeling problem of regional social potential that contains only a description of the major indicators with unknown quantitative dependences between them, may be attributed to the class of unstructured problems. Therefore, the target of this study is the structuring of the studied domain area according to available source data to further define priority areas of marked subpotentials and their main indicators (parts, attributes). In order to begin to create the conceptual space model of the "regional social potential" term, it should be noted that linguists have identified three main characteristics of the term (Kognitivnye issledovanija za rubezhom 2010):

- the term is closely associated with a specific scientific area: one and the same word in different knowledge areas has different meaning;
- the term is unambiguous (in this area) in principle, whereas common-literary words are multivalued;
- the content of the term is revealed through precise logical definition, and not expressed by lexical meaning of the word.

Formally, each frame can be represented in the form of Backus-Naur notation (BNN):

$$Frame_j ::= \langle Name_j, Attribute_{ij}, Characteristic_{jih} \rangle \quad (1)$$

The name of frame as term in the notation (1) construct the names of subpotentials. The attributes are their (subpotentials) essential parts and concepts, explaining them (their minimal list of properties), the characteristics could be selected in the first approximation by - weight w_{ji}, (j = 1,2, ... n; i = 1,2, ... m_{ji}), where m_{ji} is the number of attributes of the frame which satisfies the logic requirement for scope and content correspondence, designated by frame.

Thus, the work of a researchers (expert or experts) in preparing the source data comes down to three actions:

1) development of a frames list
$\{F_{j,,} j = 1,2, \ldots n\}$
(in the example n = 4);

2) determination of needed parts list (attributes as explanatory concepts) for each frame identification by matching the logical scope and content of frames as a source for terms modeling
$A_{ij}, j = 1,2, \ldots n; i = 1,2, \ldots . m_{ij}$

3) within each frame as the characteristics of each attribute produce a ranking of each attribute in the ordinal scale (you can assign different attributes of the same places-ranks). In other words, the place of characteristics (index h in the expression (1) refers to a single parameter) is the rank of attribute in the list of attributes that characterize a

particular frame. Then the BNN notation (1) takes the form:

$Frame_j = \langle F_j, A_{ij}, W_{ij} \rangle$ (2)

However, exhibited by researcher ranks in ordinal scale are not suitable for further use in their original form and need mappings build in a more convenient scale which is interval scale. In other words, the assignment of place to the attributes list for each frame, which is necessary to build within each formed frame of the (2) type needs corresponding mapping τ:

τ: rank scale → interval scale (3)

by the known Fishbern conversion

$$w_i = \frac{2\cdot(n-j+1)}{n\cdot(n+1)}$$

(4)

for a simple order relation $w_1 \geq w_2 \geq ... \geq w_n \geq 0$.

It should be noted that the expression (4) corresponds to mapping (3) only in the absence of groups of related ranks, whereas for cases when different attributes equal rank is assigned, weights are calculated by modified with respect to (4) formula - for the relationships with non-strict order between the computed weights (refer to column 5 of Table 3). They are characteristics of the attributes list for each fuzzy frame as carriers of fuzzy set, the degree of membership in which is shown in column 7 of the same table.

3. Definition of conceptual space of the "regional social potential" term

Realization of the investigated term conceptual space by the modeling method in the form (2) begins with the development of table, which columns include the names of frames and rows include the whole set of attributes characterizing all subpotentials - the most essential parts of social potential (SP) (refer to Table 1). At the first stage of original data modeling it is necessary and sufficient to provide the names of the frames (set Y) for columns of the table, and full list of attributes (set X) for rows, then there arises the problem of mapping of attributes set on frames set:

$\tau : X \rightarrow Y$ (5)

Mapping (5) are presented in Table 1 by symbols "+" and means that the selected attribute of social potential can be regarded as a part, an essential feature of the forming frame.

Table 1 The attributes set mapping on the names of frames

Attributes of regional social potential X = {x}	The most significant parts of SP (subpotentials) Y = {y}			
	Innovative-creative y1	Professional y2	Axiological y3	Intellectual y4
x1 Initiativity	+	+		
x2 Entrepreneurship	+			
x3 Nonconformity	+			
x4 Thinking originality	+			+
x5 Sociability	+			
x6 Diligence		+		
x7 Skill		+		+
x8 Attainments		+		+
x9 Ethics		+	+	
x10 Education		+	+	+
x11 Aesthetics			+	
x12 Knowledge				+

Because formed attributes set within each frame is in general case unbalanced in given context, it is necessary in some way to fix their real, in the opinion of the researcher, weight as the degree of importance, for example, in ordinal scale as shown in Table 2.

Table 2 Incident matrix for regional social potential modeling

Attributes of regional social potential X = {x}	The most significant parts of SP (subpotentials) Y = {y}			
	Innovative-creative y1	Professional y2	Axiological y3	Intellectual y4
x1 Initiativity	1	1		
x2 Entrepreneurship	1			
x3 Nonconformity	3			
x4 Thinking originality	2			1
x5 Sociability	2			
x6 Diligence		2		
x7 Skill		1		1
x8 Attainments		1		2
x9 Ethics		4	1	
x10 Education		3	2	1
x11 Aesthetics			3	
x12 Knowledge				1

After building and completing work tableы 1 and 2 it is necessary to present the source data model in the separate table like Table 3.

Table 3 Source data model of regional social potential

Name of frame F_i	Names of subpotentials	Features that forming parts of frame as term (attributes A_{ji})		Attribute rank in frame	Weight w_{ji}	Degree of membership μ (A) / A
1	2	3	4	5	6	7
F_1	Innovative-creative	A_{11}	Initiativity	1	0,24	1,00
		A_{12}	Entrepreneurship	1	0,24	1,00
		A_{13}	Nonconformity	3	0,14	0,58
		A_{14}	Thinking originality	2	0,19	0,79
		A_{15}	Sociability	2	0,19	0,79
F_2	Professional	A_{21}	Initiativity	1	0,20	1,00
		A_{22}	Diligence	2	0,17	0,85
		A_{23}	Skill	1	0,20	1,00
		A_{24}	Attainments	1	0,20	1,00
		A_{25}	Ethics	4	0,10	0,50
		A_{26}	Education	3	0,10	0,65
F_3	Axiological	A_{31}	Ethics	1	0,50	1,00
		A_{32}	Aesthetics	2	0,33	0,66
		A_{33}	Education	3	0,17	0,34
F_4	Intellectual	A_{41}	Education	1	0,21	1,00
		A_{42}	Thinking originality	1	0,21	1,00
		A_{43}	Skill	2	0,17	0,81
		A_{44}	Attainments	1	0,21	1,00
		A_{45}	Knowledge	1	0,21	1,00

After building the source data model on the solving problem as shown in Table 3, it is necessary to carry out its content analysis according to Cartesian product procedure (by a principle "everyone with everyone"). All such comparisons over the names of frames will number $z = [n\cdot(n-1)/2] = [4\cdot(4-1)/2] = 6$ (in our case), with regard to comparison of attributes (which it is easy to calculate). For the Table 3 it would be necessary to do 133 pairwise comparisons. If the names of attributes, fixed in the names scale, are the same, their weights are summed for each frame, that is indicated in the matrix of "object to object" type, which is obtained as the result of content analysis and is named by us as "the matrix of mutual influences" $W = \{w_{ij}, i = 1,2, ... n; j = 1,2, ... n\}$ of the form (6):

$$W = \begin{matrix} F1\,| & 1 & 0.24 & 0 & 0.19 \\ F2\,| & 0.2 & 1 & 0.23 & 0.53 \\ F3\,| & 0 & 0.67 & 1 & 0.17 \\ F4\,| & 0.21 & 0.58 & 0.21 & 1 \end{matrix} \tag{6}$$

For example, the content of the second fuzzy frame F2 is "like" the content of the third fuzzy frame F3 with degree of 0.23, and vice versa the content of F3 is "like" F2 with the degree of 0.67 (these relations are presented in Fig. 1), etc. In other words, in the expression (6) we have created *asymmetric reflexive relationships* between fuzzy frames. Author software carries out comparison of the content of fuzzy frames as joint terms, which from the acquainted positions of logic can be in identity, subordination and intersection relation. Then the matrix W shows the measure of the intersection of studied terms – names of frames.

The target of this research is the structuring of the studied conceptual space which is unstructured initially. Structuring means clustering, the source data for which are *reflexive symmetric relations* or *similarity (tolerance) relations*. Usually such relationships are easy to obtain in the form of correlation matrix if relevant source data allow. In this case, for the purpose of obtaining reflexive symmetric relations (as similarity matrix $S = \{s_{ij}, i = 1,2, ... n; j = 1,2, ... n\}$ from asymmetric reflexive relations (matrix W) it is appropriate to use a well-known transformation by computing pairwise intersection relations of given terms (concepts) or frames to their union minus the intersection that, in terms of set theory, can be expressed as:

$$s_{ij} = \frac{w_{ij} \cap w_{ik}}{w_{ij} \cup w_{ik} / w_{ij} \cap w_{ik}} \text{ (where } j \neq k\text{)} \tag{7}$$

However, the expression (7) can be represented in the algebraic form (8). If for clarity use the values of w_{ij} as the i-th frame share taking $\boldsymbol{\alpha}$ in place of them , where $\boldsymbol{\alpha}$ is with j-th frame in relation to intersection of concepts (terms) with overlapping share $w_{ji} = \beta$, the expression (7) can have the following form:

$$s_{ij} = \frac{\alpha \cdot \beta}{\alpha + \beta - \alpha \cdot \beta} \text{ (where } j \neq k\text{)} \tag{8}$$

So, on the basis of matrix of mutual influences W (8) it is possible to obtain similarity matrix S which contains *reflexive symmetric relations* (tolerance relations or similarity relations), which, in turn, can act as source of data for building structure, for example, by applying the procedure of hierarchical clustering.

$$S = \begin{matrix} & F1 & F2 & F3 & F4 \\ F1\,| & 1 & 0.12 & 0 & 0.11 \\ F2\,| & 0..12 & 1 & 0.21 & 0.23 \\ F3\,| & 0 & 0.21 & 1 & 0.1 \\ F4\,| & 0.11 & 0.23 & 0.1 & 1 \end{matrix} \tag{9}$$

This leads to solving the classification problem on the basis of the source data matrix (8). In our opinion, it could be based on hierarchical clustering procedure with usage of nearest neighbor method. Clustering results (*equivalence relations*) in the form of dendrogram, reduced to the form Ishikawa's "fish skeleton"– decision tree (DR) are shown in Figure 1. Also in Figure 1, as an example, relations between the second and third frames at the level of terminal DR branches ("leaves of the tree") are shown. Since the transition from W to S " desensitize" the total picture, information captured in clustering on the source data S in the expression (9) is supplemented by authoring software to the level of information contained in the matrix W (6). Eventually a semantic network is formed. In this case, the F3 frame (axiological subpotential) forms a single cluster, F2 and F4 frames form a separate cluster (it should be highlighted in bold in Figure 1) and together with F1 form final cluster which is in need for the name of (its name in bold).

Since the frames-factors F2 and F4, according to the authors, to a greater degree indicates the influence of the socializing environment than the nearest environment of the shaped individual, the name of the cluster in the terminology of T. Parsons must show the so-called secondary socialization, conditioned by the way of the modern society which the individual belongs to. However, this approach to naming of obtained clusters can be attributed to the frame F1 "innovation and creativity potential" as the so-called potential, indicating largely the impact of the nearest environment of the individual (family, initial training, etc.) and the innate abilities rather than acquired abilities, and that provides the opportunity to relate it to the "primary socialization potential" by T. Parsons (in Fig. 1 also in bold). Then it is possible with certain caveats the total cluster formed from F1, F2, F4 in opposition to "intellectual potential" to name as "materializing potential".

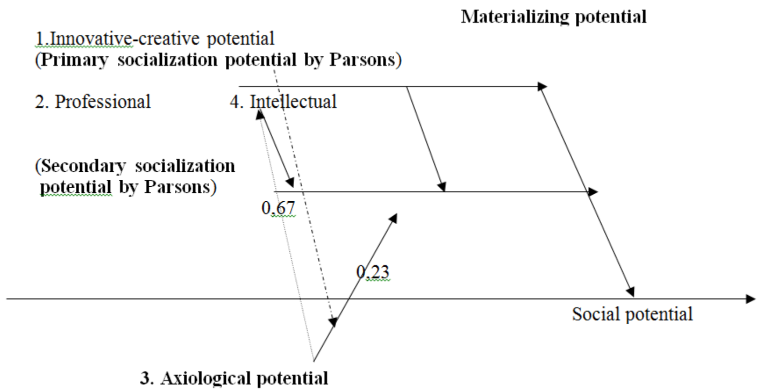

Figure 1. Semantic network on the basis of decision tree (one of the relations is illustrated).

After obtaining the clusters, and assigning them the correct names it is necessary to conduct the weighing of the decision tree branches. In the first approximation it is possible to be restricted to equivalent weights. Then the total sum of corresponding products according to the rules of classical DT weighing will be strictly equal to one to the base of the tree (excluding the elements of semantic network).

Further, after the semantic network generation, the underpass on each input in the DT with fixation the reaction at output (on DT trunk) must be done. The results of reaction must be ranked, that indicates the receipt of non-strict ordering relationships as for the frames list, and for a complete attributes list, as they are presented in Table 1 and 2 (so-called "wave algorithm"). The result will be two non-strict ordering relationships – for a frames list (10) and for an attributes list (11) which are illustrated respectively by the diagrams in Figure 2 and Figure 3 (sign » means "better"):

$$F3 \gg F2 \gg F4 \gg F1 \quad (10)$$
$$x9 \gg x11 \gg x10 \gg x1 \gg x4 \gg x2 \gg x7 \gg x5 \gg x8 \gg x3 \gg x12 \gg x6 \quad (11)$$

Expressions (10) and (11) are the result of conceptual space modelling of the " regional social potential" term taking into account the importance of subpotentials (targets) and their attributes (targets, target achievement techniques). It is clear that, with fuzzy degrees of membership of frames names and complete list of their attributes, it is easy to get the *weights responses* for frames and their attributes. Then the relationships of non-strict preferences would be expressed in weights ratio.

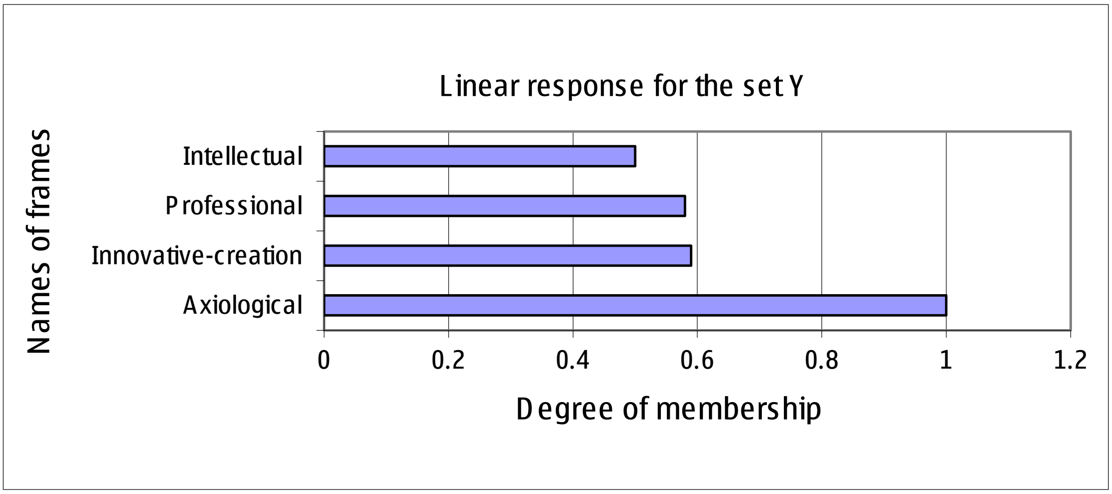

Figure 2. Rank and weights model of subpotentials of social potential

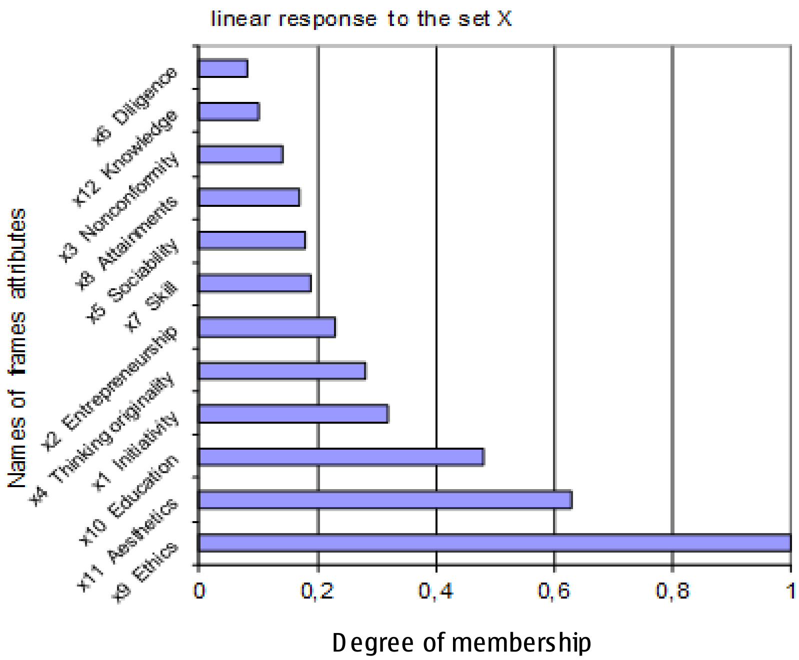

Figure 3. Rank and weights model of concept (term) attributes (names of subpotentials)

Expressions (10) and (11) are the result of conceptual space modelling of the " regional social potential" term taking into account the importance of subpotentials (targets) and their attributes (targets, target achievement techniques). It is clear that, with fuzzy degrees of membership of frames names and complete list of their attributes, it is easy to get the *weights responses* for frames and their attributes. Then the relationships of non-strict preferences would be expressed in weights ratio.

In passing, we note that the priority position of axiological potential in Fig. 2 and its attributes X9, X11 and X10 in Fig. 3 is partly explained by the fact that axiological potential F3 appeared to be a single cluster, and the weights distribution among the DT branches was equivalent. Perhaps, a picture may be somewhat modified by a researcher when other (more argumentative) weighting would be realized. Also initiativity and skill are more important than a knowledge itself (Fig. 2) and it does not cause noticeable objection.

4. Conclusions

Thus, the use of fuzzy frames allows not only to structure the investigated conceptual area, but also to build a semantic network in order to assess the priorities of conceptual space by use the source lists - frames list and the list of their attributes - with getting well interpretable results.

References

Baranov A.N., Sergeev V.M. Iskusstvennyj intellekt i tradicionnye metody analiza // Kognitivnye issledovanija za rubezhom. M., 1990, s. 5–18.

Nugaev M.A., Nugaev R.M. Socialnyj potencial regiona (Konceptualnye osnovy issledovanija) // Nauchnye trudy. Sbornik. Tom 1. – Kazan': ISEPN ANT, 1995. – s. 20 – 30.

Kognitivnye issledovanija za rubezhom. Metody iskusstvennogo intellekta v modelirovanii politicheskogo myshlenija. – M.: AN SSSR, Institut SSHA i Kanady. 2010 – s. 5 – 18

Lahlou S. (2008) Cognitive technologies, social science and the three-layered leopardskin of change. Social science information, 47 (3), 227-251

Zimmermann H.-J. (2010) Fuzzy Set Theory‖, John Wiley & Sons, vol. 2, 318-332