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Competencies Interdepencies Analysis based on Neutrosophic Cognitive Mapping

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Abstract. Recently, there has been increasing interest in competency-based education. Additionally, neutrosophic cognitive maps and its application in decision making have become a topic of significant importance for researchers and practitioners. In this paper, a framework 33based on static analysis of neutrosophic cognitive maps applied to competencies modelling and prioritization in presented. A case study based on modelling and prioritization of transversal competencies in system engineering is developed. The paper ends with conclusion and future research directions.
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Keywords: : information systems, competencies, neutrosophic cognitive mapping, prioritization.

1 Introduction

Recently, there has been increasing interest in competency-based education [1]. Competency-based education is known to improve employability in students [2]There are many interdependencies among competencies, determining the interrelationship of competencies is very import for in evaluation [3].

Neutrosophic sets and logic is a generalization of fuzzy set and logic based on neutrosophy [4]. Neutrosophy can handle indeterminate and inconsistent information, while fuzzy sets and intuitionistic fuzzy sets cannot describe them appropriately [5]. In this paper a new model for competencies analysis based on neutrosophic cognitive maps(NCM) [6] is presented giving methodological support and the possibility of dealing with interdependence, feedback and indeterminacy.

This paper is structured as follows: Section 2 reviews some important preliminaries concepts about Neutrosophic cognitive maps. In Section 3, a framework for competencies interrelation analysis based on NCM static analysis is presented. Section 4 shows a case study of the proposed model. The paper ends with conclusions and further work recommendations.

2 Neutrosophic cognitive maps

Neutrosophic Logic (NL) was introduced in 1995 as a generalization of the fuzzy logic, especially of the intuitionistic fuzzy logic [7]. A logical proposition P is characterized by three neutrosophic components:

$$NL(P) = (T, I, F) \quad (1)$$

where T is the degree of truth, F the degree of falsehood, and I the degree of indeterminacy.
A neutrosophic matrix is a matrix where the elements $a = (a_{ij})$ have been replaced by elements in $\langle R \cup I \rangle$, where $\langle R \cup I \rangle$ is the neutrosophic integer ring [8].A neutrosophic graph is a graph in which at least one edge is a neutrosophic edge [9]. If indeterminacy is introduced in cognitive mapping it is called Neutrosophic Cognitive Map (NCM) [10].
NCM are based on neutrosophic logic to represent uncertainty and indeterminacy in cognitive maps [4]. A NCM is a directed graph in which at least one edge is an indeterminacy denoted by dotted lines [11] (Figure 2.).

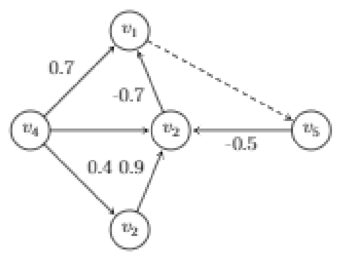

Fig. 1. NCM example

In [12] and in [13] a static analysis of mental model framework in the form of NCM is presented. The result of the static analysis result is in the form neutrosophic numbers (a+bI, where I = indeterminacy) [14]. Finally a the de-neutrosophication process as proposes by Salmeron and Smarandache [15] is applied to given the final ranking value. In this paper, this model is extended and detailed to deal with factors prioritization.

3 Proposed Framework

Our aim is to develop a framework for competencies interdependencies analysis based on NCM. The model consists of the following phases

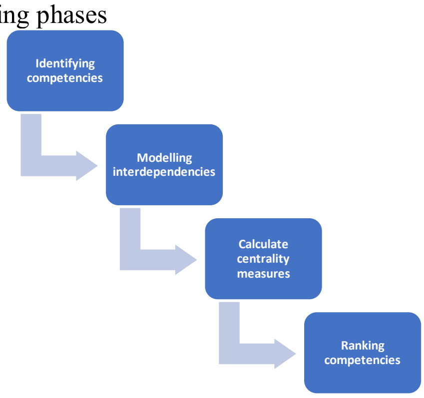

Fig. 2. Proposed framework for PEST analysis.

1.1 Identifying competencies

In this step, the relevant competencies are identified. Different techniques can be used, for example the Delphi technique[16].

1.2 Modelling interdependencies

Causal interdependencies among competencies are modelled. This step consists in the formation of NCM, according to the views of the evaluator.

1.3 Calculate centrality measures

The following measures are calculated[17] with absolute values of the NCM adjacency matrix [18]:

Outdegree $od(v_i)$ is the row sum of absolute values of a variable in the neutrosophic adjacency matrix. It shows the cumulative strengths of connections (c_{ij}) exiting the variable.

$$od(v_i) = \sum_{i=1}^{N} c_{ij} \quad (2)$$

Indegree $id(v_i)$ is the column sum of absolute values of a variable. It shows the cumulative strength of variables entering the variable.

$$id(v_i) = \sum_{i=1}^{N} c_{ji} \quad (3)$$

The centrality (total degree $td(v_i)$), of a variable is the summation of its indegree (in-arrows) and outdegree (out-arrows)

$$td(v_i) = od(v_i) + id(v_i) \quad (4)$$

1.4 Ranking competencies

A de-neutrosophication process gives an interval number for centrality. This one is based on max-min values of I . A neutrosophic value is transformed in an interval with two values, the maximum and the minimum value $I \in [0,1]$.

The contribution of a variable in a cognitive map can be understood by calculating its degree centrality, which shows how connected the variable is to other variables and what the cumulative strength of these connections are. The median of the extreme values [19] is used to give a centrality value :

$$\lambda([a_1, a_2]) = \frac{a_1 + a_2}{2} \quad (5)$$

Then

$$A > B \Leftrightarrow \frac{a_1 + a_2}{2} > \frac{b_1 + b_2}{2} \quad (6)$$

Finally, a ranking of variables is given. The numerical value it used for factor prioritization and/or reduction [20].

4 Case study

In this case, the relationship between competencies are represented by a subset of so-called transversal competencies in system engineering

Competencies	Description
c_1	Ability to solve mathematical problems
c_2	Understanding and mastering the basic concepts of information technology
c_3	Basic knowledge about the use and programming of computers
c_4	Ability to solve problems within your area of study

c_5	Be motivated by professional achievement and to face new challenges.
c_6	Use of the English language at written and oral level.

Table 1. Competencies analyzed

The NCM is developed by capturing expert's causal knowledge. The generated neutrosophic adjacency matrix is shown in Table 2.

0	0.7	0.4	I	0	0
0	0	0.9	0.7	0	0
0	0	0	0.9	0	0
0	0.5	0	0	0.9	0
0	I	0	0.7	0	0
0	0.9	0.6	0.7	I	0

Table 2: Adjacency. matrix

The centrality measures calculated are shown below.

c_1	1.1+I
c_2	1.6+I
c_3	0.9
c_4	1.4
c_5	0.7
c_6	2.2+I

Table 3: Outdegree

c_1	A	0
c_2	B	2.1+I
c_3	C	1.9
c_4	D	3+I
c_5	E	0.9+I
c_6	F	0

Table 4: Indegree

c_1	A	1.1+I
c_2	B	3.7+2I
c_3	C	2.18
c_4	D	3.4+I
c_5	E	1.6+I
c_6	F	2.2+I

Table 5: Total degree

A static analysis in NCM [10] which gives as result initially neutrophic number of the form (a + bI, where I = indeterminacy) . Finally, a de-neutrosification process as proposed by Salmerón and Smarandache [12] is developed. I ∈ [0,1] is replaced by its maximum and minimum values.

c_1	[1.1, 2.1]
c_2	[3.7, 5.7]
c_3	2.18
c_4	[3.4, 4.4]
c_5	[1.6, 2.6]
c_6	[2.2, 3.2]

Table 6: de-neutrosification

Finally, we work with the mean of the extreme values to obtain a single value [19] .

c_1	1.6
c_2	4,7
c_3	2.18
c_4	3,9
c_5	2,1
c_6	2.7

Table 7. Median of the extreme values

From these numerical values, the following ranking is obtained:

$$c_2 \succ c_4 \succ c_6 \succ c_3 \succ c_5 \succ c_1$$

In this case the most important competence is: "Understanding and mastering the basic concepts of information technology".

5 Conclusion

In the work, a model was presented to analyze the interrelationships between competencies and giving a priority is using the static analysis of neutrosophic cognitive maps. In the case study developed was determined as the most important : Understanding and mastering the basic concepts on the laws of information technology.

A future work is to analyze new competencies in the proposed framework. Incorporating scenario analysis and developing a software tool is another area of research.

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