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Neutrosophic Logic for Mental Model Elicitation and Analysis

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Abstract. Mental models are personal, internal representations of external reality that people use to interact with the world around them. They are useful in multiple situations such as muticriteria decision making, knowledge management, complex system learning and analysis. In this paper a framework for mental models elicitation and analysis based on neutrosophic Logic is presented. An illustrative example is provided to show the applicability of the proposal. The paper ends with conclusion future research directions.

Keywords: *mental model, neutrosophic Logic, neutrosophic cognitive maps, static analysis.*

1 Introduction

Mental models are useful in multiple situations such as muticriteria decision making [1], knowledge management, complex system learning and analysis [2]. In this paper, we propose the use of an innovative technique for processing uncertainty and indeterminacy in mental models.

The outline of this paper is as follows: Section 2 is dedicated to mental models and neutrosophic logic and neutrosophic cognitive maps. The proposed framework is presented in Section 3. An illustrative example is discussed in Section 4. The paper closes with concluding remarks, and discussion of future work in Section 5.

2 Mental Models and neutrosophic Logic

Mental models are personal, internal representations of external reality that people use to interact with the world around them [3]. The development of more effective end-user mental modelling tools is an active area of research [4].

A cognitive map is form of structured knowledge representation introduced by Axelrod [5]. Mental models have been studied using cognitive mapping [6].

Another approach is based in fuzzy cognitive maps [7]. FCM utilizes fuzzy logic in the creation of a directed cognitive map. FCM are a further extension of Axelrod's definition of cognitive maps [7] .

Neutrosophic logic is a generalization of fuzzy logic based on neutrosophy [8]. If indeterminacy is introduced in cognitive mapping it is called Neutrosophic Cognitive Map (NCM) [9].

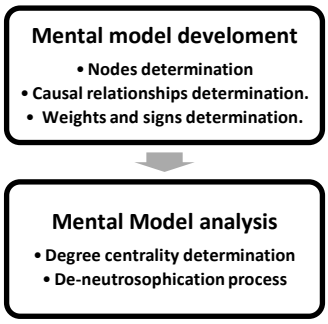
NCM are based on neutrosophic logic to represent uncertainty and indeterminacy in cognitive maps [8]. A NCM is a directed graph in which at least one edge is an indeterminacy denoted by dotted lines [6].

3 Proposed Framework

The following steps will be used to establish a framework for mental model elicitation and analysis with NCM (Fig. 1).

Figure 1: Mental model.

- **Mental model development.**



This Activity begins with determination of nodes. Finally causal relationships, its weights and signs are elicited [10].

- **Mental model analysis**

Static analysis is develop to define the importance of each node based on the degree centrality measure [11]. A de-neutrosophication process gives an interval number for centrality. Finally the nodes are ordered.

4 Illustrative example

In this section, we present an illustrative example in order to show the applicability of the proposed model. We selected a group of concepts related to people factor in agile software develoment projects sucess (Table 1) [12].

Table I. FCM nodes

Node	Description
A	Competence and expertise of team members
B	Motivation of tem members
C	Managers knowledge of agile development
D	Team training
E	Customer relationship
F	Customer commitment and presence

The FCM is developed integrating knowledge from one expert. The FCM with weighs is represented in Fig. 4.

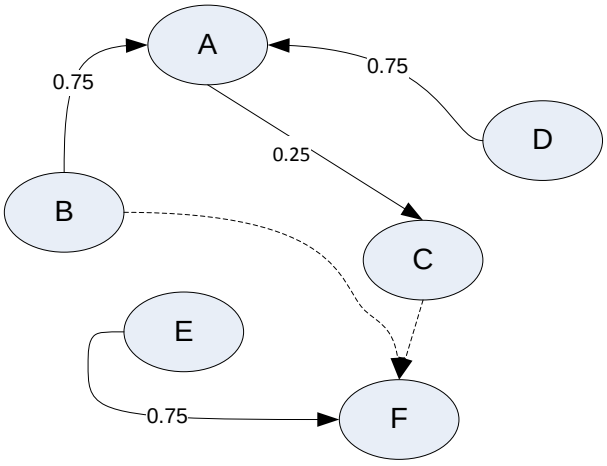


Figure 2: Mental model.

The neutrosophic score of each node based on the centrality measure is as follows:

A 1.75

B 0.75+I

C 0.25+I

D 0.75

E 0.75

F 0.75+2I

The next step is the de-neutrosophication process as proposes by Salmeron and Smarandache [13]. I $\in$[0,1] is repalaced by both maximum and minimum values.

A 1.75

B [0.75,1.75]

C [0.25,1.25]

D 0.75

E 0.75

F [0.75,2.75]

Finally we work with extreme values [14] for giving a total order:

$$A \sim F \succ B \succ C \sim D \sim E$$

Competence and expertise of team members, Customer commitment and presence are the more important factors in his mental model.

5 Conclusions

In this paper, we propose a new framework for processing uncertainty and indeterminacy in mental models. Future research will focus on conducting further real life experiments and the development of a tool to automate the process. The use of the computing with words (CWW) is another area of research.

References

1. Montibeller, G. and V. Belton, *Causal maps and the evaluation of decision options—a review.* Journal of the Operational Research Society, 2006. **57**(7): p. 779-791.

2. Ross, J., *Assessing Understanding of Complex Causal Networks Using an Interactive Game*. 2013, University of California: Irvine.

3. Jones, N.A., et al., *Mental models: an interdisciplinary synthesis of theory and methods.* Ecology and Society, 2011. **16**(1): p. 46.

4. Durham, J.T., *Mental Model Elicitation Device (MMED) Methods and Apparatus*. 2012, US Patent 20,120,330,869.

5. Axelrod, R.M., I.o.p.p. studies, and I.o.i. studies, *Structure of decision: The cognitive maps of political elites*. Vol. 1. 1976: Princeton university press Princeton.

6. Salmeron, J.L. and F. Smarandache, *Processing Uncertainty and Indeterminacy in Information Systems projects success mapping*, in *Computational Modeling in Applied Problems: collected papers on econometrics, operations research, game theory and simulation*. 2006, Hexis. p. 94.

7. Gray, S., E. Zanre, and S. Gray, *Fuzzy Cognitive Maps as Representations of Mental Models and Group Beliefs*, in *Fuzzy Cognitive Maps for Applied Sciences and Engineering*. 2014, Springer. p. 29--48.

8. Smarandache, F., *A unifying field in logics: neutrosophic logic. Neutrosophy, neutrosophic set, neutrosophic probability and statistics.* 2005: American Research Press.

9. Kandasamy, W.V. and F. Smarandache, *Analysis of social aspects of migrant labourers living with HIV/AIDS using Fuzzy Theory and Neutrosophic Cognitive Maps*. 2004: American Research Press.

10. Leyva-Vázquez, M.Y., et al., *Modelo para el análisis de escenarios basado en mapas cognitivos difusos.* Ingeniería y Universidad 2013. **17**(2).

11. Samarasinghea, S. and G. Strickert, *A New Method for Identifying the Central Nodes in Fuzzy Cognitive Maps using Consensus Centrality Measure*, in *19th International Congress on Modelling and Simulation*. 2011: Perth, Australia.

12. Chow, T. and D.-B. Cao, *A survey study of critical success factors in agile software projects.* Journal of Systems and Software, 2008. **81**(6): p. 961-971.

13. Salmerona, J.L. and F. Smarandacheb, *Redesigning Decision Matrix Method with an indeterminacy-based inference process.* Multispace and Multistructure. Neutrosophic Transdisciplinarity (100 Collected Papers of Sciences), 2010. **4**: p. 151.

14. Merigó, J., *New extensions to the OWA operators and its application in decision making*, in *Department of Business Administration, University of Barcelona*. 2008.

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