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Modeling and analyzing non-functional requirements interdependencies with neutrosofic logic

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Abstract.

Nonfunctional requirements refer to global properties of software. They are an important part of the requirement engineering process and play a key role in software quality. Current approaches for modelling nonfunctional requirements interdependencies have limitations. In this work we proposed a new method to model interdependencies in nonfunctional requirements using neutrosophic logic. This proposal has many advantages for dealing with indeterminacy making easy the elicitation of knowledge. A case study is shown to demonstrate the applicability of the proposed method.

Keywords: Nonfunctional requirements, requirement engineering neutrosophic logic.

1 Introduction

Software engineers are involved in complex decisions that require multiples points of view. One frequent reason that cause low quality software is associated to problems related to analyse requirements [1]. Nonfunctional requirement (NFR) also known as nonfunctional-concerns [2] refer to global properties and usually to quality of functional requirements. It is generally recognized that NFR are an important and difficult part of the requirement engineering process. They play a key role in software quality, and that is considered a critical problem [3].

The current approach is based solely in modeling interdependencies using only numerical Fuzzy Cognitive Maps (FCM). In this work we propose a new framework for processing uncertainty and indeterminacy in mental models.

This paper is structured as follows: Section 2 reviews some important concepts about Non-functional requirements interdependencies and neutrosofic logic. In Section 3, we present a framework for modelling non-functional requirements interdependencies with neutrosophic logic. Section 4 shows an illustrative example of the proposed model. The paper ends with conclusions and further work recommendations in.

2 Non-functional requirements interdependencies and neutrosofic logic

Nonfunctional requirements are difficult to evaluate particularly because they are subjective, relative and interdependent [4]. In order to analyse NFR, uncertainty arises, making desirable to compute with qualitative information. In software development projects analyst must identify and specify relationships between NFR. Current approaches differentiate three types of relationships: negative (-), positive (+) or null (no contribution). The opportunity to evaluate NFR depends on the type of these relationships.

Softgoal Interdependency Graphs [4] is a technique used for modelling non-functional requirements and interdependencies between them. Bendjenna [2] proposed the use on fuzzy cognitive maps (FCM) relationships between NFCs and the weight of these relationships expressed with fuzzy weights in the range 0 to 1. This model lacks additional techniques for analysing the resulting FCM.

Neutrosophic logic is a generalization of fuzzy logic based on neutrosophy [5]. When indeterminacy is introduced in cognitive mapping it is called Neutrosophic Cognitive Map (NCM) [6]. NCM are based on neutrosophic logic to represent uncertainty and indeterminacy in cognitive maps [5] extending FCM. A NCM is a directed graph in which at least one edge is an indeterminacy one denoted by dotted lines [7]. Building a NCM allows dealing with indeterminacy, making easy the elicitation of interdependencies among NFR.

3 A framework for modelling non-functional requirements interdependencies

The following steps will be used to establish a framework for modeling non-functional requirements interdependencies NCM (Fig. 1).

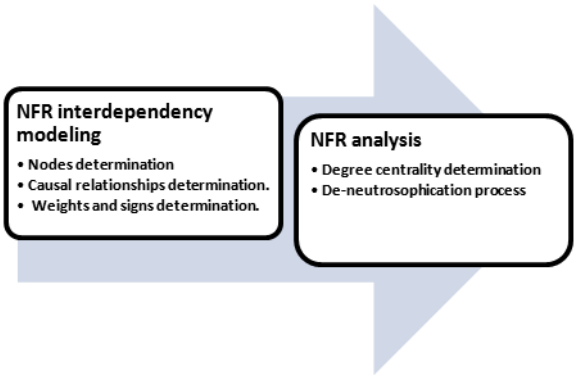

Figure 1: Proposed framework.

- **NFR interdependency modeling**

  The first step is the identification of non-functional concern in a system (nodes). In this framework we propose the approach of Chong based on a catalogue of NFR [4]. Causal relationships, its weights and signs are elicited finally [8].

- **NFR analysis**

  Static analysis is develop to define the importance of NFR based on the degree centrality measure [9]. A de-neutrosophication process gives an interval number for centrality. Finally the nodes are ordered and a global order of NFR is given.

5 Illustrative example

In this section, an illustrative example in order to show the applicability of the proposed model is presented. Five non-functional concerns $R = (NFR_1, \ldots, NFR_5)$ are identified (Table 3).

Table 3 Non-functional requirements

Node	Description
NFR_1	Quality
NFR_2	Reliability
NFR_3	Functionality
NFR_4	Competitiveness
NFR_5	Cost

Table 1 Non-functional requirements

The experts provide the following causal relations (Fig 2) .

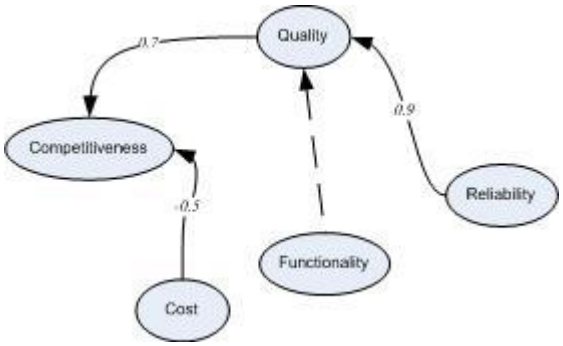

Figure 2. NCM representing NFR interdependencies.

The neutrosophic score of each NFR based on the centralitydegree measure [10] is as follows:

NFR_1 1.6I
NFR_2 0.9
NFR_3 I
NFR_4 1.2
NFR_5 0.5

The next step is the de-neutrosophication process as proposes by Salmeron and Smarandache [11]. I ∈[0,1] is repalaced by both maximum and minimum values.

NFR_1 [1.6, 2.6]
NFR_2 0.9
NFR_3 [0, 1]
NFR_4 1.2
NFR_5 0.5

The final we work with extreme values [12] for giving a total order:

$$NFR_1 \succ NFR_4 \succ NFR_2 \succ NFR_3 \sim NFR_5$$

Quality, competitiveness and reliability are the more important concern in this case.

Conclusion

This paper proposes a new framework to model interdependencies in NFR using NCM. Neutrosophic logic is used for representing causal relation among NFR.

Building a NCM allows dealing with indeterminacy, making easy the elicitation of knowledge from experts. An illustrative example showed the applicability of the pro-

posal. Further works will concentrate on two objectives: developing a consensus model and developing an expert system based.

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