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Hybrid intelligent scenario generator for business strategic planning by using ANFIS

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ABSTRACT

The aim of this study is to investigate a new method for generating scenarios in order to cope with the data shortage and linguistic expression of experts in scenario planning. The proposed hybrid intelligent scenario generator uses an Adaptive Neuro-Fuzzy Inference System (ANFIS) to deal with uncertain inputs. In this methodology, the strengths of expert systems, fuzzy logic and Artificial Neural Networks (ANNs) are joined to generate possible future scenarios. The proposed methodology includes four steps: step 1 defines the scope and internal and external variables and step 2 determines rules from experts. Then, step 3 prepares ANFIS system which is conducted by computer programming in Matlab environment. The Last step is sensitivity analysis to study the effects of variation of inputs on outputs. The applicability of the proposed method has been tested against two different case studies.

1. Introduction

The purpose of strategic planning is to guide an organisation to achieve its desired goals of the long-term development under the variation of environment (Wang, 1999). Therefore, the future events play a key role in business strategic planning and managers need a mental model of the future to make better decisions. There are some differences among uncertainties pertaining to future occurrence probability. When there is the low level of uncertainties in environment, quantitative approaches such as probability distribution and forecasting techniques are very useful for managing the existing risk and uncertainty. In the high level of uncertainty, qualitative approaches such as scenario planning may be useful to employ (Alessandri, Ford, Lander, Leggio, & Taylor, 2004). Scenario planning is not aimed at obtaining a forecast but instead produces alternative images of the future which can avoid the pitfalls of more traditional methods (Goodwin & Wright, 2001; Postma & Lieb, 2005). Managers are able to have much better positioning with regard to unexpected events by using scenario planning methods. Scenario planning attempts to capture the richness and range of possibilities, and considers changes that decision makers would otherwise ignore (Schoemaker, 1995).

Scenario planning has been defined as "a process of positioning several informed, plausible and imaginative alternative future environment in which decisions about the future may be played out for the purpose of changing current thinking, improving decision making, enhancing human and organizational learning and improving performance" (Chermack & Lynham, 2002). Various scenario planning approaches from literature are classified into two major categories: qualitative and quantitative.

SRI (Ringland, 1998), Future Group (Chermack, Lynham, & Ruona, 2001), Global Business Network (Chermack et al., 2001), Schoemaker (Schoemaker, 1995), and DSLP (Royes & Royes, 2004) methodologies are all subjective, qualitative in nature and firmly process-oriented. This means that organisational learning process in these approaches is more important than the reliability of the content of the end product, which is the scenarios (Bradfielda, Wrightb, Burta, Cairnsb, & Van Der Heijdena, 2005). These approaches are not based on past data but consider qualitative and subjective information of experts to construct scenarios. On the other hand, Godet's methodology (Godet, 2001, 2006; Godet & Roubelat, 1996) which has been known as a quantitative method is essentially outcome-oriented. A quantitative methodology develops scenarios for particular phenomenon and sets key variables for a specific subject. The experts' rules in quantitative methodologies are dominant and they judge about the occurrence probability of each scenario. Quantitative methodologies such as Godet's framework consider the conditional probability of each occurrence which is assumed for different sets of environmental and organisational variables. In all scenario planning methodologies, experts' role is critical for decision making, and uncertain data always are the basis for developing future scenarios.

Scenario planning deals with uncertain and ambiguous data and therefore, some researchers applied fuzzy logic and Artificial Neural Networks (ANNs) for better handling of the data shortage and also experts' linguistic expression. Khoo, Ho, and Choa (1994) developed a fuzzy management decision support system for scenario analysis using a hybrid technique: a combination of

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the fuzzy Delphi analysis and fuzzy reasoning technique. Wang (1999) proposed a method of fuzzy scenario analysis to forecast the possible development in a strategic planning. This method considered the uncertainties involved in strategic planning to determine the compatible and possible scenarios. Li, Ang, and Gay (1997) developed a scenario generation tool by using the theory of ANNs and truth value flow inference. ANNs were designed to forecast market share and market growth, and a fuzzy expert system model was developed to build a knowledge-base for defining a suitable marketing strategy. Royes and Royes (2004) developed a framework to indicate how the fuzzy set approach may contribute to the evaluation and exploration of scenarios for strategic planning. A hybrid methodology was developed which used three main modules: fuzzy sets, multicriteria analysis and case-based reasoning.

This paper presents a new hybrid methodology to combine the advantages of fuzzy logic and ANNs. Other methodologies use only one method, fuzzy logic or ANNs, for dealing with the data shortage and experts' linguistic expression. Li's method is the only methodology developing a hybrid intelligent system based on fuzzy logic and ANNs but the major difference of this method with the proposed methodology is related to the proposal using ANNs. In Li's framework, ANNs are utilized for forecasting market share and growth, while the suggested methodology applies ANNs as a tool to learn from experts and make decisions. The main goals of this new hybrid intelligent architecture will be:

–To improve the ability of managers to deal with uncertainty.
–To present intelligent advice on business strategic planning.
–To keep and use the experts' knowledge.

To attain these objectives, the proposed framework applies an Adaptive Neuro-Fuzzy Inference System (ANFIS) which is suggested by Jang (1993) to better deal with an ill-defined and uncertain system. It can serve as a basis for constructing a set of fuzzy if–then rules with appropriate membership functions to generate the stipulated input–output pairs (Jang, Sun, & Mizutani, 1997). ANFIS architecture is designed to tune fuzzy system parameters based on input/output pairs of data. The fuzzy inference process is implemented as a generalised ANN, which is then tuned by gradient descent techniques (Fuller, 2000). Antecedent parameters of fuzzy rules are also tuned as well as consequent parameters. ANFIS provides a method for the fuzzy modelling procedure to learn information about a dataset, in order to compute the membership function parameters allowing the associated fuzzy inference system to track the given input/output data (Huang, Chen, & Huang, 2007). ANFIS is used in many areas such as forecasting (Aznarte et al., 2007), classifying (Ozturk, Arslan, & Hardalac, 2008; Sengur, 2008), controlling (Elmas, Ustun, & Sayan, 2008), recognition (Avci & Avci, 2007; Avci, Hanbay, & Varol, 2007) and diagnosing (Güler & Übeyli, 2004; Polat & Gunes, 2007; Übeyli, 2008). The goal of this research is to develop an intelligent scenario generator based on ANFIS to eliminate the weaknesses of previous methodologies. The theory of ANNs will be used to enable learning and correcting from experts. Furthermore, fuzzy logic theory will be applied to deal with reasoning and using linguistic information acquired from experts.

In Section 2, the details of ANFIS methodology for generating scenarios have been described. Two case studies are introduced in Section 3. The findings of case studies will be discussed in Section 4. In final section, the result of this research will be explained.

2. ANFIS Methodology for generating scenarios

This section is related to design of a new intelligent methodology for generating scenarios including four steps as follows:

Step 1: Defining the scope and internal and external variables.

The first step tries to define the problem and also the boundary of the system under examination. Identifying variables, relationship between variables and defining key variables are other main objectives of this step. This research recommends Godet's method (2001) in defining the key variables.

Step 2: Determining rules from experts.

In this step, the knowledge of expert should be gathered and summarised in the form of if–then rules.

Step 3: Preparing ANFIS system.

The ANFIS architecture contains a 6-layer forward pass ANNs as shown in Fig. 1. The output and input of each layer has been presented as following: y_i^k = output of neuron i in layer k; x_i^k = input of neuron i in layer k.

Layer 1 is the input layer whose neurons transmit external crisp signals directly to the next layer as follows:

$$y_i^1 = x_i^1. \tag{1}$$

Layer 2 is the fuzzification layer. Neurons receive a crisp input and identify the degree of neurons' fuzzy sets. Based on Jang's

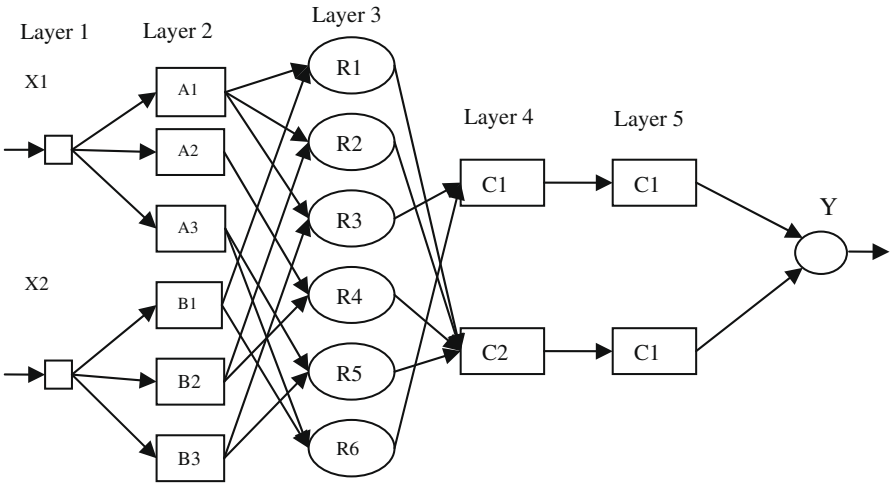

Fig. 1. Adaptive neuro-fuzzy inference system (ANFIS).