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The role of fuzzy logic in predictions and decision-making

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ABSTRACT

Traditionally, logic has been used for substantiation of a claim and sometimes, mathematical proofs helped to substantiate a scientific statement. Actually, logic has greatly helped human beings to easily understand and believe many subjects. Mathematics and its application also followed the same objective in a different manner. Perhaps, we have been applying a combination of logic and mathematics in several cases instinctively the traces of which are observable in our personal lives. Integration of logic with most widely used mathematical methods has significantly been effective in major decision making and long-run predictions. In current work, we consider the effects of two cases of such integrations called fuzzy logic. These two methods and examples of their applications are only trivial examples of an extensive knowledge. Here, we address some applications of fuzzy average for predictions and decision making in a fuzzy environment.

Keywords: *Fuzzy logic, Fuzzy average in prediction, Decision making in a fuzzy environment, Mathematics.*

INTRODUCTION

Application of most widely used methods in fuzzy logic requires acquaintance with the environment and careful review of these methods that each one somehow helps us to improve our life and economic, educational and communicative policies. Fuzzy average method in predictions helps us to evaluate and approach prospective incidents, predict them or deal with them with more scrutiny and readiness. Another advantage of this approach is that it brings the experts' views and opinions closer together. As a matter of fact, this is a model to approach ideas and achieve a common goal.

Decision making has a great impact on the life and destiny of any person or any country or even on different groups and departments. Therefore, decision making is to choose the best manner to reach a single goal. True decisions will lead to good results and the inverse of this case applies. If some information is deficient and unknown in decision making, this process will get difficult or sometimes impossible. Fuzzy logic helps an appropriate decision making by fixing some defects and removing some uncertainties.

Theoretical principles of research: As fuzzy logic is widespread and helps to improve the quality of human life, it is necessary to understand, identify and apply suitable ways to predict some future circumstances and to make true decisions with good knowledge. Prediction of future in a fuzzy environment helps us to make appropriate decisions.

Research methodology: Authentic articles and books and standpoints and methods presented by authorities concerning fuzzy logic were used in this study.

Conclusions: In fuzzy logic, prediction of future helps a good decision making. Fuzzy average is a good and common approach for prediction of future. As well, making a decision in a fuzzy environment helps to make an appropriate decision.

Fuzzy average for prediction

Prediction is among the most fundamental and important endeavor for any kind of activity. To acquire information and to find out ambiguous data in a rapidly growing environment is a demanding task. However, fuzzy logic is more suitable and applicable for several ventures, has facilitated tasks and has approached the experts' views. In the following section, some examples of prediction are provided.

Fuzzy average for rainfall forecasting

Gholam Abbas Fallah Ghalhari et al, using Mamdani-type fuzzy inference system and multivariate regression presented a rainfall forecasting from April to June in Khorasan Razavi province. In this study, synoptic weather patterns including sea level pressure, difference of sea level pressure, temperature difference between sea level and 1000 mb level, temperature of 700 mb level, thickness of 500 mb and 1000 mb levels, relative humidity of 300 mb level, precipitable water and average regional precipitation were investigated. The influence of synoptic patterns on precipitation across the northeastern areas of Iran was taken into account in selection of our study regions which included a set of points in Persian Gulf and Oman Sea, Black sea, Caspian Sea, Mediterranean Sea, Baltic Sea, Adriatic Sea, Red Sea, Gulf of Aden, Atlantic Ocean, Indian Ocean and Siberia. Then, Mamdani-type fuzzy inference system was taught in a 28-year period and finally, rainfall forecasting in a 10-year period was tested. The results indicated that Mamdani-type fuzzy inference system and regression method can forecast spring rainfall with an acceptable accuracy for most years. Root mean square error (RMSE) for fuzzy model was 36.6 mm and for regression model was obtained 5.5 mm.

Here, we observed that Fallah Ghalhari et al., investigated and forecasted rainfall using fuzzy logic. Fuzzy logic helps to predict several cases, for example, OPEC oil price forecasting, prediction of OPEC oil production, or prediction of agricultural products during the next agricultural year. However, this example was sufficient in our study. Another forecasting method in fuzzy logic is fuzzy Delphi method to which we will address.

Fuzzy Delphi method

Delphi technique relies on experts' opinions. In order to examine standpoints, verbal expressions are applied in this method. Verbal expressions have some limitations in fully manifestation of mental potentials of respondents. For example, the expression "very much" for individual A, who is a hard and strict person, is different from "very much" expressed by individual B. If an absolute value is used to quantify the viewpoints of both persons, the results will be skewed. Therefore, we can overcome this problem by developing a suitable fuzzy spectrum. Traditional Delphi method has ever been suffering from low concensus and convergence of the experts' opinions, costly implementation and probability of omission of some opinions. In order to improve the traditional Delphi technique, Moori et al. developed the concept of integration of traditional Delphi method with fuzzy theory in 1985. Ishikawa et al. further introduced application of fuzzy theory in Delphi method and developed fuzzy integration algorithm to forecast the future influence of computers on organizations. We need to distinguish between two applications of Delphi technique to describe implementation algorithm for fuzzy Delphi method.

Application of Delphi technique for "criteria screening"

Application of Delphi technique for "forecasting"

When using Delphi **technique** we should distinguish between two types of qualitative research. Some studies are exploratory. In this category, researchers seek to identify the main underlying elements of a phenomenon. Some research have a forecasting goal. In current study, implementation algorithm for fuzzy Delphi technique has been presented based on prior studies.

Fuzzy Delphi technique implementation algorithm for screening

Identification of appropriate spectrum for fuzzification of verbal expressions

Fuzzy aggregation of fuzzified values

Defuzzification of values

Selection of threshold intensity and criteria screening

In implementation of fuzzy Delphi algorithm for screening, firstly, a suitable fuzzy spectrum should be developed for fuzzification of verbal expressions of respondents. To this end, we can develop fuzzy spectrum or use conventional fuzzy spectrum.

Fuzzy Delphi algorithm implementation for forecasting

First, each expert's forecasting is presented as a triangular fuzzy number.

In order to aggregate predictions, fuzzy average will be used.

Then in order to identify discrepancies among each experts' opinions, the mean of opinions was calculated and provided for the respective expert.

Fuzzy Delphi technique is applicable for screening in a single round, however, several rounds are required for forecasting to reach a consensus. A reasonable justification is that in screening, researcher performs initial screening using the existing literature and analysis is for verification. But forecasting is more critical and analysis is exploratory. Therefore, forecasting requires more precision and scrutiny. Another method used for predictions is called PERT.

PERT

In statistics, an **outlier** is an observation point that is distant from other observations. Grubbs defines an outlier as follows: Outliers have a significant difference with other members occurred in the sample. Outliers can be seen for many reasons but they often indicate either some measurement errors or that the data has a heavy-tailed probability distribution.

The critical path is usually calculated according to the required time for each task, its float and prerequisite tasks. A path without float and with the longest time for completion of project is called a critical path. However, sometimes we face some tasks during project implementation that cannot be completed on time due to financial problems, lack of provision of the required budget or occurrence of influencing factors (risks) and if the activity is not set on the critical path, it will change the critical path of the project and an alternative path leads to delay in the completion time of the project.

In the article written by Bahram Beik, a model was presented that did not suffice to duration and considered cost, risk and quality effective in determination of the critical path. In order to find the critical path of the project, we need to take the existing uncertainty about some project parameters such as cost and time into account. Considering the above uncertainty, fuzzy theory can be applied.

This model regards risk and quality of individual tasks along with time and cost factors and weights each criterion using fuzzy entropy. For each activity a coefficient composed of four factors of time, cost, risk and quality is obtained according to which the critical path is selected and for timely completion of the project based on the allocated budget, the greatest emphasis should be on this path and it is not necessarily a path with longest duration for completion of the project.

Fuzzy logic dramatically helps our economic foresight. Now we address decision making in a fuzzy environment.

Decision making in a fuzzy environment

Rating and selection of research projects has ever been a roughly ordinary, difficult and complicated task for specialized and research councils at academic areas and research centers. Its complexity originates from considering the impacts of multiple criteria on each project and involvement of several decision makers in rating and selection of research projects based on different criteria. Decision makers express their preferences regarding the importance of criteria and provision of criteria by research projects. The decision makers' judgement is based on their uncertain and ambiguous knowledge conveyed through linguistic words. Fuzzy set theory provides the necessary flexibility to represent the uncertainty arising from lack of knowledge and is able to handle issues such as uncertainty and imprecision of a word. So it can be applied to handle imprecise information in real-life decision making in which the value of criteria and options is not precisely specified. As a result, in real decision making area where the value of criteria and research projects has been stated ambiguously, we considered TOPSIS method for decision making problems with fuzzy data. TOPSIS-based fuzzy decision making technique was established based on this principle that the selected alternative must keep the shortest distance with the ideal positive solution and the longest from the ideal negative solution. This is an intuitive and acceptable principle in human decision making process.

Different applications of decision making in a fuzzy environment

Distribution of stocks

Financial capital and corporate financing have long been controversial subjects in international economy. This kind of financing has particularly increased in the developing countries that has attracted more attention. Although development of domestic markets in the developing countries and access to low priced work force given that liberalization policies continue can lead to growth of foreign investment in such countries, attracting domestic financing for development of stock exchange follows a more complicated procedure. Current research is going to identify the most significant indicators affecting corporate shares from the standpoint of creditors (banks and financial institutions), to rate fifty superior shares at Tehran Stock Exchange using fundamental analysis in a fuzzy environment to provide the respective authorities with an inclusive model for selection of appropriate alternatives for financial capital of banks. Therefore, in the first step, for identification of fundamental indicators affecting stock rating, principal component analysis (PCA) (distribution of questionnaires among stock exchange experts) and for analysis of questionnaires, non-parametric statistics were used. In the next step, in order to determine the weighting of indicators, fuzzy ANP will be applied and next the stock exchange experts' opinions about pairwise comparisons of indicators and their weighting were extracted from the questionnaires. Finally, after collecting data related to the identified fundamental indicators from 50 top companies at Tehran stock exchange, fuzzy TOPSIS technique will be used for rating and prioritizing their financial capital.

Market management

Sharareh Azedi Tehrani and Sabra Fereidounfar in their study have addressed the role of decision making in a fuzzy environment in market management to which we pay in the following.

Today, our real world is much more complex to be described or defined precisely. Therefore, an approximate or fuzzy description that is analyzable and acceptable should be introduced for a model. Fuzzy systems are knowledge- or principle-based. The heart of a fuzzy system is a knowledge base composed of if-then principles. A fuzzy if-then principle is an if-then statement whose some words have been specified with continuous membership functions. Nowadays, challenges and complexities of mark and marketing management also have raised. A review of marketing literature suggests the necessity of a comprehensive framework to predict market conditions. It is not always easy to understand the customers' needs and demands. Direct connection with customers is a clear solution and one of the advantages of market research. However, many customers may not know what they want or they may not want what they think they want. A practical, inclusive and dynamic model will be introduced here to determine the marketing mix. This model is based on fuzzy decision making systems to deal with the dynamic, ambiguous, uncertain and threatening character of input variables and to model non-linear relationships involved in marketing problems. The main objective is to describe how a fuzzy methodology can subtly handle marketing problems.

We noticed here that decision making in a fuzzy environment and application of its methods will greatly help in market management and resolving its ambiguities. There are several cases worthy of mention for example construction or housing policies for low income families to all of which we cannot address in this article.

CONCLUSIONS

In the above sections, we addressed the role of fuzzy logic with some examples that helps us with respect to the current world speed and has more accuracy and speed compared to other methods. Let us not forget that application of fuzzy logic methods first requires understanding of this important logic.

Fuzzy logic and its methods aim to remove uncertainties and defects and we should remember that this logic is a solution for better decision making and it does not include all aspects of decision making. Moreover, such methods must resolve uncertainties not to provoke more ambiguities. This is not achieved unless through correct understanding of fuzzy logic and then its application.

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