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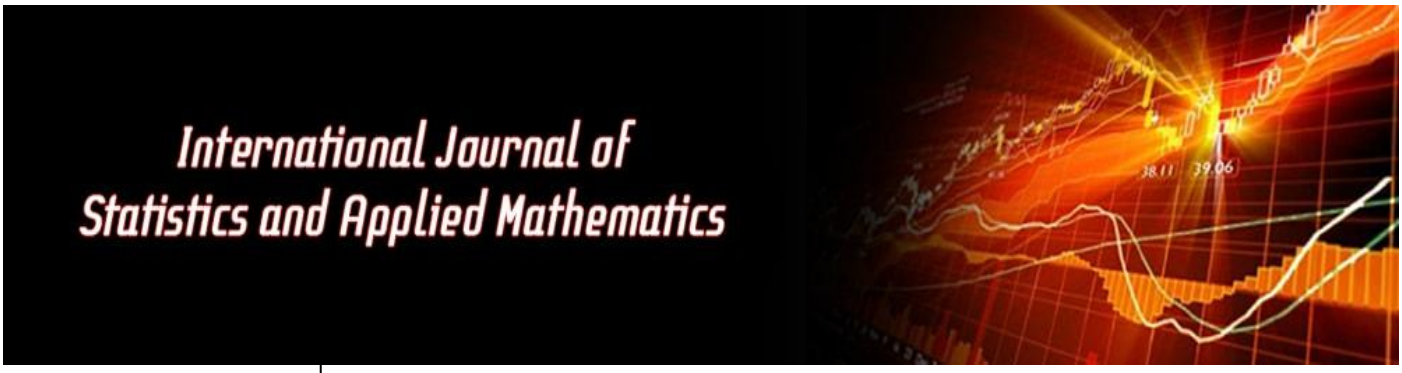

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Application of fuzzy logic: A literature review

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Abstract
Mathematics is considered as art of all arts and science of all sciences. Most of mathematical terms and functions are used in many other branches like engineering, robotics, physic s etc. One of these terms is Fuzzy Logic. This term has become more popular in mathematics and in other branches as in engineering, medical science, robotics etc. and even in households also. This paper presents the concept of fuzzy logic and its application in different branches. This study represents the use of fuzzy logic approach in chemical science, medical science, agriculture, political science, operations research, in environment science and in household. This paper represents that fuzzy logic approach has mainly three phases: fuzzification, rule or inference and defuzzification. The findings indicated that fuzzy logic is a wide approach rather than a mathematical logic and is applicable in many branches.

Keywords: Fuzzy logic, fuzzy logic application

Introduction
Fuzzy logic is a mathematical term, whose use is observed by many researcher s in different fields during different time periods. A great change has been occurred by the use of fuzzy logic. Due to the use of fuzzy logic many things has become easier and this has helped to save time, money and energy. Fuzzy logic was first time proposed by Lotti Zadeh in 1965. Before Zadeh many efforts were done in this field by many researchers like Plato, Hegel, Marx, Lukasiewicz etc. [1]. Some of them gave three valued logic and some of them gave four valued or five valued logic, which are the extension of Boolean logic, which accepts only two values true or false (0 or 1).
Lotti Zadeh in his work "Fuzzy sets" described mathematics as fuzzy sets and fuzzy logic. Before the introduction of fuzzy logic, mathematics is confined only to two conclusions that is true or false (0 or 1). But fuzzy logic has extended this range to the real numbers (0, 1). This paper presents the concept of fuzzy logic and a brief review of its application in different fields. This study represents that how fuzzy logic has been applied in different fields and how its use make the things and concepts easier.

Concept of Fuzzy logic
Boolean logic accepts only two values true or false (0 or l). In this one can talk about low or high. It does not say anything between them that is it does not take the concept of medium. This can be done by the more extended concept that is by fuzzy logic as it takes values [O, l]. Because of this concept one can talk about low, high and medium and also about very low, very high also. So it is the extended version of Boolean logic.
Fuzzy means not well known or not clear enough. Fuzzy logic is a proposition that may be true or false or have an intermediate true value. It is formed to handle the concept of partial truth. Degree of truth is represented by membership function. A membership function on a set X is any function from X to a real unit interval [O, l]. The value 0 represents the false value, lrepresents truth value and the value between 0 and l represents partial truth. One of the major advantages of fuzzy logic is that it resembles with human reasoning. In this linguistic variables are used to reduce complexity.

Fuzzy logic control

Fuzzy logic controller proceeds in three steps. First step is fuzzification. In this crisp variable is converted in fuzzy variable. In second step some rules are set up in the form of If -Then and inference system works. The third step is defuzzification. In this resulting fuzzy output is converted back into crisp variable [2].

Fuzzification --+ Inference system Defuzzification

Application of Fuzzy Logic

Fuzzy sets and Fuzzy logic are the foundations for fuzzy mathematics, which is extension of traditional mathematics. Fuzzy logic is a broad concept. Besides Mathematics, it has been used in many fields. This paper reviews a few areas where fuzzy logic has been applied successfully. Description of some of them is as follows:

In chemical science

Fuzzy logic has been used in chemical science. Davidson and Hayward [3] considered many examples based on use of fuzzy logic. The study of Almardy used a fuzzy control system to apply current to a series of anodes to protect a long buried pipeline and also to minimize power used to protect the pipeline [3]. The study showed that for this he set up a fuzzy control system with 126 rules and got output by adjusting the output membership functions. Adroer *et al* found fuzzy error, the difference between the desired and actual pH, in controlling pH of flowing waste water [3]. The fuzzy technique implemented by Adroer *et al* found that for acceptable pH control with a small mixer could be provided with a short residence time. Thus the study shows that the fuzzy logic has great contribution in chemical science.

In Healthcare Industry

Fuzzy logic has been used in healthcare industry. Biomedicine is seemed as branch of science but more than science, it is an art. because it uses human knowledge, experience and skills to diagnosis and treatment of diseases. Biomedical systems are intrinsically non linear, time varying and have time delay. To regulate the blood pressure in case of open heart patients a real time fuzzy control drug delivery system has been tried in 1980s [l O]. The study of Davidson and Hayward [3] represented that Warren *et al* presented a decision support system for automating the application of clinical practice guidelines based on fuzzy method. The study shows that the test report yields likelihood estimates rather than confirmation of presence or absence of disease and in fuzzy method, likelihood estimates can be handled as membership values and used as such in fuzzy inference model. Thus the study shows that the fuzzy logic has great contribution in health industry.

In Agriculture

Philomine Roseline T and N. Ganesan [4] studied the use of fuzzy logic in agriculture. The paper represent s application of fuzzy logic in pest management. disease management. and weed management in developing expert system for various crops and to study and analyze soil. The paper "Design and development of Fuzzy Expert System for Integrated Disease management in Finger Millets" identified diseases as Immune, highly resistant, resistant. moderately resistant. susceptible and highly susceptible. The expert system use fuzzification and defuzzification process to reason out otherwise done only by agricultural scholars or by experienced farmers. The study of paper "Integrated pest management system using fuzzy expert system" showed three inputs in fuzzy logic approach based on pest like number of pests, size of pests, damages to pests. A fuzzy based expert system "Design and development of expert system for potato crop" analyzed the soil condition using fuzzy membership function. Thus the study shows that fuzzy logic approach has great contribution in agriculture.

In Political Science

To elect a candidate for election and the prediction of election result etc. comes under political science and for these concepts fuzzy logic approach can be used. In the paper "Selection of candidate by political parties using fuzzy logic" [9] five factors are considered to select a candidate that is behavior, age, character, publicity and education. The study of the paper shows that there are no hard and fast rules or mathematical equations which can show exact result. so fuzzy logic is best for this work. The paper "Election results prediction system based on fuzzy logic" [5] represent s the use of three phases of fuzzy logic to predict the result of election. The study shows that nine parameters are selected for research work as input variable and one as output variable and then 91 rules are set up for the fuzzy system and a toolbox from MATLAB software named fuzzy logic toolbox is used. The study also shows that output is found in form of percentage, which shows the different level of chances to win. Thus fuzzy logic has great contribution in political science also.

In Operations Research

In operations research we deal about the problems which are related to optimization. Operations research helps to maximize profit and to minimize cost of production or cost of transportation etc. Fuzzy logic can be helpful in operations research also. By the use of fuzzy logic transportation cost can be minimized. Pappis and Mamdani (1977) [2] applied fuzzy logic in operation research techniques successfully. The study shows the use of fuzzy logic to control an intersection of two one way streets. Teodorovic and Kalie (1996) used fuzzy logic to choose the mode of transportation in order to minimize travel cost and travel time [2]. Fuzzy logic is helpful in traffic control also. Jarkko and Esko (2003) had applied fuzzy logic to minimize waiting time and risk of collisions during traffic signals [2]. In this way the study represents the use of fuzzy logic in operations research. Thus fuzzy logic has great contribution in operations research.

In Household

Nowadays, many home appliances are being upgraded using fuzzy logic to save time and money. Fuzzy logic system is used in many home appliances like washing machine, vacuum cleaner and in air conditioner etc. Tiryaki and Kazan's dish washer using fuzzy logic and Alhanjouri and Alhaddad's optimize wash time of washing machine using fuzzy logic are the main studies based on fuzzy logic. After that many researchers worked on this in order to reduce washing time and the less consumption of time and water. The study of the paper "Washing machine using fuzzy logic" [7] shows the use of fuzzy logic in washing machine. The study represents that four input variables and five output variables are set up together with eighty one rules to define relationship among these variables. Some other researchers used sensors in

washing machine for linguistic inputs which are type of clothes, type of dirt, mass of clothes etc. These control the linguistic output that is wash time, spin time and rinse time etc. The study shows the use of fuzzy logic in air conditioner s and in air coolers also. The study of the paper "Application of Fuzzy Logic in Daily Life" [2] showed that the design work of the room cooler may consist of more than one input and output values. The paper considered two input variables: temperature and humidity and three output variables: cooler fan speed, water pump speed and exhaust fan speed. Using these, fuzzy logic was applied to get the optimal result. Thus fuzzy logic has great contribution in household also.

In Environment Science

Fuzzy logic can be applied in Environment science also. It has been successfully used in detection of natural tragedies like flood and in environment change etc. A review of the paper "Prediction of flood detection system Fuzzy logic approach" [8] showed that fuzzy logic model using If -Then rules for the prediction of flood detection system based on Mamdani approach is very helpful. In this paper water level and climate conditions are used as input and control action is used as output and total twenty five rules are set up for the process of prediction of flood. Due to fuzzy logic it has become possible to make vehicles better, more efficient and safer to save climate. Thus fuzzy logic has great contribution in environment science also.

Conclusion

Fuzzy logic is an extension of two valued logic or Boolean logic. In this mainly three steps are used fuzzification, inference system and defuzzification. It can be easily taught by using fuzzified educational methods. So it is appropriate to use multivalued fuzzy logic rather than two valued logic. This paper presents a brief overview of fuzzy logic and its applications in different fields. Very less is covered and more are there, that means this paper presents just an overview on fuzzy logic and its applications. But it has a lot of applications that has been discovered and are realized these days. A lot are left that are to be discovered still. The paper reviews fuzzy logic concept and its application in chemical science, in healthcare industry, in agriculture. In political science, in operations research, in household and in environment science. Thus fuzzy logic has become a helping hand not only in mathematics, but in many other branches also.

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