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Applications of Fuzzy Logic in Daily life

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Abstract: The concept of fuzzy logic is based on near the human thinking and natural activities. This theory mimics human psychology as to how a person makes the decision faster. Fuzzy logic uses the whole interval between 0(False) and 1(True)to describe human reasoning. Fuzzy logic uses an imprecise but very descriptive language to deal with input data more like a human operator. It can be implemented in hardware, software or a combination of both. Fuzzy set provide an ultimate mechanism of communication between human and computing environment. Fuzzy logic has provided to be an excellent choice for many control system application.

Keywords: Fuzzy logic, Fuzzifier, Inference Engine, Humidity, Transportation, Temperature.

INTRODUCTION

A logic based on the two values True and false is sometimes inadequate when describing human reasoning. Fuzzy logic uses the whole interval between 0(false) & 1(true) except only two truth values to describe human reasoning. Lotfi Zadeh, the father of Fuzzy logic, claimed that many sets in the world that surrounds us are defined by non-distinct boundary. Zadeh decided to extend two valued logic, defined by binary pair{0,1}, to the whole continuous interval [0,1], thereby introducing a gradual transition from falsehood to truth.Fuzzy logic imitates the logic of human thought which is much less rigid than the calculations computer generally perform. Intelligent control strategies most involve a large number of inputs. The objective of using Fuzzy logic has been to make the computer think like people. Basic results linked to the development of fuzzy logic data back to Zadeh (1973)[22] and Mamdani and Assilian(1975)[9]. Introducing a concept he called 'Approximate Reasoning', Zadeh successfully showed that vague logical statements enable the formation of algorithms that can use vague data to derive vague inferences. Zadeh assumed his approach would be beneficial above all in the study of complex humanistic systems. Mendel(1995)[10] explains the concept of fuzzy logic system (FLS) as follows: in general a FLS is a non linear mapping of an input data vector into a scalar output.

It should also be emphasized that both deterministic and stochastic models that have been developed to solve a varity of complex problems are characterized by mathematics based on binary logic. The Fuzzy logic is powerful design philosophy for describing and developing control systems which provides simple and intuitive method for design engineers to implement complex systems, fuzzy logic systems allows for an input to exist with varying degree at more than one state at a time and hence allows the engineers to describe the system in more than natural terms. Fuzzy controllers as contrary to classical controllers are capable of utilizing knowledge elicited from human decisions or human operators.

Fuzzy logic has applications in various field such as Transportation, crime investigation, clinical decision support system, design of a room temperature and humidity controller and fuzzy logic washing machine, improving TV clarity. In present paper, some applications are discussed.

FUZZY LOGIC

"Fuzzy means not well known or not clear enough or their closer significance depends on subjectivity, estimation and even the intuition of person who is describing these terms"(Zdenkokovacic and stjepan Bogdan, 2005)[23]. In fuzzy logic a proposition may be true or false or have an intermediate true value, such as may be true, the sentence the level is high" is an example of such proposition in a fuzzy controller. In general, fuzzy control is found to be superior in complex problems with multi objective decision. 1965, L.A.Zadeh[21] published his famous paper "Fuzzy Sets" in information and control providing a new mathematical tool with enables us to describe and handle vague or ambiguous motion such as " a set of all real number which are much greater than 1"." a set of beautiful women" The main idea of fuzzy set theory is quite intuitive and natural. Fuzzy set allows no sharply defined boundaries because of generalization of a characteristic of membership function. (Swain et. al .2006)[13]

Fuzzy set

Fuzzy sets are a further development of the mathematical concept of a set.Fuzzy set is characterized by values from zero to one, with 0 representing no membership and 1 representing complete membership in a set i.e the grade of membership for all its members thus describes a fuzzy set. Some popular kinds of fuzzy logic membership function are shown as below.

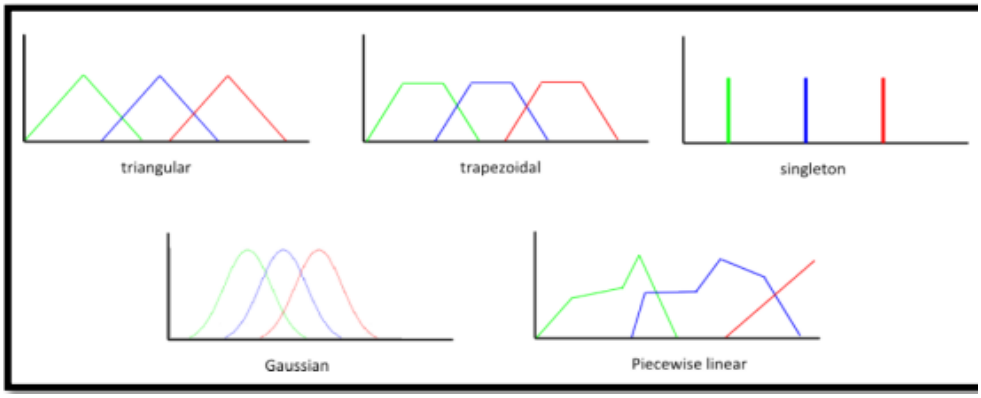

Figure 1

LINGUISTIC VARIABLES

One powerful aspect of fuzzy logic is the ability to deal with linguistic variables. Just like an algebraic variables take numbers as values, linguistic variables take words or sentences as values (Zimmermann, 1991)[24]. The set of values that it can take is called its term set. Linguistic quantifies or hedges such as more or less, very, not very, slightly etc correspond to modification in the membership function of the fuzzy set involved. Depending on the application, fuzzy hedges may be defined in different ways to meet the requirements of the process being controlled.

OPERATIONS OF FUZZY SETS

The membership function is obviously a crucial component of a fuzzy set. Therefore, it is natural to define operations on fuzzy sets by means of their membership functions. In fact a fuzzy set operation creates a new set from one or more given sets.

Let A and B be fuzzy sets on a mutual universe then set operations are

$$A \cap B = a \min b$$

$$A \bigcup B = a \max b$$

$$\overline{A} = 1 - a$$

The operation min and max are item by item comparison and $\overline{A}$ represents complement of A.

FUZZY LOGIC CONTROLLER(FLC)

Fuzzy logic basically uses a logic and decision mechanism which doesn't have certain boundaries like human logic. One of its most common implementation is in fuzzy logic based control mechanisms. Fuzzy logic control systems don't require complete model knowledge as other control system like PID. The fuzzy logic controller is easy to perform due to its simple control structure, ease of design and inexpensive cost.

Main elements of Fuzzy logic controller are a fuzzication unit, a fuzzy logic reasoning unit, a knowledge base and a defizzification unit.The fuzzy knowledge base contains 2 types of information: a data base defining the membership function of the fuzzy sets used as values for each system variable and a rule base which essential maps fuzzy values of the input to fuzzy values of the output.Input variables are often called crisp value. Then crisp value will be map into fuzzy sets to corresponding fuzzy values in fuzzification,Inference engine consists of rule base and data base. The process of fuzzy inference involves

I. Defining if then rules
II. Defining membership functions
III. Applying logical operations

There are two types of fuzzy inference system that usually can be implemented. Mamdani type and sugenotype. These two types of inference systems vary somewhat in the way outputs are determined Fuzzy rule form : if x is A the y is B

Fuzzy knowledge base consists of a number of fuzzy rules with several sentence connectives namely AND, OR and AlSO

If X1 is A1 OR X2is A2 and X3is A3 then Y1 is B1 Also Ys is B2

With "if" part is called antecedent part describing causes and the rest one is called a consequent part describing results.

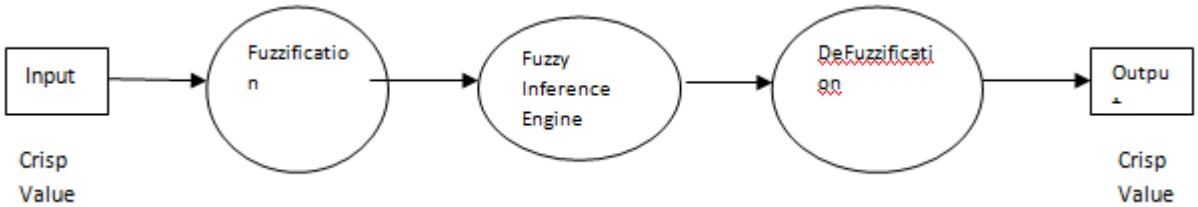

Figure 2

In the next step, the inference engine combines and maps fuzzy sets onto fuzzy set to get a fuzzy output set.During defuzzification one crisp value ischosen for the output variable by raking a weighted average of the various recommendations by 2 ways: centre of gravity (COG) defuzzification and center average (CA) defuzzification.

FUZZY LOGIC APPLICATIONS

TARSPORTATION PROBLEM

Transportation problem is a wide human oriented field with diverse and challenging problems waiting to be solved. Characteristics and performances of transport systems-services, costs, infrastructures, vehicles and control systems are usually defined on the basis of quantitative evaluation of their main effects. Most of the transport decisions take place under imprecision, uncertainty and partial truth. Some objectives and constraints are often difficult to be measured by crisp values.

Recently several authors observe that fuzzy logic is a useful technique in real life transportation problems, starting from Pappis and Mamdani(1977)[11] who applied fuzzy logic to control an intersection of two one way streets or others used fuzzy logic in decision making system such as Gianluca(2012) and Brito etal. (2012).

TRANSPORTATION PLANNING

Trip generation constitutes the first stage in the traditional transportation planning process. Trip generation defines that how many people want to go out of their homes and what their purposes are. Researchers emphasized that more non-congestion trip generation models have better prediction and adaptation ability. Trip generation problem was solved using fuzzy logic by Kalic and Teodorovic (1997a) [8]. Fuzzy rule base was generated by learning from numerical examples. For this purpose, the procedure proposed by Wang and Mendel (1992a, b, c)[17,18,19] was used. Firstly, the available set of data was divided into two subsets: the first was used for generation of the fuzzy rule base, and the other was intended to be a control data subset. After the fuzzy rule base was created, the obtained fuzzy system was tested on both subsets of data. After the testing, the fuzzy logic approach proved to give the closest estimate of the actual number of trips generated in a given area.

TRIP DISTRIBUTION

Trip distribution constitutes the second stage in the traditional transportation planning process. Trip distribution models are used to determine the number of trips between pairs of zones when the number of trips generated attracted by particular zones is known. Traffic flows and trip distribution resulted from human choices that are affected by social and individual variables of the commuters.A three phases fuzzy inference system (FIS) was proposed by Jassbi et al.(2011) [7] to map social and demographic variables to total number of trips between origin-destination (OD) pairs. Conceptual model of trip forecasting input output space mapping shown below

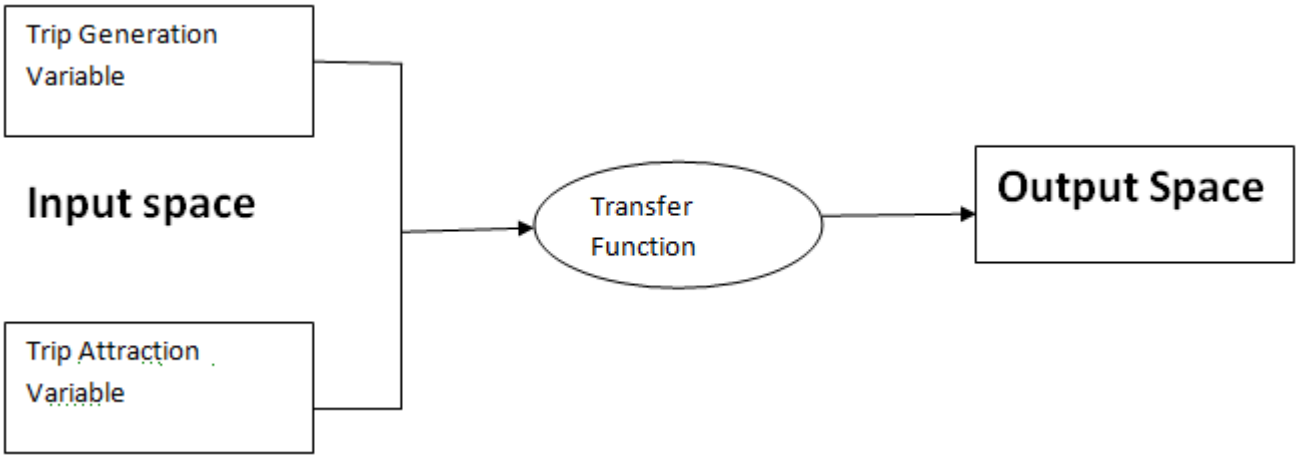

Figure 3

MODAL SPLIT

The third phase of transport planning named as modal split is intended to know which modes of transportation are used by how much fraction of people. Teodorovic and Kalic (1996)[15] used fuzzy logic to solve the mode choice problem. The fuzzy rule base was generated using available numerical data on the differences between the travel times and travel costs of competitive modes. The technique proposed by Wang and Mendel (1992a)[17] was used to generate the fuzzy rule base by learning from examples. There was extremely good agreement between the results obtained using fuzzy logic and real results.

TRAFFIC SIGNAL CONTROL

Fuzzy logic also helped to control traffic signal situation including multiple solution and vehicle's movements. Fuzzy control achieved in problem where mathematical modeling is difficult to solve but an experienced human can conduct this process, it is also useful in complex issues with multi-objective problem. As seen, from Pappis and Mamdani (1977)[11] work, Chiu and Chand (1993) distributed architecture in which each intersection independently adjusts its cycle time, phase split, and offset using only local traffic data collected at the intersection. Jarkko and Esko (2003)[6] had applied fuzzy logic to the performance of signalized intersection-the combination of time value, environmental effect and traffic safety to be exact- to control a signalized isolated pedestrian crossing in a minimum waiting time and also with a minimum risk of rear-end collisions, as well as managing multiphase vehicle control. Actually, traffic signal control is essential to maintain the safety and quality of traffic condition.

TRANSPORTATION DECISION AND INVESTMENT

Traffic management always is a complicated problem in society. In recent time, there are some authors using fuzzy logic in decision process, for example, fuzzy logic used as synthetic evaluation and to justify highway alignment choices in environment impact study analysis which explore innovation in integrating infrastructure and land using planning for transportation corridors (GianlucaDell'Acqua., 2012)[5]. David and Pandian (2011)[4] cited that fuzzy logic method attempts to simultaneously minimize the total product and transportation cost and total delivery time with reference to budget constraints and available supply. AOjha et al. (2010)[3] applied fuzzy logic for comparing and minimizing total transport cost together with minimize transportation time

FUZZY LOGIC IN WASHING MACHINE

One of the most practical application of FLS is using them as "process control system". Washing machine is commonly used household appliances in India. On using a washing machine, the user manually sets the washing time, based on the type of clothes, , type of dirt and amount of clothes. Many people find it very difficult to decide that which cloth need what amount of washing time. Unfortunately , a precise mathematical relation between inputs and output cannot be defined. Building a washing machine with automatic washing time determination means building the following two subsystems

I. The sensor system- collects data from outer environment and send them to controller
II. The controller system sets the washing time based on the information recived from the sensor system a fuzzy logic controller will be used.

The fuzzy logic controller for washing machine can consists of linguistic inputs i.e. type of dirt, type of clothes, dirtiness of clothes, mass of clothes.The sensors for all these linguistic inputs are also available. All the above LIs control the Linguisticoutput(LO) i.e. washtime, spin time, rinse time etc.

Fuzzy logic controller mainly consists of three blocks i.e. fuzzifier, fuzzy inference engine or fuzzy rule select and Defuzzifier.

There is a membership function which turns the crisp input values into fuzzy values and after that suitable operation is performed on them. The process which converts crisp value into fuzzy value is known as fuzzification. The decision made by fuzzy logic controller and obtained from the rules known as fuzzy rules.The result obtained from fuzzy inference engine is then processed to produce the output in crisp value and centroid method is used for defuzzification.

ROOM AIR COOLER

A control system is an arrangement of physical component which manages commands, directs or regulates the behavior of other systems. A control system is used to achieve the desired output. The fuzzy systems are prototype of computational intelligence (CI). In the area of modern technologies the fuzzy sets are generally used. Fuzzy logic control systems are also used to design the temperature and humidity controller room cooler.

The design work of the room cooler may consists of more than one input and output vaules. We consider presently two input (linguistic) variables: temperature and humidity and three output variables: cooler fan speed, water pump speed and exhaust fan speed.

The basic block diagram of room cooling system using fuzzy logic control system is

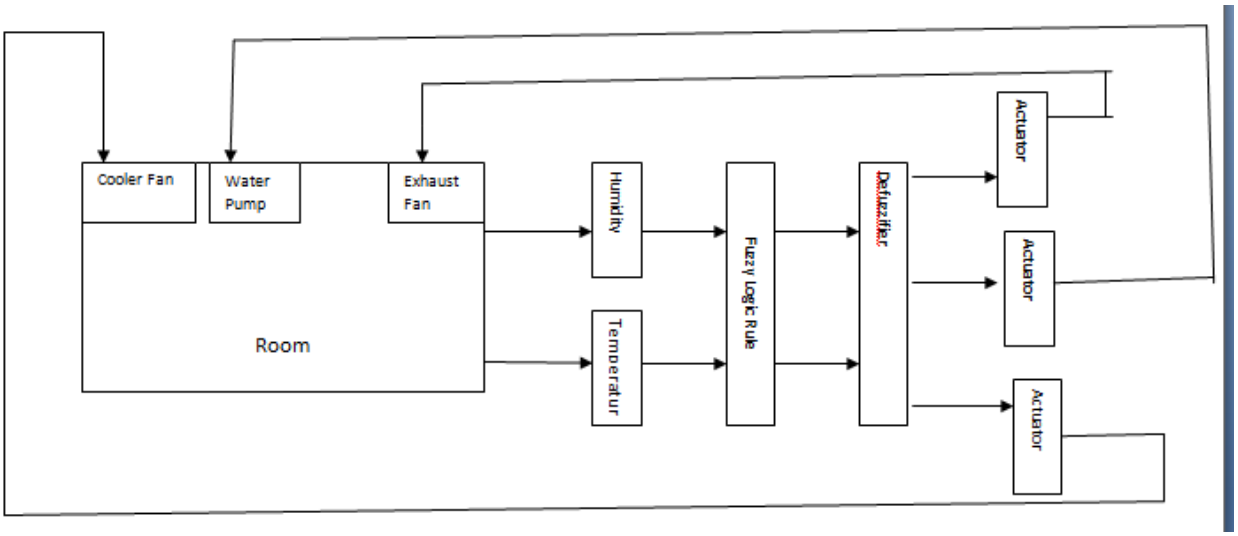

Figure 4

This system is mounted in a room which consists of cooler fan, water pump and exhaust fan. Water is spread on the boundary wall of grass roots or wooden shreds by water pump. Exhaust fan is used to monitor the humidity and temperature sensors for room environment. There are 3 output of defuzzifiers which are connected through the actuators.

APPLICATION OF FUZZY LOGIC IN MEDICAL SCIENCE

Development of medical domain application has been one of the most active research areas. One example of the medical domain application is the detection system for heart disease. Fuzzy logic is used for this purpose clinical decision. Clinical decision support systems are widely categorized

into two major groups namely (1) knowledge based CDSS and (2) non-knowledge based CDSS (Abbasi and Kashiyarndi, 2006)[1]. The knowledge based clinical decision support system comprises rules mostly in the form of IF–Then statements. Generally the data are associated with these rules. For instance, generate warning and more only if the pain intensity is up to a certain level. Generally the knowledge based CDSS encloses three main parts – knowledge base, inference rules and a mechanism to communicate. The adaptive guidelines from a knowledge base server prove to be much more effective than others in certain cases, such as that of chest pain management (Ali et al., 1999)[2]. Vagueness, impreciseness and uncertainty are the fundamental and indispensable aspects of knowledge, so as in several practical problems, the experts face vagueness in feature vectors and uncertainty in decision-making. Basically, a symptom is an uncertain indication of a phenomenon since it may or may not occur with it. Especially, uncertainty characterizes a relation between symptoms and phenomena (Straszecka, 2007; De et al., 2001)[12]. Sources of uncertainties may comprise that patients cannot describe accurately what has happened to them or how they suffer, doctors and nurses cannot explain exactly what they detect, laboratory reports' outcomes may be with some degrees of error, physiologists do not precisely understand how the human body works, medical researchers cannot precisely characterize how diseases modify the normal functioning of the body and no one can precisely determine one's prognosis (Szolovit, 1995; Kong et al., 2008)[14]. Decision support systems that are implemented with the support of artificial intelligence have the capability to espouse in a new environment and to learn with instance (Warren et al., 2000; Anderson, 1997)[20]. In computer-aided support systems/expert systems, various methods are exploited to congregate information used for the process of decision-making. Statistical method, neural network, knowledge based methods, fuzzy logic rule-based, genetic algorithms and more are included in these methods (Abbasi and Kashiyarndi, 2006)[1]. Since the idea of computer-based CDSSs emerged at first, significant research has been made in both theoretical and practical areas. In recent years, clinical decision support system based on computeraided diagnosis methodologies have been proposed in the literature by which evaluating the data obtained by some of the methods or other sources (i.e., laboratory examinations, demographic and/or history data, etc.) from a computer-based application leads to a computer-aided diagnosis. The data analysis methods used in most of the proposed methods cannot provide clear and direct explanation for the decisions made to examine the risk factors for cardiovascular diseases as they are based on neural networks. Hence, a method based on easily obtained features capable of calculating the risk level of computer-aided diagnosis and providing explanation for the decisions made would be of immense clinical value (Tsipouras et al., 2008)[16]. So, the soft computing technique in particular the fuzzy logic technique is used for assessing the risk level of heart patients in developing the clinical decision support system of heart disease diagnosis. For better prediction of risk level, we make use of fuzzy logic, where the decision to be taken on heart disease of patients is based on the weighted fuzzy rules. By considering the CDSS based on fuzzy logic, the efficiency mainly depends on the fuzzy rules employed in the system. In general, the domain experts or professionals in the corresponding domain provide the fuzzy rules for prediction problem. The fuzzy rules are weighted in accordance with their importance using the attribute weightage. These weighted fuzzy rules are applied on the rule base of the fuzzy system and then the prediction can be carried out on the designed fuzzy-based CDSS.

CONCLUSION

We have discussed various applications which were found to be very difficult to solve with traditional analytical techniques. Even hard computing models cannot deal effectively with these problems. In this situation fuzzy logic theory proved itself very beneficial and fruitful. There are so many problems like power system fault diagnosis, decision making behavior, crime investigation etc which can be handle by fuzzy logic.

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