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A Novel Knowledge Expert System for Water Type Analysis

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Abstract: Fuzzy expert system is one of the interesting research areas in the field of artificial intelligence. Now a day's environment pollution is one of the major issues running wide. Water is one of the essential elements in daily lives. In this aspect we need to have awareness of the water that we are using. Classifying of water resources to satisfy the water quality standards is an important issue. In this paper we are proposing a fuzzy expert system that is helpful for differentiating the type of water based on the parameters taken. Based on the expert opinions and national experiences, five water quality parameters DO, Ph value, BOD, Sulphate and Chlorine were considered as the significant indicator parameters to assess the type of water. Fuzzy expert system makes it possible to combine the certainty levels for the acceptability of water based on the approved parameter. This is possible because of having high variety of rules inserted in the inference system. Here we are going to explain how mamadani inference system works for giving an appropriate result of water type analysis.

Keywords: knowledge base, fuzzy logic, inference system, fuzzy expert system.

I. INTRODUCTION

Rule-based expert systems have played an important role in modern intelligent systems and their applications in strategic goal setting, planning, design, scheduling, fault monitoring, diagnosis and so on. A fuzzy expert system is an expert system that uses a collection of fuzzy membership functions and rules, instead of Boolean logic, to reason about data. A collection of fuzzy member functions with rules without Boolean logic to reason explains the data. The rule is x is low and y is high then z is medium. Where x and y are the input for data values and z is result data. Expert knowledge is often represented in the form of rules or as data within the computer. Depending upon the problem requirement, these rules and data can be recalled to solve problems.

A rule-based system consists of if-then rules, a bunch of facts, and an interpreter controlling the application of the rules, given the facts. These if-then rule statements are used to formulate the conditional statements that comprise the complete knowledge base. A single if-then rule assumes the form 'if x is A then y is B' and the if-part of the rule 'x is A' is called the antecedent or premise, while the then-part of the rule 'y is B' is called the consequent or conclusion. There are \ two broad kinds of inference engines used in rule-based systems: forward chaining and backward chaining systems. In a forward chaining system, the initial facts are processed first, and keep using the rules to draw new conclusions given those facts. In a backward chaining system, the hypothesis (or solution/goal) we are trying to reach is processed first, and keep looking for rules that would allow concluding that hypothesis. As the processing progresses, new sub goals are also set for validation. Forward chaining systems are primarily data-driven, while backward chaining systems are goal-driven. Consider an example with the following set of if-then rules

Rule 1: If A and C then Y
Rule 2: If A and X then Z
Rule 3: If B then X
Rule 4: If Z then D

If the task is to prove that D is true, given A and B are true. According to forward chaining, start with Rule 1 and go on downward till a rule that fires is found. Rule 3 is the only one that fires in the first iteration. After the first iteration, it can be concluded that A, B, and X are true. The second iteration uses this valuable information. After the second iteration, Rule 2 fires adding Z is true, which in turn helps Rule 4 to fire, proving that D is true. Forward chaining strategy is especially appropriate in situations where data are expensive to collect, but few in quantity. However, special care is to be taken when these rules are constructed, with the preconditions specifying as precisely as possible when different rules should fire.

The general inference process proceeds in three steps.

1. Under FUZZIFICATION, the membership functions defined on the input variables are applied to their actual values, to determine the degree of truth for each rule premise.

2. Under INFERENCE, the truth value for the premise of each rule is computed, and applied to the conclusion part of each rule. This results in one fuzzy subset to be assigned to each output variable for each rule. Usually only MIN or PRODUCT is used as inference rules. In MIN inference, the output membership function is clipped off at a height corresponding to the rule premise's computed degree of truth (fuzzy logic AND). In PRODUCT inference, the output membership function is scaled by the rule premise's computed degree of truth.

3. Finally DEFUZZIFICATION, which is used when it is

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useful to convert the fuzzy output set to a crisp number. There are more Defuzzification methods. Two of the more common techniques are the CENTROID and MAXIMUM methods. In the CENTROID method, the crisp value of the output variable is computed by finding the variable value of the centre of gravity of the membership function for the fuzzy value. In the MAXIMUM method, one of the variable values at which the fuzzy subset has its maximum truth value is chosen as the crisp value for the output variable.

II. RELATED WORK

A knowledge-based system (KBS) is a PC program that reasons and uses a knowledge base to take care of complex issues. The term is wide and is utilized to allude to a wide range of sorts of systems. The one basic subject that unites all knowledge based systems is an endeavor to speak to knowledge unequivocally through instruments for example the ontology's and standards instead of verifiably by means of code the way a traditional PC project does. A knowledge based system has two sorts of sub-systems is a knowledge base and a deduction motor.

They were initially created by Artificial Intelligence scientists. These early knowledge-based systems were principally master systems. Actually the term is regularly utilized synonymously with master systems. The distinction is in the perspective taken to depict the system. Master system alludes to the kind of assignment the system is attempting to settle to supplant or help a human master. Knowledge-based system alludes to the structural engineering of the system is that it speaks to knowledge unequivocally instead of as procedural code. As knowledge-based systems became more complex the techniques used to represent the knowledge base became more sophisticated. Rather than representing facts as assertions about data, the knowledge-based became more structured, representing any kind of information using similar techniques to object-oriented programming such as hierarchies of classes and sub classes, relations between classes, and behavior of objects. The main objective of this is traditional decision tables and for establishing the analysis systems tool. It is for presenting the decision tables and for developing the expert system knowledge bases and also for presenting the limitations. Using this tool we can validate the decision tables and rules and generate e2gRuleEngine knowledge bases.

Expert system rules typically provide a higher level of abstraction than decision table rule columns: the ability to use 'or' logical operators illustrated in the last section provides one example. It may take many columns in a decision table to represent a single expert system rule. Extensions to the classic decision table format, permitting 'or' logical operators 'else' actions and other features are sometimes implemented to minimize these limitations. Using a decision table to produce a knowledge base requires learning another piece of software beyond the expert system shell. The conversion from the decision table to the knowledge base is typically one-way: you can't derive the decision table from the knowledge base. If the knowledge base is edited outside the decision table software many of the knowledge base maintenance advantages are lost.

Before developing the tool it is necessary to determine the time factor, economy and company strength. Once these things are satisfied, then next step is to determine which operating system and language can be used for developing the software. Once the programmers start building the software the programmers need lot of external support. This support can be obtained from senior programmers, from book or from websites [7][8][19]. I got interest and motivated to study more by working with expert system. Before building the system the above considerations are taken into account for developing the proposed system. So the fuzzy expert system helps in this aspect as it uses fuzzy logic to give an accurate result. Unlike two-valued Boolean logic, fuzzy logic is multi-valued. It deals with degrees of membership and degrees of truth. Fuzzy logic uses the continuum of logical values between 0 (completely false) and 1 (completely true). We are using mamadani inference system which uses fuzzy rules in the form of knowledge base.

III. PROPOSED SYSTEM

In this paper we are proposing an efficient knowledge expert system over water analysis, here we analyze the water based on the important characteristics or attributes of the water, we propose member functions with set of rules and ranges and maintains it as training set, input parameters and their respective range parameters to classify the attributes based on the member functions. Interface engine take care of member ship function evaluation while passing parameters. We improved traditional approach of knowledge expert system with missing value integration i.e., if we ignore few sample ranges while passing input parameters, our system passes values to missing values with standard and defined rule set. To capture and preserve irreplaceable human experience Solutions can be developed faster than human experts. The type of water can be classified based on the parameter values.

Fuzzy Expert System (fig.1) is a rule based expert system where fuzzy logic is used as a tool for representing different form of knowledge about the problem

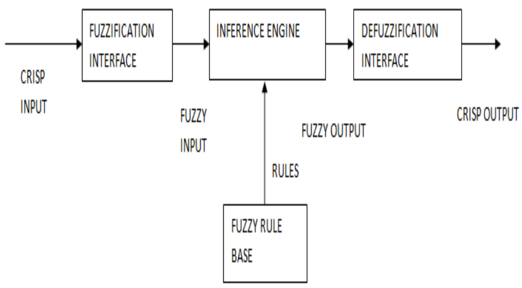

Fig.1.Architecture of Fuzzy Expert System

The architecture shows how the flow of system works. When an input is entered into the system it is converted into fuzzy inputs through the fuzzification interface. This

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fuzzified input and the rules from the knowledge base are combined together in the inference engine. The result obtained is fuzzified output. This fuzzified output is again converted into crisp output through the Defuzzification interface.

The results were taken for the fuzzy interference system (FIS) model to assess the water type using 5 parameters viz., ph value, chlorine, bio dissolved oxygen, Sulphate, dissolved oxygen. Though there are other parameters in water quality guidelines, we have limited the assessment to these six parameters.

Fuzzy set theory has been designed to supplement the interpretation of linguistic or measured uncertainties for real-world random phenomena. Fuzzy set theory may be regarded as a generalization of classical set theory. In classical set theory the membership function of a set is 1 within the boundaries of the set and is 0 outside. A fuzzy set is defined in terms of a membership function which maps the domain of interest onto the interval (0, 1). Symbol μ has been used to represent fuzzy memberships. If x represents the value of an environmental variable, then μ(x) is the corresponding membership. Fuzzy method utilizes the max-min operator to perform the FIS. The standard fuzzy set operations are: union (OR), intersection (AND) and additive complement (NOT).

Mamadani Inference System: A fuzzy inference system is a system that uses fuzzy set theory to map inputs to outputs. There are kinds of fuzzy inference systems like mamadani, sugeno, tsukomato. An Inference Engine is a tool from artificial intelligence. The first inference engines were components of expert systems. The typical expert system consisted of a knowledge base and an inference engine. The knowledge base stored facts about the world. The inference engine applied logical rules to the knowledge base and deduced new knowledge. This process would iterate as each new fact in the knowledge base could trigger additional rules in the inference engine. Inference engines work primarily in one of two modes: forward chaining and backward chaining. Forward chaining starts with the known facts and asserts new facts. Backward chaining starts with goals, and works backward to determine what facts must be asserted so that the goals can be achieved. In this paper we are using mamadani fuzzy inference system. To compute the outputs of the FIS given the inputs, one must go through six steps. This shows how the inference system works in this system

Step 1: Determining a set of fuzzy rules over attributes of water

These are the sample attributes that are taken for analyzing the type of water

TABLE I Attribute Values

	Drinking Water	Irrigation Water	Industrial Water
DO	2-9	0-4	7-10
Ph value	6-9	6-7	6-9
BOD	0.2	2-5	4-7
SO_4	200-250	0-700	0-250
Cl	<250	<500	>500

Step 2: Fuzzifying the inputs using the input membership function

The crisp inputs in the step1 are fuzzified by the member functions given below

MF for DO

M= {(x,μDO(x))/x϶[0,10]}

μDO(x)={0 x≤4, low
9-x/9-2 2<x<9, med
1 7<x<10, high

MF for BOD

M= {(x,μBOD(x))/x϶[0,10]}

μBOD(x)={0 x≤0.2, low
5-x/5-2 2<x<5, med
1 4≤x≤7, high

Step 3: Combining the fuzzified inputs according to the fuzzy rules to establish rule strength

The result obtained by the step 2 are combined with the linguistic terms

DO value is obtained as low
Ph value is obtained as high
BOD value is obtained as med

Step 4: Finding the consequence of the rule by combining the rule strength and the output membership function.

The rules are designed as

if DO is low and ph value is high and BOD is med and SO_4 is high and Cl is med

similarly set of rules are designed to obtain the output.

Step 5: Combining the consequences to get an output distribution.

The rules and the member function are combined to obtain the output distributions. The outputs obtained are in the form of fuzzified outputs.

Step 6: Defuzzifyng the output distribution.

The fuzzified outputs are converted into the crisp output. The result is shown in normal terms i.e., the type of water is either drinking water or agriculture or industrial water

Ranges and type of water defined along with membership functions, so input parameters along with standard defined rules for missing values forwarded to training dataset to analyze the testing sample and gives the output as type of water.

IV. RESULT ANALYSIS

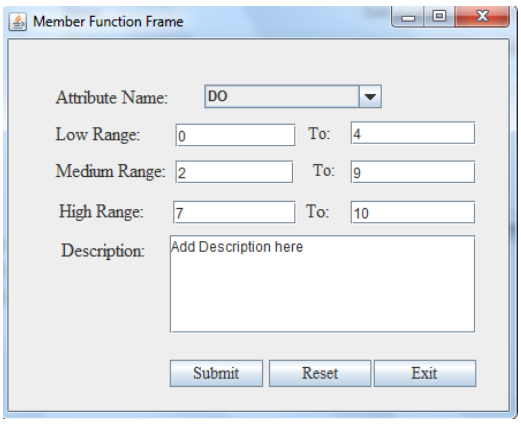

Fig.2. Membership function

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For experimental analysis we implemented the proposed approach with java programming language, we provided an option for conversion of membership function into table set of values and dynamic possible set of rules for different types of water.

The fig. 2 represents that how the values are given to each and every attribute. Based on these attribute values the member function values are obtained.

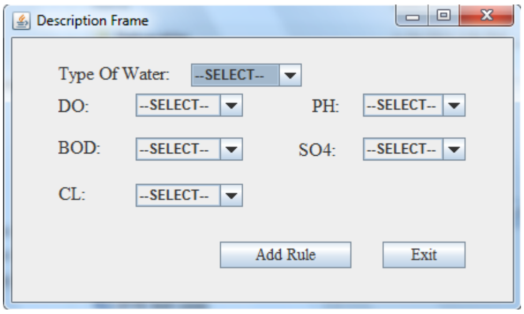

Fig.3. Rule generation

Fig. 3 represents that the design of rules in the knowledge base.

Engine works in a way that the user gives testing sample input value ranges for all individual parameters ,so engine gets the collection of evaluation parameters like low, mid, high etc. ,so the parameter meta data forwarded to rules to analyze the type of water. The following diagram shows membership function graph representation.

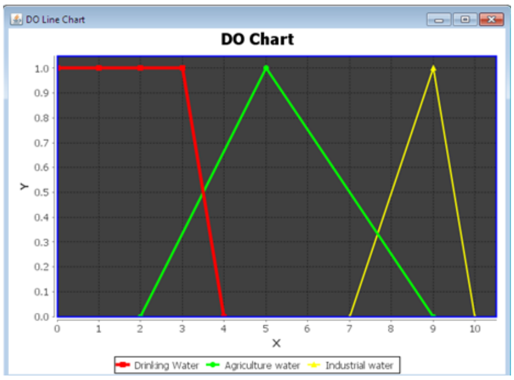

Fig.4.Graph representation of DO

The graph in Fig-4 represents the member function graph of DO attribute for three types of water

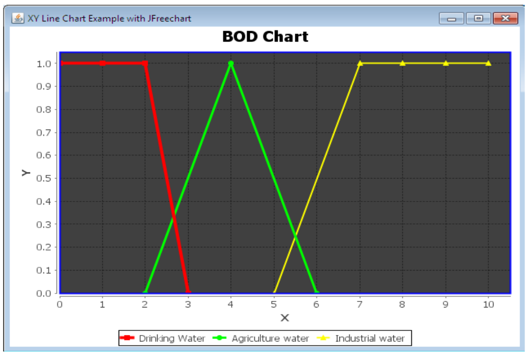

Fig.5. Graph representation of BOD

The graph in Fig.5 represents the member function graph of BOD attribute for three types of water

V. CONCLUSION

We have been concluding our current research work with efficient knowledge expert system. Expert system can be initially defined with set of fuzzy rules and member functions with set of ranges .input parameters can be forwarded to membership function to analyze the behavior of the testing sample and obtaining the rule strength. Our experimental analysis shows more efficient results than the traditional approaches. We not only providing the result or fact to the user, but we also showing a graph for the member function for every attribute individually for all types of water.

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BIOGRAPHIES

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