An Evaluation of Student's Behavioral Value and Personality Using Adaptive Neuro- Fuzzy Inference System (ANFIS)

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***Abstract*: The state-of-the art of psychological knowledge about the personality types is distilled to provide a basis for the specification of fuzzy agents with dynamic personality for the simulation of human behavior. Three concise representations of the primary characteristics of human personality are presented; they are: compassion, respect, and social harmony. In an accompanying article, the first two of these representations provide the basis for using fuzzy logic to process qualitative (or linguistic) personality variables A direct and exhaustive field survey is done to collect data from over 40 schools and 1000 students by a fuzzy questionnaire. The students' responses about their values were obtained in the linguistic regions of low, medium and high. A fuzzy based mapping model between the students' values and the level of value education imparted in schools is prepared.**

***Keywords*: Personality analysis, linguistic regions, fuzzy questionnaire, Student's evaluation, Neuro-Fuzzy Mode**

Introduction

The main issue in modeling students' behavior or evaluation process is the interpretation of their response to a particular system. The information gathered about the students' behavior is usually very restricted, imprecise, error prone and its interpretation is vague and uncertain. All these issues fall in the domain of fuzzy logic and therefore a neuro-fuzzy approach to the students' modeling is suggested as it can successfully deal with imprecise information in linguistic form. The underlying neural networks enable adaptability of the fuzzy model.

Fuzzy Logic

Fuzzy logic has been proposed by Lotfi A. Zadeh in the year 1965 which is a generalization of classical set theory. Fuzzy logic was proposed on fuzzy set theory to capture the way human beings represent and reason real world knowledge to solve uncertain problems. Uncertainty arises due to some peculiar characteristics like generality, vagueness, ambiguity and incomplete knowledge. When it comes to fuzzy sets many degrees of freedom are allowed. A membership function is associated with a fuzzy set so that the function maps every element in the set on to a value between 0 and 1. It provides a meaningful representation of vague concepts which are expressed in any natural language. Only two values "true" and "false" are allowed in symbolic logic but in fuzzy logic multi valued truth values such as true, absolutely true, fairly true, false, absolutely false, partly false are allowed. Fuzzy inference rules are computational procedures used in evaluating linguistic descriptions and fuzzy rule based systems are a set of fuzzy IF-THEN statements used in many applications.

Fuzzy Inference System

Fuzzy inference system maps the given input to output using fuzzy logic (See Fig.1). The process of fuzzy inference involves membership functions, logical operations and a set of IF-THEN rules. Fuzzy inference engine can be implemented using either Mamdani type or Sugeno type, where both the systems vary in the way outputs are determined. Strength of fuzzy inference system lies on the linguistic concepts and the nonlinear mappings between inputs and outputs. The first type of fuzzy inference system focuses on the ability of fuzzy logic to model natural language problems. Fuzzy deals with the limitations of human knowledge and particularly the difficulties in formalizing interactions in complex processes. Several fuzzy inference systems have been described by different researchers (Zadeh, L.A., 1965; Mamdani, E.H., 1974; Takagi, T. and M. Sugeno, 1985; Sugeno, M. and G.T. Kang, 1988; Sugeno, M. and K. Tanaka, 1991 ;). In the case of a Mamdani-type fuzzy inference system, both premise (if) and consequent (then) parts of a fuzzy if-then rule are fuzzy propositions.

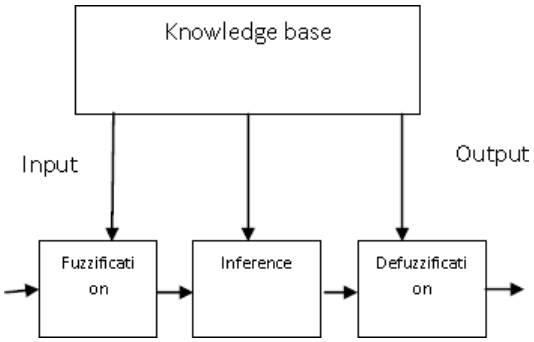

Fig.1.Fuzzy Inference system.

Fuzzy inference process contains different stages like fuzzification of the input variables, application of fuzzy operators in the antecedent, implication from the antecedent to the consequent, aggregation of the consequents across the rules, and defuzzification.

A. Fuzzify Inputs

The first step is to take the inputs and determine the degree to which they belong to each of the appropriate fuzzy sets via membership functions.

B. Apply Fuzzy Operator

After the inputs are fuzzified, the degree to which each part of the antecedent is satisfied for each rule is known. If the antecedent of a given rule has more than one part, the fuzzy operator is applied to obtain one number that represents the result of the antecedent for that rule.

C. Apply Implication Method

Before applying the implication method, the rule's weight will be determined. Every rule has a weight (a number between 0 and 1), which is applied to the number given by the antecedent. After proper weighting has been assigned to each rule, the implication method is implemented. A consequent is a fuzzy set represented by a membership function, which weights appropriately the linguistic characteristics that are attributed to it.

D. Aggregate All Outputs

Because decisions are based on the testing of all of the rules in a Fuzzy Inference System (FIS), the rules must be combined in some manner in order to make a decision. Aggregation is the process by which the fuzzy sets that represent the outputs of each rule are combined into a single fuzzy set.

D. Defuzzify

The input for the defuzzification process is a fuzzy set (the aggregate output fuzzy set) and the output is a single number.

The most commonly used fuzzy inference technique is the so called Mamdani method. In 1975 professor Ebrahim Mamdani of London University built one of the first fuzzy systems to control a steam engine and boiler combination. Mamdani fuzzy inference has 4 steps.

1. Fuzzification of the input variables.
2. Rule evaluation.
3. Aggregation of the rule outputs.
4. Defuzzification.

Neuro-Fuzzy Modeling Using Adaptive Neuro- Fuzzy Inference System (ANFIS)

Neuro fuzzy system is a combination of two different systems and is called as a hybrid system that contains the advantage of both neural networks and fuzzy system. It has a combination of advantages like robustness, learning, training and parallelism that are present in artificial neural networks and uncertainty present in fuzzy logic. Hybrid neuro fuzzy system, ANFIS (Adaptive neuro fuzzy inference system) is a multilayered connected. Adaptive means that output of some nodes depend on the input. ANFIS uses either an available fuzzy inference system to train data pairs or constructs a fuzzy inference system whose membership functions are tuned using a learning algorithm. ANFIS architecture is represented in figure 2.

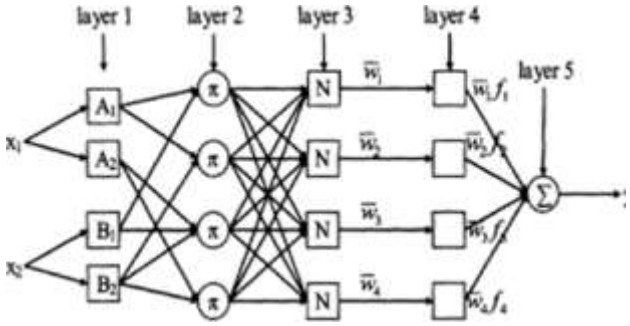

Fig.2 ANFIS Archetecture

Modeling Process in ANFIS:

ANFIS process has two important phases namely system identification, determining the network structure and learning algorithm

1. System Identification: Identification of input and output variables

2. Determining the network structure: once the variables are identified the six layered network is constructed.

Layer1: Input layer

Each node in input layer represents an input variable. This layer simply transmits these input variables to fuzzification layer.

Layer 2: **Fuzzification layer**

This layer describes membership function of each input fuzzy set, where membership functions are used to characterize fuzziness in fuzzy sets.

Layer 3: **Inference layer**

Each node in this layer is a fixed node that represents the „if part" of a fuzzy rule. This layer aggregates membership grades using any fuzzy intersection operation, which can perform fuzzy AND operation. The fuzzy intersection operators are commonly referred to as T-norm operators.

Layer 4: **Normalization Layer:**

The ith node of this layer is also a fixed node and calculates ratio of ith rule"s firing strength in inference layer to sum of the entire rule"s firing strength.

Layer 5: **Output layer:**

This layer represents the THEN part of the fuzzy rule. The operation performed by the nodes in this layer is to generate qualified consequent of each rule depending on firing strength. Every node in this layer is an adaptive node. Output of the node computed as

$$O_i = w_i f_i$$

where wi is the normalized firing strength from layer I, fi is the linear function of the input

Layer 6. Defuzzification layer:

This layer aggregates qualified consequents to produce a crisp output. The single node in this layer is a fixed node. It computes weighted average of output signals of output layer as

$$O=\Sigma O_i = \Sigma w_i f_i / \Sigma w_i$$

The advantage of using ANFIS is a hybrid learning rule for estimation of the premise and consequent parameters, in this process ANFIS keeps the premise parameters fixed and estimates them in a forward pass and then in a backward pass by keeping fixed the consequent parameters the process would be continued. In the forward pass the input is forwarded and propagated and then by applying the least square method the error would be calculated and forwarded to the next layer. In the second pass the error would be backward to and the premise parameters are updated by a gradient method. The advantages of Fuzzy logic for grade estimation are clear because it is a powerful tool that is flexible and in lack of data with its ability which is IF-THEN rules would be able to solve the problems. One of the biggest problem in fuzzy logic application is the shape and location of the membership function used for each fuzzy variable which can be solved by trial and error method.

This paper presents an adaptive neural network functionally equivalent to Mamdani fuzzy inference system. These two methods are universal approximator and used for non-linear modeling. Fuzzy neural networks implements main steps of fuzzy inference in an

ordered layers on neural networks with an architecture such that the weights to be adjusted in the networks, which makes fuzzy inference more closer to the actual situation by learning capability of the neural network.

Mamdani model has greater superiority to ANFIS in expression of consequent part and intuitive of fuzzy reasoning. It can show its legibility and understandability to the lay people. It shows its advantage in output expression. Its advantages are (i) its intuitive (ii) It has widespread acceptance (iii) It is well suited to human cognition. In Mamdani fuzzy inference system, the following functional operates are needed:

1. AND operator (usually T-norm) for calculating the rule firing strength with AND'ed antecedents
2. OR operator (usually T-norm) for calculating firing strength of a rule with OR'ed antecedents
3. Implication operator (usually T-norm) for calculating qualified consequent MFs based on given firing strength
4. Aggregate operator (usually T-conorm) for aggregating qualified consequent MFs to generate an overall output MF
5. Defuzzification operator for transforming an output MF to a crisp single output value

If AND operator and Implication operator is product, and aggregate operator is sum, defuzzification operator is centroid of area (COA). This composite inference method in the Mamdani-ANFIS has the ability of learning because of differentiability during computation. Final crisp value for the centroid defuzzification is equal to weighted average of centroid of consequent MFs,

Personality Analysis

Modelling human behaviour is a great challenge due to "human nature", i.e. humans are unstable, unpredictable and capable of independent action. The performance of individuals will fluctuate depending not only on their ability, training and education, but also on their physiological and psychological states and traits. However, models and techniques are emerging within the military or social science domains that clearly indicate that some useful modeling of human performance is possible. Three main challenges in capturing complex patterns of human behaviour in agent based simulations have been identified in:

(a) humans are not limited to one identity or any common set of emotions;

(b) humans are not limited to acting in accordance with predetermined rules;

(c) humans are not limited to acting on local patterns.

At first sight, such challenges look daunting. Clearly, it is difficult to consider all scales of human awareness simultaneously; instead it is possible to choose one circle of influence when devising mental models to represent human behaviour in a specific context. Furthermore, on further reflection these challenges may not be critical for simulating certain social collectives.

We propose that it is possible to simulate part of the human behaviour in the context of student value. The first step to achieve the student's behavior simulation is to identify the set of relevant human characteristics that we consider affect the performance of a student in this specific context. They can be grouped into cognitive capabilities, personality trends, emotional states and social characteristics.

Cognitive Capabilities.

Human cognitive capabilities involve several brain processes such as learning and memory among others. In our model, the cognitive capabilities of a person (here student) were defined as his/her degree of expertise in a particular domain (subject).

Personality Trends.

We have taken into account two different psychological approaches to identify the personality trends that influence the behaviour of a person when performing his/her work value. The first approach is based on the CLEAVER technique, used to identify the predominant personality trend of a person. The CLEAVER technique is applied to the candidates through several questions about his/her likely actions in front of different work situations. The result of this questionnaire is a numerical value between 1 and 99 for each of the following personality trend parameters (DISC): Drive – leadership; capability to achieve results, overcome challenges and display high initiative.

Influence –capability to interact with people and motivate them to improve their behaviour.

Steadiness –capability to follow routine and continuous activities without large variations in behaviour.

Compliance –capability to execute work following established rules and procedures.

The other approach is from Schubert. Schubert proposes four general personality trends that may influence behaviour of a person: **Amiable, Driver, Expressive** and **Analytical**. These four personality trends are closely related to the CLEAVER trend parameters: **Drive – Driver, Influence – Expressive, Steadiness – Amiable,** and **Compliance – Analytical**. We therefore consider that the parameter with the highest value from among the CLEAVER parameters defines the Schubert personality type.

Emotional State. From the large set of basic emotions, we select a small set of four basic emotions to model the agents' emotional state at work. Two of them are positive emotions and the other two have a negative influence over performance:

- **Positive emotions: Desire** and **interest** of a person to execute a specific task in a given moment.
- **Negative emotions: Disgust** and **anxiety** generated by a specific task in a given moment.

In addition to these four basic emotions, we also consider the **stress** parameter as part of the internal state of the agents. The stress is not an emotion, but its influence over the performance of a student is recognized in several studies. In our model, the difference between the basic emotions and the stress parameter is given when the behaviour of the agent is generated.

Social Characteristics.

Human relations are important to achieve a good communication and co- ordination among the colleagues. In a group of student in particular, an environment with good human relations is crucial to achieve common goals. The modeling and analysis of human relations within groups and teams (such as competitiveness, trust, co-operation, etc.) is the main goal of several research areas such as social psychology, social sciences and organizational behaviour. Inclusion of all these characteristics within our model is out of the scope of this research. Nevertheless, we consider a small set of social characteristics (in a similar fashion to the set of basic emotions) to influence the student's behaviour.

Fuzzy Logic to Model Human Behavior

Once we have related specific parameters to each of the internal characteristics of a person, the following step is to decide how these characteristics will be represented and measured. All the characteristics are closely linked together, so they need to be combined to model the global behaviour of a person. Our goal was to build a simulation tool in which we would be able to:

- Modify the parameters (i.e. change their value within a given range).
- Combine parameters.
- Measure and evaluate the effects that one parameter has over the others.

The behaviour of a person, i.e. the simulation of his/her performance within the study individually and as a group member, is generated by the combination of all the previously mentioned characteristics. It is difficult to accept that a numerical value could be used to measure the intensity of either human emotion, experience or creativity level. However, we frequently use qualitative (linguistic) attributes to describe properties of human moods, features and emotions. Expressions as "she is **very** experienced", "you seem a **little** tired", "I feel **less** stressful today" are commonly used. Following this fact, we believe that it is more natural and intuitive to associate qualitative (linguistic) values to the person's internal parameters. We can talk in terms of **low, medium** and **high** values. For example, we can say that a person has a **high level of experience, low level of stress, a medium desire** to develop his/her task, **high level of creativity**, etc.

It is possible to express the intensity of the above mentioned parameters through the use of **Fuzzy Logic.** In classical logic a statement is either true or false. This principle of **truth or falsehood** was formulated by Aristotle some 2000 years ago as the Law of the Excluded Middle, and has dominated mathematical logic ever since until the first half of the 20th century. The idea that things must be either **true** or **false** is in many cases uncertain. Is the statement "my child is good", completely true or completely false? Probably neither. How about "I am rich"? Or "she is beautiful"? The idea of **gradations of truth** is familiar to everyone. Fuzzy logic offers a more flexible way of representing reality. In fuzzy logic, a statement is true to various degrees, ranging from completely true through half-true to completely false. Here we present how we employ fuzzy logic to model the human characteristics at school.

6. A Case Study

Student's Evaluation and Value Content of Curriculum

Evaluating student's behavior

Student's behavior is any observable response that is used as input to the student modeling process. Communication channel between the student and the ITS (Intelligent Tutoring Systems) is very restricted (usually a keyboard and a mouse) and observable responses of the student during the interaction with the ITS are limited and quite different from observable responses by a human teacher. In the neuro-fuzzy model several kinds of information, measured during the interaction, are evaluated. The number of correct or incorrect answers is evaluated with an overlay technique comparing the answers with the domain knowledge, providing assessments of student's knowledge level. A specific group of questions and exercises is used to detect misconceptions. The time spent to read the theory and to find the correct answers is measured and evaluated, since the time of task is a very reliable and powerful predictor of learning. Assessments of several characteristics of the student are finally created relevant to individual differences in learning performance, such as the knowledge status (knowledge level, mistakes, misconceptions, etc.), the cognitive abilities (learning speed, attention, memory limitations, etc.).

Value Evaluation Based on Neuro-Fuzzy Modeling

Teachers usually do not built detailed models for understanding/evaluating students' performance to a particular system. Generally, students are classified by conventional means in terms of some dimensions like motivation, intellectual ability and knowledge level on some topics. The present paper is based on an exhaustive survey conducted in different schools of the Chhattisgarh (India) with the help of a fuzzy questionnaire prepared. More than 50 values were grouped into the 12 basic groups and the students' response was obtained in the linguistic regions of low, medium and high. Data set contains a random sampling of more than 40 schools and 1000 students. The overall assessment of the values was done and a correlation was established with the students' assessment to the content of value education in the overall curriculum. The fuzzy approach enables approximate reasoning and is suitable for modeling students' decision process. The use of linguistic variables and fuzzy sets enables mapping of verbal to fuzzy model straightforward. The goal of fuzzy modeling is to imitate the strategy of human.

Discussion

The exhaustive survey conducted based on the fuzzy questionnaire facilitated the construction of membership function and conversion to fuzzy model easily as it was directly based on the human communication principle, which is nothing but the domain of the fuzzy logic. The value grouping has soft boundary and a sense of belonging and overlapping to many other similar groups. The author observed no result when tried to get some response in exact mathematical or hard boundary term. This means that fuzzy logic is really proved in dealing with human. Since the survey and model is based on direct interaction with the students and interpretation of the response, and hence a model prepared by (one) teacher may have differences from the other because of the data interpretation and the way of interaction. The neuro-fuzzy model incorporates both general and subjective knowledge in a cognitive domain. General knowledge is incorporated in the definition of the fuzzy sets and in assigning weights of importance of each preliminary decision to evaluate a characteristic of the student. This knowledge represents the expertise of the teacher in defining thecharacteristics of the student. The back propagation network represents the experience of the teacher in evaluating the students and can be adapted by training to a teacher's personal way of evaluation. Furthermore, this approach permits the representation and processing of incomplete, imprecise and vague information about the student, i.e. controversial answers and unstable behavior, as well as precise data. This evaluation of student's characteristics is further used for deciding about the appropriate teaching strategy

Conclusions

The state-of-the-art of the personality theories and applications are reviewed and outlined and pointers to important sources are given. The article by Ghasem- Aghaee and Ören [2003] uses fuzzy logic conceptsto process personality knowledge representations used in this article. Furthermore, it provides the basis for the specification of fuzzy software agents with dynamic personality. In simulation of intelligent entities, understanding and representing of both static and dynamic knowledge about personality is paramount. This article bridges the psychological knowledge about personality and modeling and simulation. Hence may facilitate the validation of the model to represent personality knowledge in a simulation study. Harmon et al. [2002] provide additional knowledge on the validation of human behavior representation

In the process of fuzzy inference, ANFIS adopts a linear equation in consequent part, which can not exhibit human's judgment reasonably. So, the authors proposed the Mamdani model based, which has greater superiority in consequent part and the intuitive of fuzzy reasoning. ANFIS is a universal approximator because of its infinite approximating capability by training. All parameters in ANFIS are nonlinear parameters which can be adjusted by learning rules discussed above. ANFIS model can show its legibility and understandability and exhibit the essence of fuzzy logic more clearly. Many authors have shown that the ANFIS can achieve the desired target.

The present paper has demonstrated the application of ANFIS for the evaluation of the students' value. It can therefore be said that the model can achieve the desired target and can be safely used in modeling the social, educational, economic or business activities or the case when a public gathering or interaction is evolved.

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