A GFA Driven Framework for Classification of Multiple Intelligence

Kunjal B. Mankad and Priti S.Sajja

***Abstract*—Machine Learning has facilitated needs for automatic decision support in a very efficient manner by applying various techniques. Due to capabilities of providing easy implementation and low cost solution, soft computing techniques are gaining popularity. Genetic Algorithms have achieved great success in search and optimization while Fuzzy Systems have achieved success in handling imprecision and uncertainty. The paper focuses on machine learning with genetic fuzzy hybridization. The research work discusses novel framework of genetic fuzzy rule based system for classifying managerial and technical intelligence of students. The objective is to reduce the system's developmental and maintenance effort and evolve strong rules. To support the proposed model the paper accompanies literature survey, detailed discussion of methodology with encoding strategy, operations used as well as implementation details. To experiment the proposed model, a domain of Multiple Intelligence is chosen and sample prototype is presented to identify skills of students.**

Keywords: Genetic Algorithms (GA), Genetic Fuzzy Hybridization, Machine Learning (ML), Soft Computing (SC), Theory of Multiple Intelligence (MI)

I. Introduction

Soft computing(SC) provides several techniques emphasize on computational intelligence. Family of Soft computing consists of several methods such as Fuzzy Logic (FL), Neural Network (NN), Evolutionary Methods, Probabilistic Reasoning, Support Vector Machines (SV) and their hybrid forms. It has been found that hybridization of such methods have proven very useful for machine learning tasks. As a result of integration of such techniques, Fuzzy-Neural, Fuzzy-Genetic-Neural, Genetic-Fuzzy hybridization became possible. The major advantage of these techniques is ease of implementation and low cost solution. Among family of soft computing, genetic algorithms have achieved success in search and optimization and fuzzy logic has achieved success in handling imprecision and uncertainty in real life applications. The proposed approach is based on hybridization of genetic algorithm and fuzzy logic. The proposed application focuses on education domain to classify student's multiple intelligence.

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According to modern theories, every human being is enriched with intelligence in multiple areas. In today's competitive world, everybody needs to have education according to their areas of interest and capabilities. It is very important to select appropriate career in order to achieve professional success. Among many types of intelligences, the technical and managerial abilities play a critical role in one's success. In order to measure human intelligence, the proposed paper deals with Theory of Multiple Intelligence. It highlights identification of users' managerial and technical skills using genetic fuzzy approach of soft computing. The framework provides integration of front end and genetic evolution process. This paper is organized as follows: Section 2 represents overview of Genetic fuzzy systems in area of the machine learning and soft computing. The third section discusses literature review of fuzzy genetic hybridization. The forth section highlights role of human intelligence, Theory of Multiple intelligences with its types and related work in the same area using computer technology. The fifth section represents proposed system's framework with computational results. Final section discusses results, conclusion and future work.

II. Genetic Fuzzy Hybridization for Machine Intelligence

Machine Learning consists of various activities which include following (Turban, Aronson, and Liang, 2005) :

- Acquisition of knowledge through historical examples;
- Implicitly induces expert knowledge from history;
- Different from the way that humans learn;
- Implications of system success and failure unclear;
- Manipulates of symbols instead of numbers;

Intelligence is loosely defined as the capability of a living organism to adapt itself to an ever-changing environment. Normally, adaption in living organism any change in the characteristics and behavior was considered as adaption to experience over its history. As a result of such adaptation; environmental changes from old to new generations has been observed. Evolution is natural phenomena operates on populations of organisms, ensuring by natural selection that characteristics that serve the members well tend to be passed on to the next generation. Evolution can be seen as optimization of population's ability to survive and reproduce in a specific environment. Soft Computing is capable of handling such evolution with bio inspired techniques. Soft computing describes the term computing with family provides set of techniques for machine learning. The major consortium of soft computing includes fuzzy logic, support vector machine, genetic algorithms and genetic programming, probabilistic reasoning as well as neural

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network. The conventional computing can deal with problems having analytical models while soft computing has been proven efficient in handling uncertainty and imprecision in real life problems. In general though, Soft Computing is a good option for complex systems [2]; where:

- The system is non-linear, time-variant or ill defined;
- The variables are continuous;
- A mathematical model is either too difficult to encode, does not exist or is too complicated and expensive to be evaluated.

Machine Learning methods provide framework for intelligent systems. Automatic learning has been always a critical task for intelligent system design. Here, a novel approach is presented in order to deal with automated machine learning with the help of genetic fuzzy hybridization. Fuzzy logic has achieved great success in handling uncertainty and imprecision. Fuzzy Logic is also known as multi valued logic as it deals with multiple degrees (values) in order to handle imprecision; hence exact classification of values becomes possible with fuzzy logic which is almost impossible with classical bivalent logic. It does provide another advantage by making knowledge representation very easy and in human understandable format with the help of linguistic features. In spite of having such great advantages, fuzzy logic still suffers with deficiency of self learning. The solution is achieved with the help of hybridization of Fuzzy Logic with genetic algorithm.

III. Literature Review of FGA

Enlisted examples are very useful real world applications those dealing with intelligent information systems where genetic fuzzy methodology has been successfully implemented.

- Integrating design stages for engineering using GA [3];
- Diagnostic system for decease such as myocardial infarction, breast cancer, diabetes, dental development age prediction, abdominal pain, etc. [2,4,5];
- A trading system with GA for optimized fuzzy model [6];
- For optimizing social regulation policies [7];
- Self integrating knowledge-based brain tumor diagnostics system[8];
- Classification of rules in dermatology data sets for medicine [9];
- Multilingual question classification through GFS [10];
- University admission process through evolutionary computing [11];
- Genetic mining for topic based on concept distribution [12];
- Intelligent web miner with Neural-Genetic-Fuzzy approach [13];
- Extraction of fuzzy classification rules with genetic expression programming [14];
- Integrated approach for intrusion detection system using GA [15];
- A genetic fuzzy control for HIV immunology model [16];
- Travel choice behavior in public transport network using GFA [17]
- Logistic decision making in management accounting with GFS[18];
- Hybrid PID controller for position control and improvement in magnetic suspension [19];
- Evolutionary Rule-Based System for IPO Under pricing Prediction [20] and many more.

As a result, it is found that education domain has not utilized hybridization of Fuzzy-Genetic in order to apply intelligent decision support to satisfy user needs. Hence, we focus on an application for education domain.

IV. Role of Human Intelligence for Success

Intelligence is loosely defined as an ability to handle complex problems in useful context. In order to achieve success, problem solving skills are essential for every individual. Though individuals are enriched with certain level of intelligence genetically, it is found that appropriate training and development methods in every field can increase the level of intelligence by utilizing instructional technologies.

A. Types of Human Intelligence

According to the Theory of General Intelligence, every individual is born with a certain intelligence or potential intelligence, which is difficult to be changed. Psychologists can assess one's intelligence (IQ) by means of short-answer tests and other purer measures such as the time it takes to react to a flashing light or the presence of a certain pattern of brain waves.

Table I
Types of Intelligence

Type of intelligence	**Meaning**
Linguistic/Verbal Intelligence	The capacity to learn, understand and express using languages e.g. formal speech, verbal debate, creative writing, etc.
Logical-Mathematical Intelligence	The capacity to learn and solve problems using mathematics e.g. Numerical aptitude, problem solving, deciphering codes, etc.
Spatial/Visual Intelligence	The ability to represent the spatial world of mind using some images e.g. patterns and designs, painting, imagination, sculpturing, etc.
Bodily-Kinesthetic Intelligence	The capacity of using whole body or some to solve a problem e.g. body language, physical exercise, creative dance, physical exercise, drama, etc.
Musical Intelligence	The capacity to understand music, to be able to hear patterns, recognizes them and perhaps manipulates them. e.g. music performance, singing, musical composition, etc.
Interpersonal Intelligence	The ability to understand other people. e.g. person-to-person communication, group projects, collaboration skills, etc.
Intrapersonal Intelligence	The ability to understand oneself regarding of every aspects of the personality. e.g. emotional processing, knowing yourself, etc.
Naturalist Intelligence	The ability to discriminate among living things and sensitivity towards natural world e.g. knowledge and classification of plants and animals with naturalistic attitude, etc.
Existential and Moral Intelligence	It concerns with ultimate issues as well as capable of changing attitude. It is said to be required with every individual.

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But the traditional IQ tests did not satisfy the researchers, so they developed a number of alternative theories, all of which suggest that intelligence is the result of a number of independent abilities that uniquely contribute to human performance. These theories suggest that rather than being fixed, unitary, and predetermined, intelligence is modifiable, multi-faceted, and capable of development [21]. Dr. Howard Gardner has developed Theory of Multiple Intelligence (MI), which defines intelligence as potential ability to process a certain sort of information [22]. Gardner has identified nine intelligences but there is also a possibility of many other types of intelligence in individuals [23]. Table 1 describes the various types of intelligence along with their meanings [24].

B. *Work done so far in Multiple Intelligence*

The field of education and technology has contributed numerous research projects by implementing Theory of MI for the last few decades, some of them are as follows [25-34]:

- Classification of types of intelligence among young boys and girls (age (12-14)years);
- International educational online learning programs for students as well as teachers;
- Adult developmental programs;
- Curriculum planning, parents' interaction, etc. ;
- The research project "EDUCE", implemented as a predictive system using MI ;
- Employees' developmental programs;
- New AI approach for students' academic performance using fuzzy rule generation;
- Application of the Theory of Multiple Intelligence (MI) to Digital Systems Teaching;
- Learning style improvement using information technology and many more.

V. Proposed GFA Approach for Classifying Human Intelligence

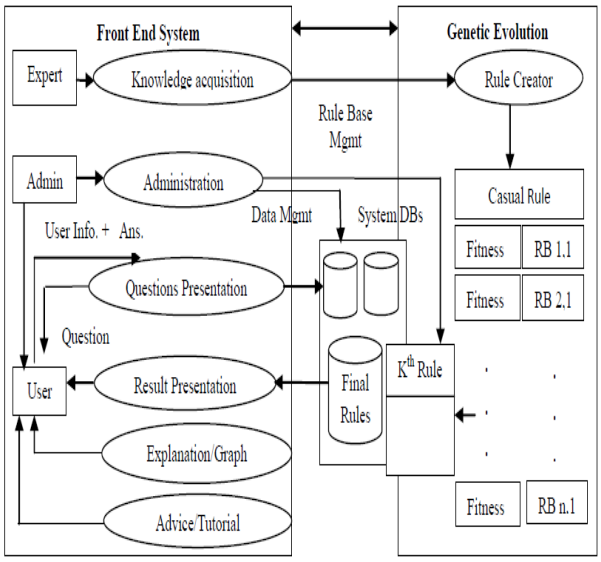

Figure 1: Framework of Proposed System

It has been observed that many applications areas have been utilizing evolving rule based approach still the hybrid model using genetic fuzzy approach to classify user's multiple intelligence has yet not been developed. Hence, we propose the novel model for classification of user's capability based on Theory of MI for education domain.Fig.1 presents the generalized framework using genetic fuzzy hybrid approach. The detailed discussion on each component of fig. 1 is presented as under:

A. *Front End System*

Domain Expert will design knowledge acquisition process in order to extract domain knowledge. This knowledge can be created with set of rules which can be collected, analyzed, and finalized during interviews with experts or from multiple references as well as from example sets using theory of MI. Later, this domain knowledge is inserted and modified by human expert. Different users with their access rights will be created according to their categories; for example, higher secondary education students, college students, and professionals. User interface is designed for different user registration purpose. System Administrator is responsible for handling management between Front end system and genetic evolution. According to user's category, questionnaires will be presented. User selects answer from given list of multiple choices. These answers will be stored in the database and result is shown to the users. Once score is shown to users, system provides decision using evolved rules to select appropriate class such as technical or management. For the proposed system, we have created the rule base consisting of verbal and logical intelligence to classify the students as shown in Table 3. Different sets of interactive questionnaires for different user categories are created/ collected by human/domain experts. Fig. 2 shows relationship among database objects for questioner presentation for different users' categories.

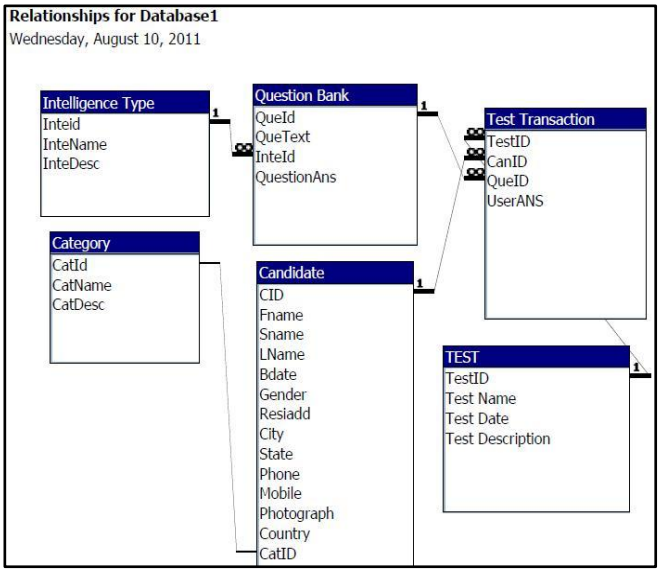

Figure 2: Relationship among objects for Questioner presentation to the user's categories

B. *Genetic Evolution Process*

Rule base in application architecture can be generated by predefining membership functions either by a human expert or by some other processes automatically. For the proposed system, RB becomes fixed during the process. Initially, rules are suggested by human expert using different types of intelligence for efficient categorization of skills of users.

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The knowledge engineer facilitates rules within the rule bases in encoded fashion. There are different types of fuzzy membership functions available such as gaussian, trapezoidal and triangular, etc. The proposed model is implementing triangular fuzzy membership mamdani functions as shown in Fig.3.

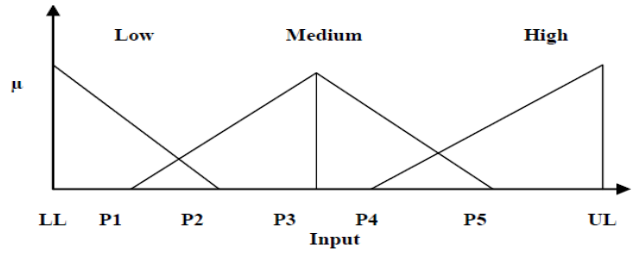

Figure 3: Triangular Membership Functions

Fitness of each rule is measured with application specific fitness function. It is obvious that higher the fitness, the rule is considered as stronger. An individual is evaluated through fitness function. Application specific fitness function has been designed which calculates strength of population selected as a parent for next generation. The score is calculated after matching answers from databases and later classified with low, mid, high labels. The proposed evolving procedure is as follows [35]:

Step (1): Generate an initial population of encoded rules. Initial population can be generated using random number that can be assumed values from 0 to ki where ki is the number of fuzzy sets utilized to represent the attribute ai. Here, the code is obtained by concatenating rules using AND operator. The rule code is fixed and consequently location on the chromosome indicates the start and end of a particular rule code. The overall number of fuzzy sets in the DB is L.L is defined as follows:

$$L=La+Lc; \quad (1)$$

Where;
$La= \sum Ni$, where i=1 to n ;
$Lc= \sum Mj$, where j=1 to m;

Here, n and m are the number of input and output variables. Ni represents the number of linguistic terms associated to input variable Xi and Mj the number of linguistic terms associated to output variable Cj. The general structure of a rule with AND operator is:

If X1 is Y1 AND X2 is Y2 then Z1 is C1 (2)

Where X1,X2 are input variables, Y1,Y2 is Linguistic Value; Z1 is output variable and C1 is value.

Binary encoding scheme has been used to encode rule condition and prediction parts. The proposed encoding scheme is a novel approach as it deals with every label associated with the rule as shown in Table 2. A chromosome is divided into n genes in which each gene corresponds to a full rule. There can be many conditions in antecedent part of a rule.

TABLE II
BINARY REPRESENTATION OF A RULE

Value of X1,X2 (Conditional Variables)	Encoding	Value of A1,A2 (Linguistic Variables)	Encoding	Consequent Variables (Y)	Encoding (C1)
X1=SLogical	1110	High	1001	Y=Class	111
X2=SVerbal	0111	Medium	1000	Technical	11
		Low	0001	Mgmt	01

For implementing fuzzy rules, proposed system uses fuzzy mamdani membership functions used in Term set1: {High, Medium, Low} while Term set 2 consists of output label set {Technical, Mgmt} for output variables. Different combinations from Table 4 will be utilized for chromosome representation scheme.

Step (2): Evaluate fitness of these rules and store into the rule profile.

$$Fitness= CF*Comp \quad (3)$$

$$\text{Where } CF \text{ (Precision)} = TP/(TP+FP) \quad (4)$$

$$Comp=TP/ (TP+FN) \quad (5)$$

Eq. (3), (4), (5) are calculated based on following terms of confusion matrix.

- TP=True Positive=Number of examples satisfying A and C.
- FP=False Negative=Number of examples satisfying A but not C.
- FN=False Negative=Number of example not satisfying A but satisfying C.
- TN=True Negatives=Number of examples not satisfying A nor C.

Step (3): Determine the fitness accepted for the application.

Step (4): Identify and discard the weak rules according to rule matching criteria.

Step (5): Apply crossover and mutation operators on rules.

Here, two point crossover operator has been implemented as shown in below:

Rule 1: If SLogical is High and SVerbal is Low then class is Technical

Individual 1(I1): 1100 1001 0011 0001 1000 111

Rule 2: If SLogical is Medium and SVerbal is High then class is Mgmt

Individual 2(I2): 1100 1110 0011 1001 1000 011

I1	1	1	1	0	1	0	0	1	0	1	1	1	0	0	0	1	1	1	1	1	1
I2	1	1	1	0	1	0	0	0	0	1	1	1	1	0	0	1	1	1	1	0	1

As a result of two point crossover operation, we got;

New I1	1	1	1	0	1	0	0	0	0	1	1	1	1	0	0	1	1	1	1	1	1
New I2	1	1	1	0	1	0	0	1	0	1	1	1	0	0	0	1	1	1	1	0	1

Step (6): Go to step (ii) and repeat the procedure till required fit rules are achieved.

Hence we can determine that, using the proposed scheme, new feasible rules can be evolved in upcoming generations.

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Here, Table 3 shows rule set designed by human expert to identify technical and managerial skills [36].

TABLE III
RULE SET IDENTIFYING CLASSES

1	If SLogical is High and SVerbal is Low then class is Technical
2	If SLogical is High and SVerbal is High then Class is (Technical OR Mgmt)
3	If SLogical is High and SVerbal is Medium then Class is Technical
4	If SLogical is Medium and SVerbal is Medium then Class is (Technical OR Mgmt)
5	If SLogical is Medium and SVerbal is Low then Class is Technical
6	If SLogical is Medium and SVerbal is High then Class is Mgmt
7	If SLogical is Low and SVerbal is High then Class is Mgmt
8	If SLogical is Low and SVerbal is Medium then Class is Mgmt
9	If SLogical is Low and SVerbal is Low then Class is Rejected

C. Results

For good performance of the system, the design of fuzzy membership function is very important. Here, Mamdani FIS is used for implementation of fuzzy inference mechanism. Three different triangular membership functions (Low, Medium, and High) have been used to represent degree of truth of two input (conditional) variables: SLogical and SVerbal. For output variables, triangular membership functions have been used. "AND" method is used as a part of aggregation and "Centroid" method is used for de-fuzzification. The rule base consists of nine rules. The rules are implemented along with membership function plotting with MATLAB 7.0. Over many generations, natural population evolves according to principle of evolutionary computation. By continuing the method of automatic evolution, self tuning of membership function became possible [36].

Questionnaires are presented to users with the help of forms. To analyze the result, different criteria viz. High, Low, Mid are determined. Fig. 4 presents comparative chart of logical and verbal intelligence in students of science and management streams.

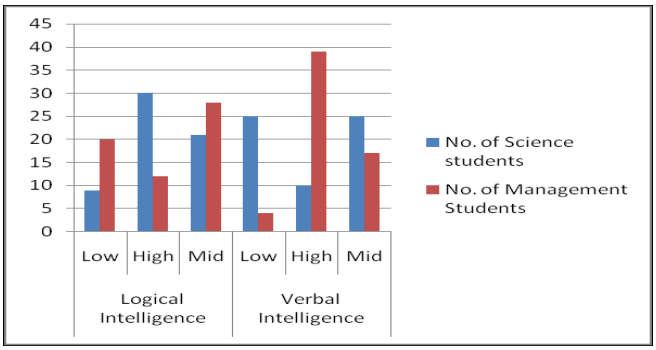

Figure 4: No of students Vs Type Of intelligence

VI. CONCLUSION AND FUTURE WORK

There are many automated system exist, yet generic architecture for evolving rule bases is a novel approach for designing system. The system suggested here presents many advantages such as handling imprecision and minimizing efforts for documentation of knowledge. The proposed framework is a novel approach for design of intelligent decision support system in evolutionary manner. Other important domains such as such as Human Resource Management, Child development, etc. can take advantage of such strategies. The presented application is to classify users' different skills in education domain. The same approach can be used to provide training for teachers, planning for resources and many more. The proposed architecture of evolving rule based model using genetic-fuzzy approach can also be applied to various domains like advisory systems, decision support systems, data mining systems, and control and monitoring systems, etc. For this application, one point and two point crossover operators have been tested. Further, new operators such as cyclic crossover, ring crossover, arithmetic crossover, etc. can be identified using suggested encoding schemes. Specific rule selection scheme will be designed in order to discard infeasible rules. The system can also be extended to different areas where analysis of human intelligence is required. New inventions in Multiple Intelligence can also be integrated with designed rule sets. The proposed system presents a platform for a generic commercial product with an interactive editor in the domain of multiple intelligence identification. This increases the scope of the system and meets the requirements of increased number of non-computer professionals in various fields.

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