ISSN: 0369-8963

IMPROVING THE DESIGN OF FUZZY SYSTEMS USING TYPE-2 FUZZY RULES

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Abstract-Fuzzy logic is a computing approach which deals with uncertain and imprecise information. It is different from Boolean algebra and based on degree of truth rather than true or false. The word fuzzy mean uncertain or vague but type -1 fuzzy sets has no uncertainty associated with it. Type -2 fuzzy sets are generalization of type-1 fuzzy sets to handle more uncertainty. In this paper a new student performance indicator system is proposed and implemented using Juzzyonline which is a java based library to design, construct and visualize a type -1, interval type-2 and general type -2 fuzzy systems.

Also student performance indicator system is designed with guaje an open access software and interpretability and accuracy parameters are also studied.

Keywords-General type-2, interval type-2, juzzyonline, FLS, Guaje

I. INTRODUCTION

It is observed that human being has excellent capability of reasoning and making decisions in the environment flooded with the imprecision, uncertainty, ambiguity partial truth etc.[1] .Fuzzy logic is a way reasoning really works and deals with uncertain and imprecise information. Finding the accuracy interpretability tradeoff in fuzzy systems is biggest issue. Maximization of one leads to deterioration of another. In precise fuzzy modelling accuracy is good while in linguistic fuzzy modelling interpretability is good. Type-2 fuzzy logic allows for better modelling of uncertainty as type-2 fuzzy sets encompass a Footprint of uncertainty (FOU)which, associated with its third dimension ,gives more degrees of freedom of type-2 fuzzy sets [2,3]. It is expected that general type-2 fuzzy sets employed within the general type-2 FLS will have the ability to model uncertainty more accurately than the interval type-2 fuzzy sets which in turn will result in potential for a superior control performance in comparison to type-1 and interval type-2 FLSs [4]. Type-2 fuzzy logic systems handle a different kind of uncertainty than that handled by non-singleton type-1 FLS [5]. A non-singleton system deals with the uncertainty in the input, whereas a type-2 system deals with the uncertainty in our knowledge about the system [6]. To obtain a single output set The defuzzifier combines the output sets corresponding to all the fired rules in some way and then finds a crisp number that is representative of this combined output sets. [7]. we can defuzzify the type-reduced set to obtain a crisp output from a type-2 FLS [8]. Type reduction is very intensive so General type-2 FLSs is computationally intensive [9]. Interpretability is a feature of the modeled system, showing, if its behavior is human understandable by seeing it, or not where as accuracy is the quantification of the capability of modeled system to faithfully represent the real system [10]. In [11] interpretability is of two types, Complexity Based Interpretability (CBI) and Semantics Based Interpretability (SBI). In CBI, approaches are focused to decrease the complexity of obtained model (usually computed by number of rules, labels, variable per rule etc.). Section II describes the literature reviewed .Section III is describing the proposed methodology for student performance indicator system. Section IV is showing experimental results. Section V is conclusion of paper.

II. LITERATURE REVIEW

S.NO.	AUTHOR NAME	TITLE	YEAR	DESCRIPTION
1.	L. Magdalena	Designing interpretable Hierarchical Fuzzy Systems	2018	Complexity affects the interpretability of the system. Hierarchical fuzzy systems has capability to reduce fuzzy systems complexity. Interpretability of each component in hierarchical fuzzy systems is evaluated and finally aggregated to achieve overall interpretability.
2.	Praveen Kumar Shukla, Surya Prakash Tripathi	Handling High Dimensionality and Interpretability-Accuracy Trade-Off Issues in Evolutionary Multiobjective Fuzzy Classifiers	2014	Evolutionary multiobjective optimization framework is implemented using 'MATLAB' and Fuzzy classifier 'Teacher-Performance Fuzzy System is implemented using Guaje.
3.	Prabhash Chandra, Devendra Agarwal and	MOBI-CLASS: A Fuzzy	2019	A new fuzzy classification system titled MOBI-CLASS is proposed and Implemented using

https://doi.org/10.5281/zenodo.19672365

ISSN: 0369-8963

	Praveen Kumar Shukla	Knowledge-Based System for Mobile Handset Classification		Guaje an open access software. The accuracy and interpretability Parameters are studied.
4.	Hisao Ishibuchi, Yusuke Nojima	Discussions on Interpretability of Fuzzy Systems using Simple Examples	2009	Discussions on how to measure the interpretability of systems with different examples
5.	Nilesh N. Karnik, Jerry M. Mendel	Introduction to Type-2 Fuzzy Logic Systems	1998	set operations on type-2 sets, properties of membership grades of type-2 sets, type2 relations and their compositions, and defuzzification are studied.
6.	Nilesh N. Karnik, Jerry M. Mendel, Qilian Liang	Type-2 Fuzzy Logic Systems	1999	Type-2 fuzzy systems were discussed. It can handle rule uncertainties and consist of output processing block which contains type – reduction followed by defuzzifcation.
7.	Praveen Kumar Shukla, Surya Prakash Tripathi	A Survey on Interpretability-Accuracy (I-A) Trade-Off in Evolutionary Fuzzy Systems	2011	Interpretability and accuracy assessing techniques have been surveyed.
8.	Nilesh N. Karnik, Jerry M. Mendel	Type-2 Fuzzy Logic Systems : Type-reduction	1998	Structure of a type-2 FLS is reviewed and type-reduction is described in detail.
9.	Christian Wagner, Hani Hagras	zSlices – Towards bridging the gap between Interval and General Type-2 Fuzzy Logic	2008	ZSlices for representing general type-2 sets based on interval type-2 sets are discussed.
10.	Praveen Kumar Shukla, Surya Prakash Tripathi	Interpretability and accuracy issues in evolutionary multi-objective fuzzy classifiers	2016	An Engineering Student-Fuzzy Classification is proposed and implemented using type-2 and type-1 fuzzy logic. The accuracy improvement is done by the application of linguistic hedges.

III PROPOSED MODEL: STUDENT PERFORMANCE INDICATOR

Type 1 fuzzy systems are those whose membership functions are type -1 fuzzy sets ,are unable to directly handle rule uncertainties whereas in type 2 fuzzy sets are those in which antecedent and consequent membership function are type 2 fuzzy sets ,can handle rule uncertainties. Type -2 fuzzy sets are extension of type -1 fuzzy sets which adds an extra degree of freedom to an uncertainty factor in the system .The defuzzifier block of type -1 fuzzy system is replaced by an output processing block in a type -2 fuzzy system. Type 1 fuzzy systems are those whose membership functions are type -1 fuzzy sets ,are unable to directly handle rule uncertainties whereas in type 2 fuzzy sets are those in which antecedent and consequent membership function are type 2 fuzzy sets ,can handle rule uncertainties. Type -2 fuzzy sets are extension of type -1 fuzzy sets which adds an extra degree of freedom to an uncertainty factor in the system .The defuzzifier block of type -1 fuzzy system is replaced by an output processing block in a type -2 fuzzy system. Type 1 fuzzy systems are those whose membership functions are type -1 fuzzy sets ,are unable to directly handle rule uncertainties whereas in type 2 fuzzy sets are those in which antecedent and consequent membership function are type 2 fuzzy sets ,can handle rule uncertainties. Type -2 fuzzy sets are extension of type -1 fuzzy sets which adds an extra degree of freedom to an uncertainty factor in the system .The defuzzifier block of type -1 fuzzy system is replaced by an output processing block in a type -2 fuzzy system. Designing the fuzzy system using type-2 fuzzy logic and finding the tradeoff of interpretability and accuracy. Interpretability is the system behavior is human understandable or not by seeing it whereas accuracy is closeness between real and modeled system. Two modeling approaches precise and linguistic fuzzy modeling are used to design the fuzzy system in precise modeling accuracy is good while in linguistic interpretability is good. We are going to design a fuzzy system in which optimization of accuracy and interpretability will be achieved. A student performance indicator system is proposed and implemented in this paper. The objective is to predict the level of student based on four parameters as follows:

1. Marks: This is the mark obtained by the student in the subjective examination of that particular subject. Marks of one subject is taken to evaluate the performance of the students.
2. Attendance: Attendance is criteria to judge hardworking of the student. So it is calculated at the end of session in theory and lab sessions of particular subject.
3. Human values: when one human interact with other than virtues possed by them is also important to evaluate the performance of students. Principles, conviction, and internal beliefs adopted by human's plays important role in today's world.
4. Co-cular activities : activities performed by the students outside the normal curriculum of colleges or schools and which take place outside the classroom without pen and pencil plays important role in today's education system.

Output parameter:

Level: level of the student will be good, avg, bad based on performance of the students. For a good student level is 3, for an avg student level is 2 and for a bad student level is 1.

IV. IMPLEMENTATION OF PROPOSED SYSTEM

A.Using juzzyonline: Proposed system is implemented using juzzyonline a java based toolkit to design the fuzzy systems. The proposed toolkit does not require any prior programming knowledge and both enables the rapid design and development of T1, interval and

 https://doi.org/10.5281/zenodo.19672365

ISSN: 0369-8963

general T2 FLSs from the convenient environment of a web-browser, as well as the straightforward sharing and execution of the resulting systems [12].juzzyonline is available to use at http://juzzyonline.wagnerweb.net. Juzzyonline is an internet platform aimed at allowing each novices and superior practitioners to design, assemble, execute, analyse and visualize fuzzy logic systems. A type-1, interval type-2 and general type-2 FLSs,are supported with a variety of options including different t-Norms and both singleton and non-singleton fuzzification.Juzzyonline is web browser based so it is easily accessible to anyone through web browsers. Juzzyonline is also platform independent. We don't need any additional code or any software to use this application. These features makes this toolkit more accessible than previously developed toolkit. We expect that this toolkit will provide direct and easy access to basic and most advanced fuzzy systems to both students and professionals. Juzzyonline is web browser based so it is easily accessible to anyone through web browsers. Juzzyonline is also platform independent. We don't need any additional code or any software to use this application. These features makes this toolkit more accessible than previously developed toolkit. We expect that this toolkit will provide direct and easy access to basic and most advanced fuzzy systems to both students and professionals

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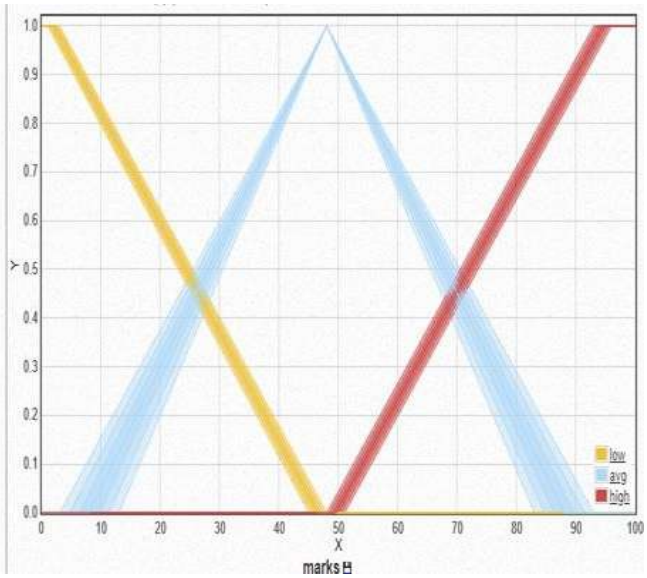


Fig.1 Graph for input variable marks

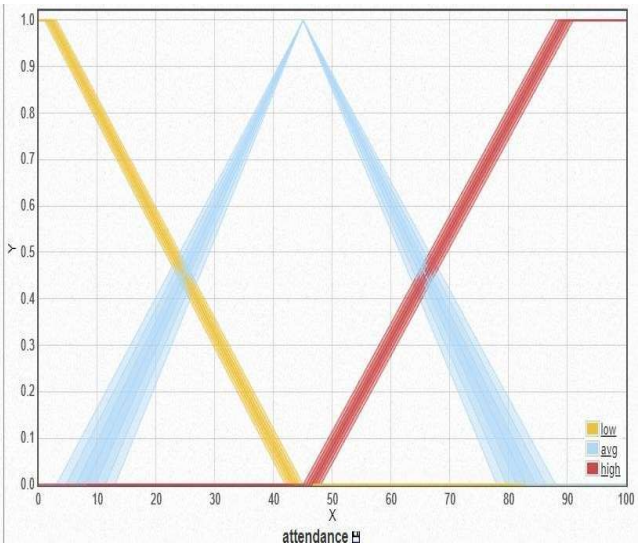


Fig.2 Graph for input variable attendance

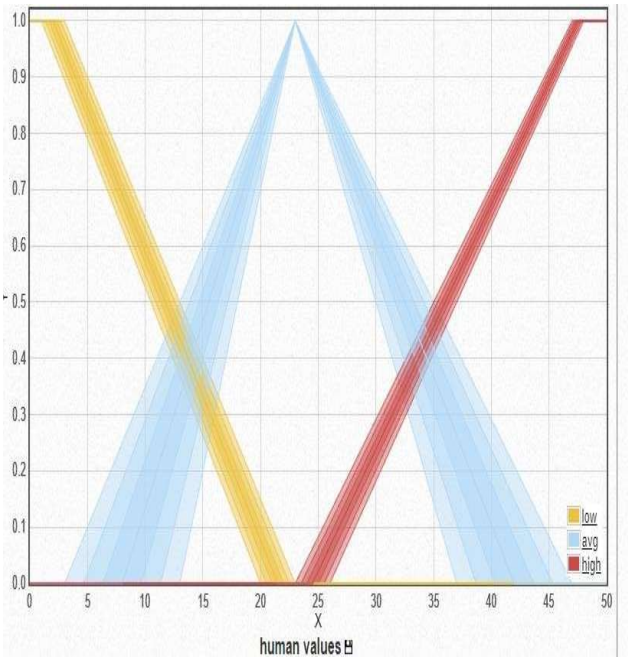


Fig.3 Graph for input variable human values

https://doi.org/10.5281/zenodo.19672365

ISSN: 0369-8963

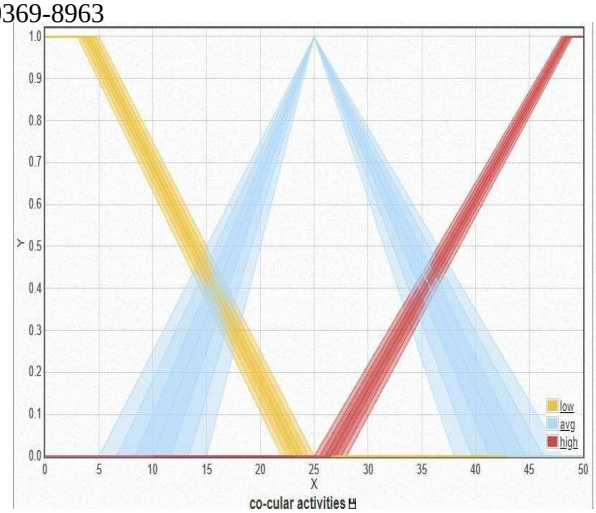


Fig. 4 Graph for input variable Co-cular activities

B.OVERALL DEFUZZIFIED VALUE :

Table1 crisp values for the student performance indicator system

MARKS	ATTENDANCE	HUMAN VALUES	CO-CULAR ACTIVITIES	OVERALL DEFUZZIFIED VALUE
95	95	45	45	3.00
50	50	35	35	2.16
45	45	35	35	1.92
35	35	20	20	1.71
30	30	15	15	1.53
90	95	40	45	2.99

Accuracy of the system =80%

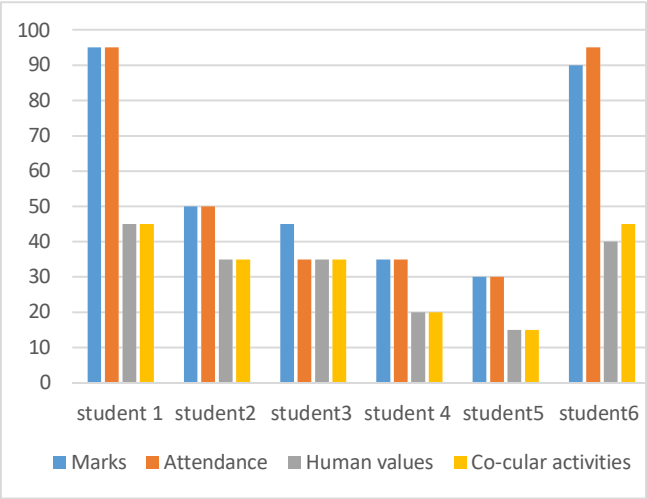


Fig.5 Different values of input parameters for different students

C. INTERPRETABILTY AND ACCURACY BY GUAJE: GUAJE stands for Generating Accurate and Understandable fuzzy systems in a Java Environment. It is licensed under GPL-v3. It is freely available tool. Its aim is to design an interpretable and accurate fuzzy model in java environment. It supports the design of interpretable and accurate fuzzy systems by means of combining several preexisting open source tools. Guaje pays special attention on interpretability of the systems. It is user friendly portable tool licensed under GPL-v3. Guaje is the combination of several system modelling tools such as Fispro, ORE, Graphviz, Weka etc. for designing of interpretable fuzzy systems. Fispro is used for simulating a physical or biological systems. It is open source tool used in guaje for creating fuzzy inference systems (FIS) that is used for reasoning purposes. For generating fuzzy partitions and rules from experimental data many algorithms are used in fispro most of them are implemented in C programs. Algorithms such as K-means, hierarchical fuzzy partition (HFP), Wang and Mendel (WM), fast prototyping algorithm (FPA), fuzzy decision tree (FDT) is provided by fispro which is used in guaje fuzzy tool. Graph visualization software graphviz is used to represent structural information as diagrams of abstract graphs and diagrams. It is open source graph visualization software. It consist of web and interactive graphical interfaces, and auxiliary tools, libraries, and language bindings. Diagrams in several useful formats such as images, SVG for web pages, postscript are made by graphviz layout programs. For concrete diagrams many useful features such as font, colors, and link styles is also present in graphviz. IT is collection of free software for viewing and manipulating abstract graphs. Module of GUAJE responsible for a novel interpretability analysis at fuzzy inference level (fingrams analysis) uses graphviz. Graphviz is licensed under the Eclipse Public License.

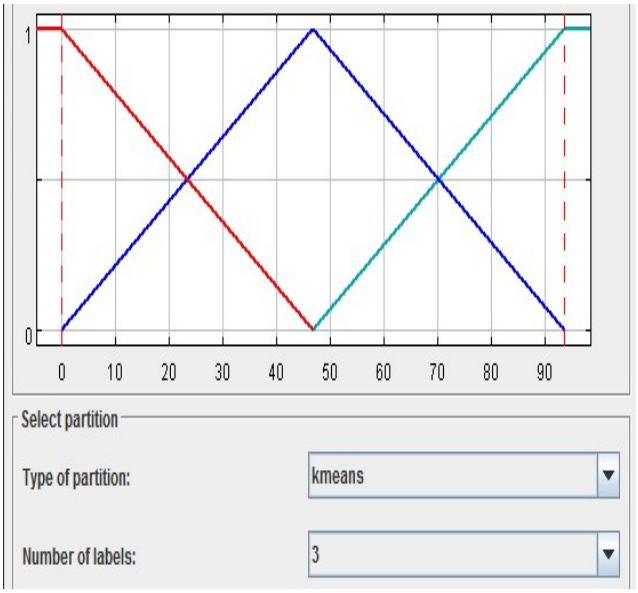


Fig.6 Membership function for input variable marks

https://doi.org/10.5281/zenodo.19672365

ISSN: 0369-8963

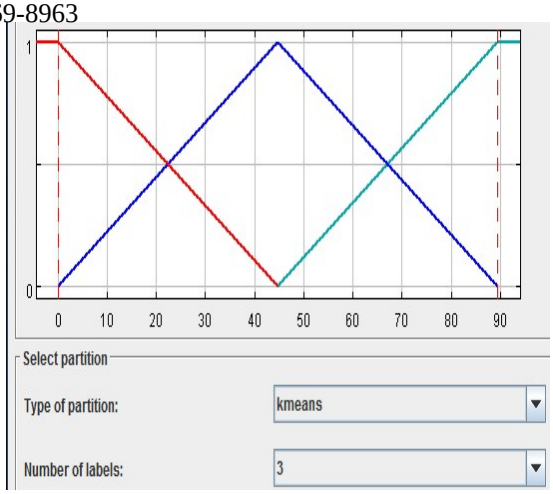


Fig.7Membership function for input variable attendance

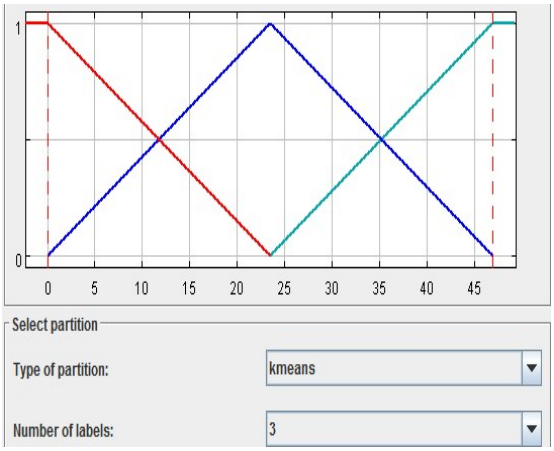


Fig.8 Membership function for input variable human values

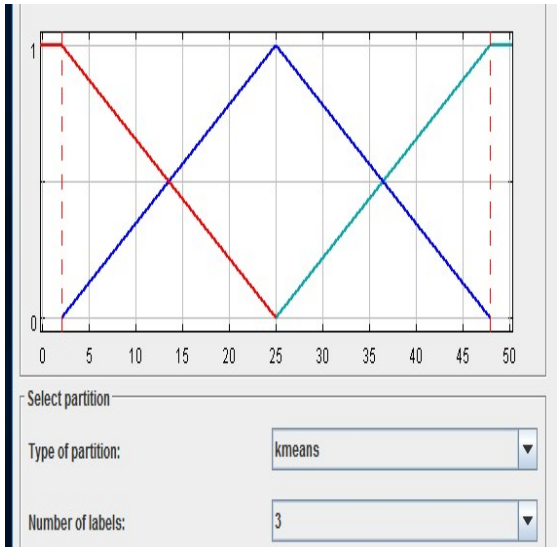


Fig.9 Membership function for input variable co-cular activites

Table2 Accuracy and interpretability by different algorithm

ALGORITHM	RULES	ACCURACY	INTERPRETABILITY
Fuzzy decision tree	13	0.803	0.042
Wang and Mendel	42	0.858	0.009
Fast prototyping	54	0.811	0.007

Table3 Accuracy parameters for the proposed student performance indicator system

Accuracy parameters	Experiment1	Experiment2	Experiment 3
Accuracy (%)	80.3	81.1	85.8
Accuracy(CONS)	71.7	72.4	75.6
Mean square classification error	0.077	0.092	0.091

Table4 Interpretability measures for the proposed student performance indicator system

Interpretability parameters	Experiment1	Experiment2	Experiment3
Nauck's index	0.042	0.007	0.009
Number of rules	13	54	42
Total rule length	36	216	168
Average rule length	2.769	4	4
Accumulated rule complexity	59.074	416.667	42.231

Using different algorithms interpretability and accuracy is calculated .In experiment 1 fuzzy decision tree algorithm is used in experiment 2 fast prototyping method is used while in experiment 3 Wang and Mendel method is used.

V. CONCLUSION

Fuzzy systems has capability to deal with uncertain and imprecise environment. Interpretability is system behavior is human understandable or not while accuracy is the difference between modeled system and real system. This paper introduces a new fuzzy knowledge base system using juzzyonline and guaje for the performance of the students. The performance is analyzed by guaje with two parameters interpretability and accuracy. Wang and Mendel algorithm for rule creation gives more interpretable and accurate fuzzy systems. Centroid type defuzzification method is used by juzzyonline to generate a crisp value from a fuzzy value. This paper introduces zslices based general type-2 fuzzy system using juzzyonline. Accuracy of the student performance indicator system was 80% using juzzyonline. Accuracy of the system with guaje software were 85.8% and interpretability was .009.

https://doi.org/10.5281/zenodo.19672365

ISSN: 0369-8963

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