Improved Fuzzy Modeling of Thyroid Disease Detection using Interval Type-2 Fuzzy Techniques

Prabhash Chandra, Devendra Agarwal, Praveen Kumar Shukla

Abstract*: *Fuzzy Systems are the managers for the modeling environment uncertainty for real time decision making. Type 1 fuzzy systems are much interpretable but less accurate than the type 2 and Interval Type 2 Fuzzy Systems (IT2FS). The paper introduces an experimental analysis to address the interpretability quantification and accuracy measurement in all types of fuzzy implementations. The experiment is carried out on the Thyroid dataset which leads to predict the level of Thyroid in the patients.

Keywords: Fuzzy Modeling, Knowledge Base, Inference, Mamdani Type Fuzzy System.

I. INTRODUCTION

Fuzzy systems [1] have extraordinary capability to model linguistic computation [2]. Membership functions which are based on mathematical formulation of linguistic values are the core part of any fuzzy system. Triangular, Trapezoidal, Gaussians are important membership functions. In a simple fuzzy system the membership degree lies between 0 and 1 (including 0 and 1) which is definite value for any member of fuzzy set. But to get more precision, this membership degree can be further represented by a new fuzzy set. Such systems are called Type-2 Fuzzy Systems (T2FS) [3, 4]. Which gives more generalized approximation and accurate decision making? But sometimes the computation cost of the fuzzy systems (type 2) is high, so an alternative is proposed to replace new fuzzy set with an interval 0 and 1 [4] interval type 2 fuzzy system (IT2FS). Interpretability [5,6,7,8] shows the level of understanding about the functionality of the system by inspecting its rule base and database. Number of rules Nauck's index, Total Rule Length, Average Rule Length are the several parameters to assess the interpretability. Following Table 1 shows the nature of interpretability quantification and accuracy assessment values in the fuzzy systems. The interpretability and accuracy are contradictory with each other and have trade-off relations. Evolutionary multi-objective optimization techniques are most important approaches to deal with this trade-off. Pareto solutions will be the solutions set to different parameters and will provide the set of solutions.

Table-1 Interpretability Quantification and Accuracy Assessment of Fuzzy Systems [9,10,11]

System Name	Interpretability	Accuracy
Simple Fuzzy System (SFS)	Higher than ITFS and TES	Lower than ITFS and TFS
Interval Type-2 Fuzzy System	Higher than TFS but Lower than SFS	Higher the SFS but lower to TFS
Type-2 Fuzzy System (TFS)	Lower than SFS and ITFS	Higher than SFS and ITFS

This paper introduces new findings for the application of IT2FS and T2FS in place of simple fuzzy systems for improving the system accuracy. Juzzy online is used to implement T2FS and IT2FS.

II. RELATED WORK

To deal with uncertain linear systems addressing the problem of sliding model control an IT2FS Takasi Sugeno Fuzzy Model is used in [12].

The IT2FS are used for cyber attacks which are based on observer-based adaptive sliding node in [13]. In this approach the input-to-state stability (ISS) is used.

The conservativeness of membership-dependent stability conditions are discussed in [14].

A time delay system for finite time control is introduced in [15] using IT2FS. A novel delay function 'Lyapunov-Krasouskii' is investigated.

III. PROPOSED FRBS MODEL

Mamdani Type Fuzzy Rule Based System is used to model the system (Fig. 1). There are FIVE variables of input and one output predicting the value of Thyroid level in the patient. The processing is done using T1FS and IT2FS. The processing mechanism is given in Fig. 2 & 3.

Mamdani Type FRBS is composed of Fuzzification Interface, Defuzzification Interface and Knowledge Base.

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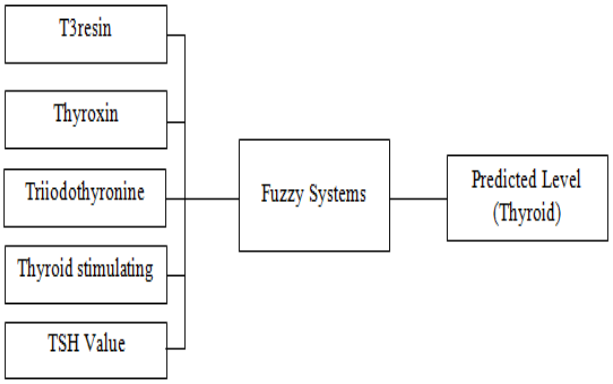

Fig.1 Proposed Model for Thyroid Prediction

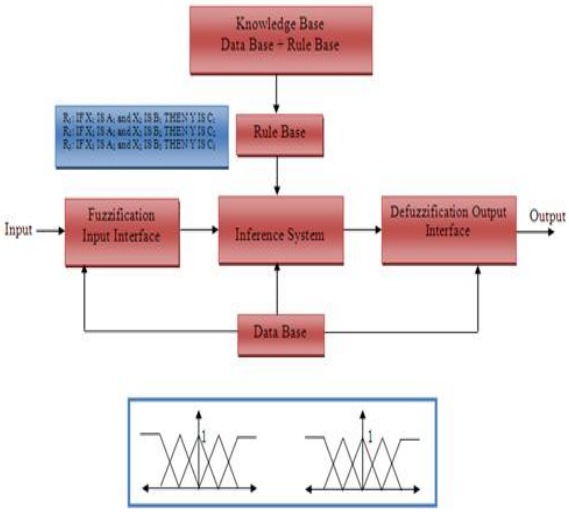

Fig. 2 Mamdani Type Fuzzy Rule Based System [20]

The IT2FS are functioning on the model shown in Fig. 3.

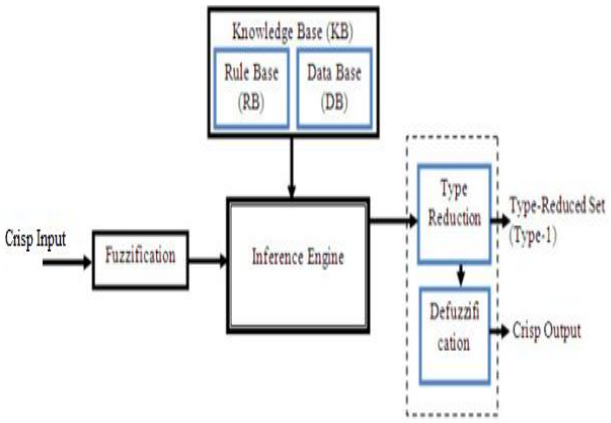

Fig. 3 Sketch diagram of IT2FS [17]

The model shown in Fig. 3 has one extra component which converts T2FS into T1FS.

IV. EXPERIMENTS AND RESULT ANALYSIS

The experiments are carried out with the data set about Thyroid available at the UCI repository. The other features of the data set are given below.

1. The type of data set is :Classification
2. Total Number of Instances: 215
3. Total number of Features: 5
4. Total number of Classes: 3

The membership function (MF) parameters are as follows,

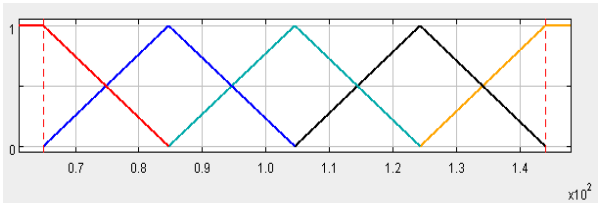

Fig. 4 MF-"T3resin"

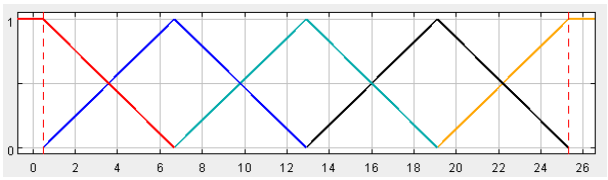

Fig. 5 MF-"Thyroxin"

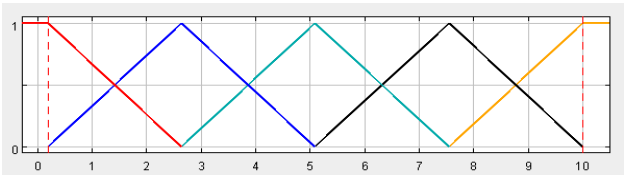

Fig. 6 MF-"Triiodothyronine"

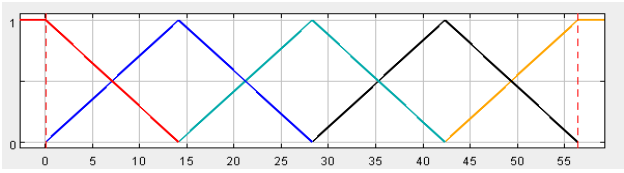

Fig. 7 MF- "Thyroidstimulating"

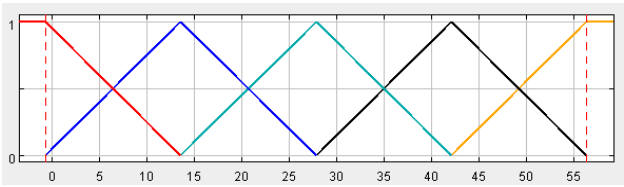

Fig. 8 MF-"TSH Value"

Rule Generation Method: Wang Mendel Procedure

Experiment -1 Fuzzy Type-1 Implementation

Table-2 Interpretability and Accuracy Parameters Interval Type-2 Implementation

Accuracy Parameters		Interpretability Parameters	
Parameter	**Value**	**Parameter**	**Value**
Accuracy	89.3	Nauck's Index	0.003
MSE	0.091	NOR	51
		TRL	255
		ARL	5
		TFR (Average)	8.556
		IFR (Average)	8.912

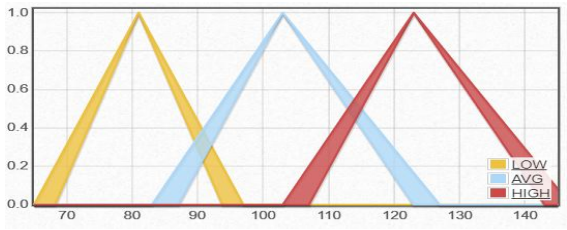

Fig. 9 MF-"T3Rsin"

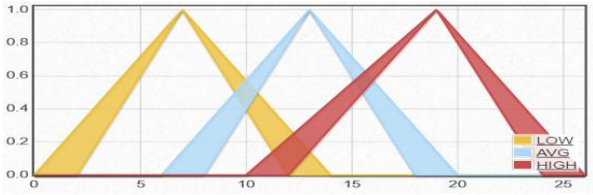

Fig. 10 MF-"Thyroxin"

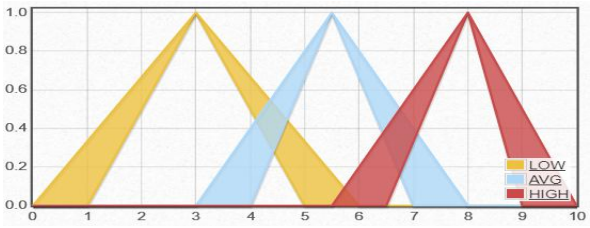

Fig. 11 MF-"Triiodothyronine"

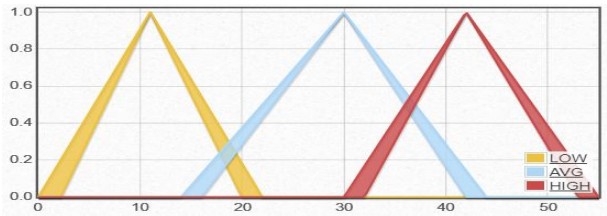

Fig. 12 MF-"Thyroidstimulating"

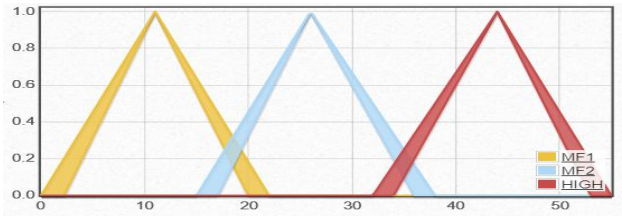

Fig. 13 MF-"TSH"

Table -3 Accuracy Parameters of Interval Type-2 Fuzzy Systems

Accuracy Parameters	
Parameter	Value
Accuracy	93.87
MSE	0.041

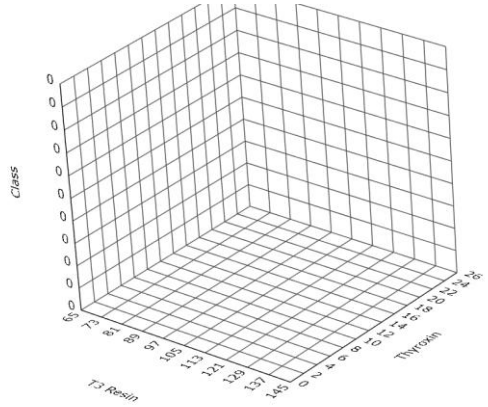

Fig. 14 Inference Mechanism for specific data value

The inference mechanism of the data set values is as follows; {145, 0.9, 3, 30, 25}

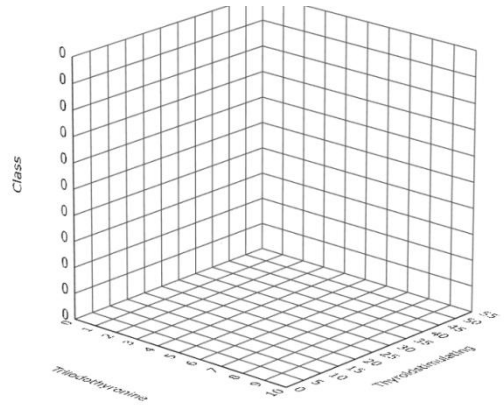

Fig. 14 Inference Mechanism for specific data value

V. DISCUSSION

T2FS are subjected to provide more accurate implementation. But if the complexity of the system is concerned, an IT2FS are used which are developing less complex system with competitive accuracy.
The comparative results are shown below in the table 4.

Table 4 Comparative Result Analysis

Parameters	T1FS	IT2FS
Accuracy	89.3	93.87
MSE	0.091	0.041

VI. CONCLUSION

T1FS have the capability to deal with the models consisting of lot of uncertainty in the development and working environment. But fortunately Type-2 fuzzy systems have capability to improve the accuracy of the prediction of the proposed model. The Thyroid data set is used to make experimentation for proving the above theory.
There is an improvement of 4.57% improvement in the accuracy when IT2FS are used in place of T1FS. The systems developed with the IT2FS are less interpretable but are more accurate. In future, the authors are interested to use T2FS for the implementation of proposed model for more accurate systems

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