Implementation of Neutrosophic Function Memberships Using MATLAB Program

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Abstract. Membership function (MF) plays a key role for getting an output of a system and hence it influences system's performance directly. Therefore choosing a MF is an essential task in fuzzy logic and neutrosophic logic as well. Uncertainty is usually represented by MFs. In this paper, a novel Matlab code is derived for trapezoidal neutrosophic function and the validity of the proposed code is proved with illustrative graphical representation

Keywords: Membership function, Matlab code, Trapezoidal neutrosophic function, Graphical representation

1 Introduction

The membership function (MF) designs a structure of practical relationship to relational structure numerically where the elements lies between 0 and 1. By determining the MFs one can model the relationship between the cognitive and stimuli portrayal in fuzzy set theory [1]. The computed MF will provide a solution to the problem and the complete process can be observed as a training and acceptable approximation to the function from the behavior of the objects [2]. This kind of MFs can be utilized for the fuzzy implication appeared in the given rules to examine more examples [3].

The MFs of fuzzy logic is nothing but a stochastic representation and are used to determine a probability space and its value may be explained as probabilities. The stochastic representation will to know the reasoning and capability of fuzzy control [4]. MFs which are characterized in a single domain where the functions are in terms of single variable are playing a vital role in fuzzy logic system. FMFs determine the degree of membership (M/S) which is a crisp value. Generally MFs are considered as either triangular or trapezoidal as they are adequate, can be design easily and flexible [5].

MFs can be carried out using hardware [6]. MFs are taking part in most of the works done under fuzzy environment without checking their existence for sure and also in the connection between a studied characteristic for sure and its reference set won't be problematic as it is a direct measurement [7]. It is adorable to have continuously differentiable MFs with less parameters [8]. MFs plays an important role in fuzzy classifier (FC). In traditional FC, the domain of every input variable is separated into various intervals. All these intervals is assumed to be a FS and a correlated MF is determined. Hence the input space is separated again into various sub regions which are all parallel in to input axes and a fuzzy rule is defined for all these sub regions if the input belongs to the sub region then it is also belongs to the associated class with the sub region.

Further the degrees of M/S of an unidentified input for all the FSs are evaluated and the input is restricted into the class with maximum degree of M/S. Thus the MFs are directly control the performance of the fuzzy classifier [10]. If the position of the MF is changed then the direct methods maximize the understanding rate of the training data by calculating the total increase directly [11]. Estimation of the MF is usually based on the level of information gained with the experiment transferred by the numerical data [12]. Due to the important role of MFs, concepts of fuzzy logic have been applied in many of the control systems for controlling the robot, nuclear reactor, climate, speed of the car, power systems, memory device under fuzzy logic, aircraft flight, mobile robots and focus of a camcorder.

There has been a habit of restrain the MFs into a well-known formats like triangular, trapezoidal and standard Gaussian or sigmoid types [13]. In information systems the incomplete information can be designed by rough sets [20]. Neutrosophy has established the base for the entire family of novel mathematical theories which generalizes the counterparts of the conventional and fuzzy sets [21]. The success of an approach depends on the MFs and hence designing MFs is an important task for the process and the system. Theory of FSs contributes the way of handling impreciseness, uncertainty and vagueness in the software metrics. The uncertainty of the problem can be solved b considering MFs in an expert system under fuzzy setting. Triangular and trapezoidal MFs are flexible representation of domain expert knowledge and where the computational complexity is less. Hence the derivation of the MF is need to be clarified.

The MFs are continuous and maps from any closed interval to [0,1]. Also which are all either monotonically decreasing or increasing or both [22]. A connectively flexible aggregation of crisp and imprecise knowledge is possible with the horizontal MFs which are capable of introducing uncertainty directly [23]. There are effective methods for calculating MFs of FSs connected with few multi criteria decision making problem [25]. Due to the possibility of having some degree of hesitation, one could not define the non-membership degree by subtracting membership degree from 1 [26]. The degree of the fuzzy sets will be determined by FMFs. [30] Crisp value is converted into fuzzy during fuzzification process. If uncertainty exists on the variable then becomes fuzzy and could be characterized by MFs. The degree of MF is determined by fuzzification.

In the real world problems satisfaction of the decision maker is not possible at most of the time due to impreciseness and incompleteness of the information of the data. Fuzziness exist in the FS is identified by the MF [27]. he uncertainty measure is the possible MF of the FS and is interpreted individually. This is the advantage of MFs especially one needs to aggregate the data and human expert knowledge. Designing MFs vary according to the ambition of their use. Membership functions influence a quality of inference [31].

Neutrosophy is the connecting idea with its opposite idea also with non-committal idea to get the common parts with unknown things [36]. Artificial network, fuzzy clustering, genetic algorithm are some methods to determine the MFs and all these consume time with complexities. The MFs plays a vital role in getting the output. The methods are uncertain due to noisy data and difference of opinion of the people. The most suitable shape and widely used MFs in fuzzy systems are triangular and trapezoidal [37]. Properties and relations of multi FSs and its extension are depending on the order relations of the MFs [38]. FS is the class of elements with a continuum of grades of M/S [39].

The logic of neutrosophic concept is an explicit frame trying to calculate the truth, IIndetrminacy and falsity. Smarandache observes the dissimilarity of intuitionistic fuzzy logic (IFL) and neutrosophic logic (NL). NL could differentiate absolute truth (AT) and relative truth (RT) by assigning 1^+ for AT and 1 for RT and is also applied in the field of philosophy. Hence the standard interval [0,1] used in IFS is extended to non-standard $]^-0,1^+[$ in NL. There is not condition on truth, indeterminacy and falsity which are all the subsets of non-standard unitary interval. This is the reason of considering $^-0\ ^-0 \le \inf T \le \inf I \le \inf F \le \sup T \le \sup I \le \sup F \le 3^+$ and which is useful to characterize para consistent and incomplete information [40]. The generalized form of trapezoidal FNs, trapezoidal IFNs, triangular FN and TIFNs are the trapezoidal and triangular neutrosophic fuzzy number [48].

2 Review of Literature

The authors of, [Zysno 1] presented a methodology to determine the MFs analytically. [Sebag and Schoenauer 2] Established algorithms to determine functions from examples. [Bergadano and Cutello 3] proposed an effective technique to learn MFs for fuzzy predicates. [Hansson 4] introduce a stochastic perception of the MFs based on fuzzy logic. [Kelly and Painter 5] proposed a methodology to define N-dimensional fuzzy MFs (FMFs) which is a generalized form of one dimensional MF generally used in fuzzy systems. [Peterson et al. 6] presented a hardware implementation of MF. [Royo and Verdegay 7] examined about the characterization of the different cases where the endurance of the MF is assured.

[Grauel and L. A. Ludwig 8] proposed a class of MFs for symmetrically and asymmetrically in exponential order and constructed a more adaptive MFs. [Straszecka 9] presented preliminaries and methodology to define the MFs of FSs and discussed about application of FS with its universe, certainty of MFs and format. [Abe 10] examined the influence of the MFs in fuzzy classifier. [Abe 11] proved that by adjusting the slopes and positions the performance of the fuzzy rule classification can be improved [Pedrycz and G. Vukovich 12] imposed on an influential issue of determining MF. [J. M. Garibaldi and R. I. John 13] focused more MFs which considered as the alternatives in fuzzy systems [T. J. Ross 14] established the methodology of MFs.

[Brennan, E. Martin 15] proposed MFs for dimensional proximity. [Hachani et al. 16] Proposed a new incremental method to represent the MFs for linguistic terms. [Gasparovica et al. 17] examined about the suitable MF for data analysis in bioinformatics. [Zade and Ismayilova 18] investigated a class of MFs which conclude the familiar types of MFs for FSs. [Bilgic 19] proposed a method of measuring MFs. [Broumi et al. 20] established rough neutrosophic sets and their properties. [Salama et al. 21] proposed a technique for constructing. [Yadava and Yadav 22] proposed an approach for constructing the MFs of software metrics. [Piegat and M. Landowski 23] proposed horizontal MFs to determine the FS instead of usual vertical MFs. [Mani 24] reviewed the relation between different meta theoretical concepts of probability and rough MFs critically.

[Sularia 25] showed their interest of multi-criteria decision analysis under fuzzy environment. [Ali and F. Smarandache 26] Introduced complex NS. [Goyal et al. 27] proposed a circuit model for Gaussian MF. [Can and Ozguven 28] proposed fuzzy logic controller with neutrosophic MFs. [Ali et al. 29] introduced δ-equalities and their properties of NSs. [Radhika and Parvathi 30] introduced different fuzzification methods for intuitionistic fuzzy environment. [Porebski and Straszecka 31] examined diagnosing rules for driving data which can be described by human experts. [Hong et al. 32] accumulated the concepts of fuzzy MFs using fuzzy c-means clustering method.

[Kundu 33] proposed an improved method of approximation of piecewise linear MFs with the support of approximation of cut function obtained by sigmoid function. [Wang 34] proposed the operational laws of fuzzy ellipsoid numbers and straight connection between the MFs which are located on the junctions and edges. [Mani 35] studied the contemplation of theory of probability over rough MFs. [Christianto and Smarandache 36] offered a new perception at Liquid church and neutrosophic MF. [Asanka and A. S. Perera 37] introduced a new approach of using box plot to determine fuzzy Function with some conditions. [Sebastian and F. Smarandache 38] generalized the concepts of NSs and its extension method. [Reddy 39] proposed a FS with two MFs such as Belief and Disbelief. [Lupianeza 40] determined NSs and Topology.

[Zhang et al. 41] derived FMFs analytically. [Wang 42] framed a framework theoretically to construct MFs in a hierarchical order. [Germashev et al. 43] proposed convergence of series of FNs along with Unimodal membership. [Marlen and Dorzhigulov 44] implemented FMF with Memristor. [Ahmad et al. 45] introduced MFs and fuzzy rules for Harumanis examinations [Buhentala et al. 46] explained about the procedure and process of the Takagi-Sugeno fuzzy model. [Broumi et al. 47-55] proposed few concepts of NSs, triangular and trapezoidal NNs.

From this literature study, to the best our knowledge there is no contribution of work on deriving membership function using Matlab under neutrosophic environment and hence it’s a motivation of the present work.

3 Preliminaries

Definition:A trapezoidal neutrosophic number $a=\langle (a,b,c,d);w_a,u_a,y_a\rangle$ is a special neutrosophic set on the real number set R, whose truth-membership, indeterminacy– membership and falsity-membership functions are defined as follows:

$$\mu_a(x)=\begin{cases}\dfrac{(x-a)}{(b-a)}w_a & , \quad a\le x\le b\\ w_a & , \quad b\le x\le c\\ \dfrac{(d-x)}{(d-c)}w_a & , \quad c\le x\le d\\ 0 & , \quad otherwise\end{cases}\qquad v_a(x)=\begin{cases}\dfrac{(b-x)+u_a(x-a)}{(b-a)} & , \quad a\le x\le b\\ u_a & , \quad b\le x\le c\\ \dfrac{(x-c)+u_a(d-x)}{(d-c)} & , \quad c\le x\le d\\ 1 & , \quad otherwise\end{cases}$$

$$\lambda_a(x)=\begin{cases}\dfrac{(b-x)+y_a(x-a)}{(b-a)} & , \quad a\le x\le b\\ y_a & , \quad b\le x\le c\\ \dfrac{(x-c)+y_a(d-x)}{(d-c)} & , \quad c\le x\le d\\ 1 & , \quad otherwise\end{cases}$$

4. Proposed Matlab code to find Trapezoidal Neutrosophic Function

In this section, trapezoidal neutrosophic function has been proposed using Matlab program and for the differennt membership values, pictorical representation is given and the Matlab code is designed as follows.

```
Trapezoidal neutrosophic Function (trin)
%x=45:70;
%[y,z]=trin(x,50,55,60,65, 0.6, 0.4,0.6)%

U truth membership
V indterminacy membership
W :falsemembership

function [y,z,t]=trin(x,a,b,c,d,u,v,w)
y=zeros(1,length(x));
z=zeros(1,length(x));
t=zeros(1,length(x));
for j=1:length(x)
if(x(j)<=a)
    y(j)=0;
    z(j)=1;
    t(j)=1;
elseif(x(j)>=a)&&(x(j)<=b)
y(j)=u*(((x(j)-a)/(b-a)));
z(j)=(((b-x(j))+v*(x(j)-a))/(b-a));
t(j)=(((b-x(j))+w*(x(j)-a))/(b-a));
elseif(x(j)>=b)&&(x(j)<=c)
y(j)=u;
    z(j)=v;
    t(j)=w;
elseif(x(j)>=c)&&(x(j)<=d)
     y(j)=u*(((d-x(j))/(d-c)));
     z(j)=(((x(j)-c)+v*(d-x(j)))/(d-c));
     t(j)=(((x(j)-c)+w*(d-x(j)))/(d-c));
elseif(x(j)>=d)
    y(j)=0;
z(j)=1;
t(j)=1;
end
end
plot(x,y,x,z,x,t)
legend('Membership function','indeterminate function','Non-membership function')
end
```

4.1 Example

The figure 1 portrayed the pictorical representation of the trapezoidal neutrosophic function $a = \langle (0.3, 0.5, 0.6, 0.7); 0.4, 0.2, 0.3 \rangle$

The line command to show this function in Matlab is written below:

```
x=0:0.01:1;
[y,z,t]=trin(x,0.3,0.5,0.6,0.7, 0.4, 0.2,0.3)
```

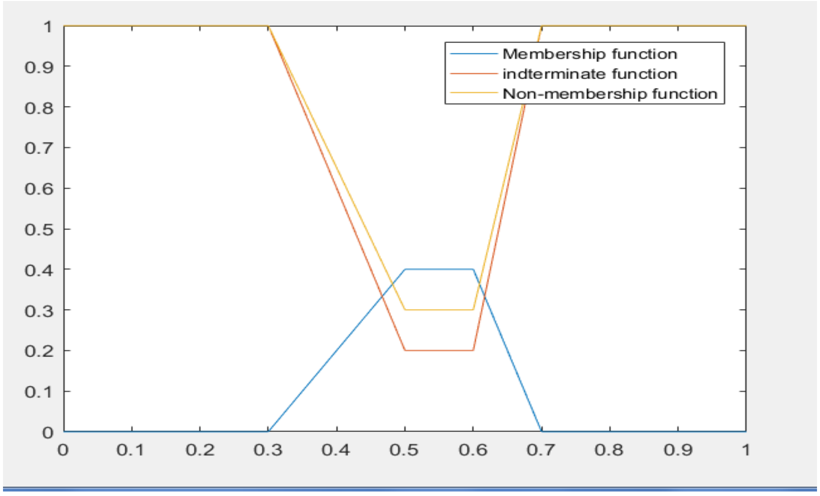

Figure 1: Trapezoidal neutrosophic function for example 4.1

4.2 Example

The figure 2 portrayed the trapezoidal neutrosophic function of $a = \langle (50,55,60,65);0.6,0.4,0.3 \rangle$

The line command to show this function in Matlab is written below:

```
>> x=45:70;
[y,z]=trin(x,50,55,60,65, 0.6, 0.4,0.3)
```

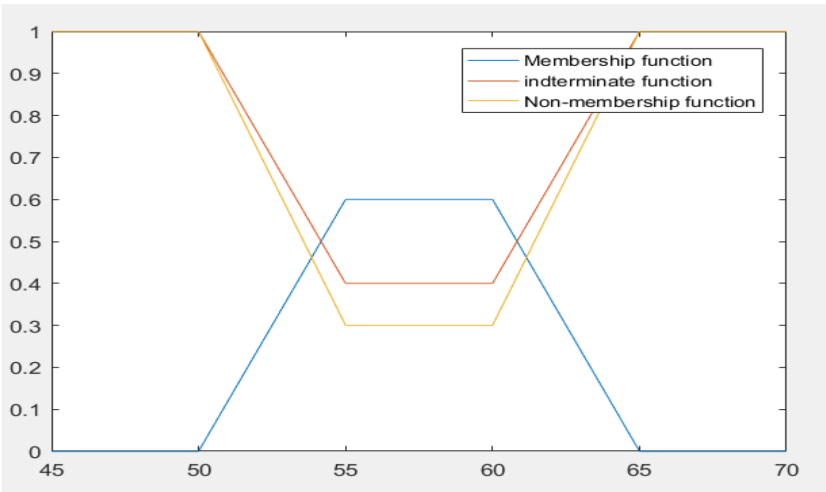

Figure 2: Trapezoidal neutrosophic function for example 4.2

4.3 Example

The figure 3 portrayed the triangular neutrosophic function of $a = \langle (0.3,0.5,0.5,0.7);0.4,0.2,0.3 \rangle$

The line command to show this function in Matlab is written below:

```
x= 0:0.01:1;
[y,z,t]=trin(x,0.3, 0.5,0.5,0.7, 0.4, 0.2,0.3)
```

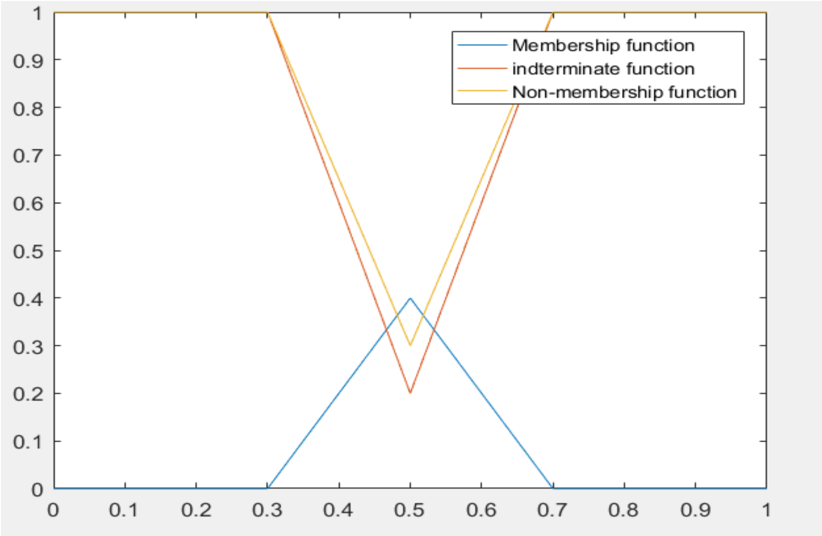

Figure 3: Triangular neutrosophic function for example 3

Remark: if b= c, the trapezoidal neutrosophic function degenerate to triangular neutrosophic function as protrayed in figure 3.

5. Qualitative analysis of different types of graphs

The following analysis helps to know the importance of the neutrosophic graph where the limitations are possible as mentioned in the table for fuzzy and intuitionistic fuzzy graphs.

Types of graphs	Advantages	Limitations
Graphs	• Models of relations • describing information involving relationship between objects • Objects are represented by vertices and relations by edges • Vertex and edge sets are crisp	• Unable to handle fuzzy relation (FR)
Fuzzy graphs (FGs)	• Symmetric binary fuzzy relation on a fuzzy subset • Uncertainty exist in the description of the objects or in the relationships or in both • Able to handle FR with membership value • FGs models are more useful and practical in nature	• Not able to deal interval data
Interval valued FGs	• Edge set of a graphs is a collection of intervals	• Unable to deal the case of non membership
Intuitionistic fuzzy graphs (IntFGs)	• Gives more certainty into the problems • Minimize the cost of operation and enhance efficiency • Contributes a adjustable model to define uncertainty and vagueness exists in decision making • Able to deal non membership of a relation	• Unable to handle interval data

Interval valued IntFGs	• Capable of dealing interval data	• Unable to deal indeterminacy

6. Conclusion

Choosing a MF is an essential task of all the fuzzy and neutrosophic system (Control system or decision making process). Due to the simplicity (less computational complexity) and flexibility triangular and trapezoidal membership functions are widely used in many real world applications. In this paper, trapezoidal neutrosophic membership function is derived using Matlab with illustrative example. In future, this work may be extended to interval valued trapezoidal and triangular neutrosophic membership functions.

Notes

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Received: Juanary 27 2019. Accepted: March 27, 2019