The Evaluation of Fuzzy-Linear and Non- Linear

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Abstract

The linear and non-linear fuzzy systems are modified with examples of some fuzzy solutions by the application of fuzzy sets, arithmetic solutions, and other major formulas. In this topic, the ongoing topic will discuss fuzzy equations, where linear and non-linear portions are equally discussed. Even the non-linear equation is constructing the process of co-efficient of the corresponding fuzzy solution. Here define the unbiased connection between the linear and non-linear equation with Fuzzy sets of problems and some specific examples. Also, dictation the fuzzy appropriate solution on general theory. The upper limit of the model rule and numerical variables structure for practical method. Lastly, the Fuzzy methods are the most perfect estimated mathematical characteristic for both applied and pure mathematics.

Introduction

Since the mathematics theorem, Fuzzy's linear and non-linear system may be converted by Fuzzy set methods. The Fuzzy models, as well as the general rule, depend on the uncertain linear and non-linear solution. Near about the Fuzzy linear and non-linear solution makes distinguish variables over new numerical values. Even the Fuzzy linear equation can be determined by the Fuzzy polynomial, Fuzzy system, and Fuzzy parameters. The numerical subject solution co-operates with the Fuzzy equation like iterative technique, Interpolation and Range-Kutte method, and Fuzzy derivative, integration calculation. Basically the Fuzzy equation as directly inverse to an indefinite fuzzy equation.

The one of triangle fluffy numbers is extremely explaining the main data and defined by

$$\tilde{u} = (\alpha, c, \beta)$$

$$\tilde{u} = \begin{cases} \dfrac{x-\alpha}{c-\alpha}, & \alpha \le x \le c, \\ \dfrac{\beta-x}{\beta-c}, & c \le x \le \beta, \\ 0, & \text{otherwise.} \end{cases}$$

Again be a triangular Fuzzy system, try to define by,

$$\operatorname{supp}(\bar{u}) = [\alpha, \beta], \qquad \operatorname{core}(\bar{u}) = c.$$

(i) $[\underline{x}, \overline{x}] + [\underline{y}, \overline{y}] = [\underline{x} + \underline{y}, \overline{x} + \overline{y}]$,
(ii) $[\underline{x}, \overline{x}] - [\underline{y}, \overline{y}] = [\underline{x} - \overline{y}, \overline{x} - \underline{y}]$,
(iii) *for each* $k \in R$,

$$k[\underline{x}, \overline{x}] = \begin{cases} [k\underline{x}, k\overline{x}], & \text{if } k \geq 0, \\ [k\overline{x}, k\underline{x}], & \text{if } k < 0. \end{cases}$$

Let us assume that every definite Fluffy variable on R and I be F(R). The arrangement will be in matrix form as given below:

$$\begin{aligned} a_{11}x_1 + a_{12}x_2 + \cdots + a_{1n}x_n &= y_1, \\ a_{21}x_1 + a_{22}x_2 + \cdots + a_{2n}x_n &= y_2, \\ &\vdots \\ a_{m1}x_1 + a_{m2}x_2 + \cdots + a_{mn}x_n &= y_m, \end{aligned}$$

Interval fuzzy system of linear equation

A fuzzy system of straight line Ax=b, where A is the original matrix and B is the variables sector, x is all variables calculated, which is arranged by n x n fuzzy arrangement with the special arranging (Abba, *et al.* 2022). Now, will be discussed interval fuzzy language and fluffy numbers, The n by n matrix form can ordinate the reak matrix form as

$$\begin{aligned} a_{11}x_1 + a_{12}x_2 + \cdots + a_{1n}x_n &= y_1 \\ a_{21}x_1 + a_{22}x_2 + \cdots + a_{2n}x_n &= y_2 \\ \vdots \quad\quad \vdots \quad\quad \vdots \quad\quad \vdots \quad\quad \vdots & \\ a_{n1}x_1 + a_{n2}x_2 + \cdots + a_{nn}x_n &= y_n, \end{aligned}$$

Where the coefficient matrix A = (aij), 1<i and j< n.
The Interval Arithmetic of the fuzzy solution can be optimized by the addition, subtraction, product, division, and other materials of numbers (Bhattacharyya, & Mukherjee, S. (2020)). Now if the additional Fuzzy system is expressed by

$$[a_1, a_2] + [b_1, b_2] = [a_1 + b_1, a_2 + b_2]$$

The Subtraction is expressed by

$$[a_1, a_2] - [b_1, b_2] = [a_1 - b_2, a_2 - b_1]$$

The production variables is revealed by

$$[a_1, a_2] \bullet [b_1, b_2] = [\min(a_1b_1, a_1b_2, a_2b_1, a_2b_2), \max(a_1b_1, a_1b_2, a_2b_1, a_2b_2)]$$

The divisional value is revealed by

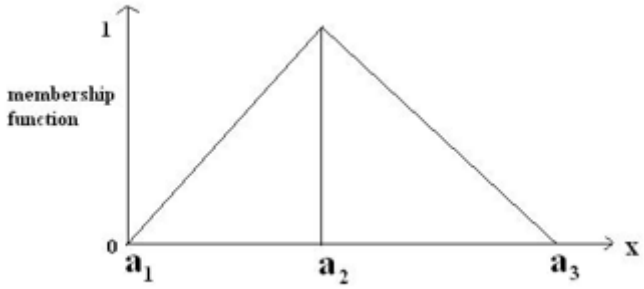
$$[a_1, a_2]/[b_1, b_2] = [\min(a_1/b_1, a_1/b_2, a_2/b_1, a_2/b_2), \max(a_1/b_1, a_1/b_2, a_2/b_1, a_2/b_2)] \quad b_1, b_2 \neq 0$$

The Fuzzy set is defined by , if any variable 'X' be a universal set, then A matrix must be determined as $A = \{(x, \mu_A(x)) / x \in X, \mu_A(x) \in [0,1]\}$, where A(x) is defined an unnecessary number of Fuzzy set (Chakraborty, A, *et al.* 2022). On the other step, the Fuzzy number is to be defined by:

$$\mu_{\tilde{A}}(x) = \begin{cases} l_{\tilde{A}}(x), & a \le x \le b, \\ 1, & b \le x \le c, \\ r_{\tilde{A}}(x), & c \le x \le d, \\ 0, & \text{otherwise}, \end{cases}$$

There have two kinds of Fuzzy numbers, as apparently, one is

a) Triangular Fuzzy number,



A triangular Fuzzy number is to be considered as A(x), which is claimed by

$$\mu_{\tilde{A}}(x) = \begin{cases} 0, & x \le a, \\ \dfrac{x - a_1}{a_2 - a_1}, & x \in [a_1, a_2], \\ \dfrac{a_3 - x}{a_3 - a_2}, & x \in [a_2, a_3], \\ 0, & x \ge a_3. \end{cases}$$

b) Next is a Fuzzy number, a trapezoidal Fuzzy number to be defined by

$$\mu_{\tilde{A}}(x)=\begin{cases}0, & x\le a_1,\\ \dfrac{x-a_1}{a_2-a_1}, & x\in[a_1,a_2],\\ 1, & x\in[a_2,a_3],\\ \dfrac{a_4-x}{a_4-a_3}, & x\in[a_3,a_4],\\ 0, & x\ge a_4.\end{cases}$$

It can also be

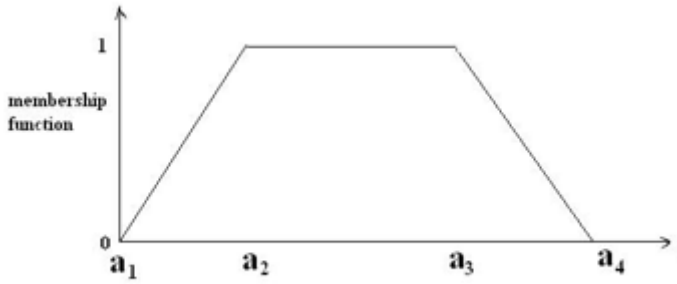


Figure: trapezoidal Fuzzy Number

Fuzzy sets

Let R be one of the real numbers that the matrix set A is to modify as A=x, x belongs to R, where μA(x) is denoted by the Fuzzy set which is closet range 0 to 1 (Dbouk, & Jamali, (2018 $(A)=\{x\in\mathbb{R}|(x)>0\}$ to be mentioned by

The central fuzzy set has to be targeted to the set R, a real number with X=1. The Fuzzy set has also a special effect by A∝= x belonging to R.

In fuzzy Arithmetic, let X= x1,x2,x3 and Y =y1,y2,y3 be two triangular fuzzy variables that belong to R.

$$r\tilde{x}=\begin{cases}(rx_1,rx_2,rx_3), & r\ge 0,\\ (rx_1,-rx_3,-rx_2), & r<0,\end{cases}$$
$$\tilde{x}+\tilde{y}=(x_1+y_1,x_2+y_2,x_3+y_3),$$
$$\tilde{x}-\tilde{y}=(x_1-y_1,x_2+y_3,x_3+y_2),$$
$$\tilde{x}\tilde{y}=\begin{cases}(x_1y_1,x_1y_2+y_1x_2,x_1y_3+y_1x_3), & \tilde{x}>\tilde{0},\tilde{y}>\tilde{0},\\ (x_1y_1,y_1x_2-x_1y_3,y_1x_3-x_1y_2), & \tilde{x}<\tilde{0},\tilde{y}>\tilde{0},\\ (x_1y_1,-x_1y_3-y_1x_3,-x_1y_2-y_1x_2), & \tilde{x}<\tilde{0},\tilde{y}<\tilde{0}.\end{cases}$$

Ranking Function

If we choose a suitable practical theory of non-similar types, there have something parameter types available components of F (Demby's, J., *et al.* 2022). Here has to capacitor the triangular Fuzzy number

$\tilde{a} \prec_{\Re} \tilde{b}$ if $\Re(\tilde{a}) < R(\tilde{b})$,
$\tilde{a} \approx_{\Re} \tilde{b}$ if $\Re(\tilde{a}) = \Re(\tilde{b})$,
$\tilde{a} \succ_{\Re} \tilde{b}$ if $\Re(\tilde{a}) > R(\tilde{b})$.

FLP test

Let's guess if the Fuzzy number is in triangular and trapezoidal numbers with some vectors

$[\tilde{a}_i, \tilde{b}_i], i = 1,2,\cdots,n$, is denoted by
$X = \left([\tilde{a}_1, \tilde{b}_1], [\tilde{a}_2, \tilde{b}_2], \cdots, [\tilde{a}_n, \tilde{b}_n]\right)^T$.

The blunk position or new-void place is the local variable to find the local strategy. The strategic data is to be given there and find the value x (Hadi, S. *et al.* 2022). This is called the FLP test. When again to choss the X set on arranging the module on the FLP test, it can be easier than ever to happen. When the parameters of non-linear and linear numbers are found, the arrangement of A will be like as a fresh number. A strategy the to utilize the non-lined equation and bisection method. It is a non-linear arrangement to compile more like Fuzzy sets. The fuzzy non-linear function can be utilized by the second system (Karlekar, A., *et al.* 2022). The same linear and non-linear concepts may be consecutive triangular Fuzzy numbers, which is defined by

i.e. $\tilde{a}(\lambda x_1 + (1-\lambda)x_2) \geq \min\{\tilde{a}(x_1), \tilde{a}(x_2)\}$, for all
$x_1, x_2 \in R$ and $\lambda \in [0,1]$.

$\tilde{a}$ is normal i.e., there exists an $x \in R$ such tha
$\tilde{a}(x) = 1$

A fuzzy number on R can be a fuzzy system for the compilation characterized:

$$\mu(x) = \begin{cases} 0, \text{if } x \leq a \\ \dfrac{x-a}{b-a}, \text{if } a \leq x \leq b \\ \dfrac{c-x}{c-b}, \text{if } b \leq x \leq c \end{cases}$$

Basis concepts about Fuzzy numbers,

A Fuzzy number is to clarify like U such that R-I, which is a full complete set of Fuzzy components. The many characteristics are followed by the corresponding properties:

1. U is the upper limit for half-persistent
2. U(x) =0 is the outcome of external variables [c,d]
3. There are some basic numbers like a, and b with the focusing points,c<a<b<d
4. U(x) is monotonically expanding on [c, a]
5. U(x) is the monotonic decreasing function on [b,d]

A Fuzzy number full of preservation law,

1. $\underline{u}^{\alpha}$ Is a limited variable for monotonic including left function
2. $\overline{u}^{\alpha}$ Is a limited variable and decreasing left non-stoping variables
3. The number is verified by $\underline{u}^{\alpha} \leq \overline{u}^{\alpha}$ for $\propto$ belongs to [0,1]

Interval arithmetic and Fuzzy Arithmetic

The n x n matrix set is under conditions, which can be produced by

$$a11\ x1 \quad a12\ x2 \quad \ldots\ldots \quad a1n\ xn \quad y_1$$

$$a21\ x1 \quad a22\ x2 \quad \ldots\ldots \quad a2\ nxn \quad y_2$$

$$an1\ x1 \quad an\ 2x2 \quad \ldots\ldots \quad amn\ xn \quad y_n$$

Where the coefficient matrix A, under variable i,j,n is a fresh number. The Fuzzy variables and constant and other section interval construction by the interim number for about Fuzzy set (Maity, S *et al.* 2022).

Interval arithmetic is an interval of A[a1,a2] and B[b1,b2] are two functions in arithmetic functional variables. The operation can be determined by the interval solutions as:

Addition [a1,a2][b1,b2][a1b1,a2 b2]

Subtraction [a1,a2][b1,b2][a1b2,a2b1]

Product [a1,a2][b1,b2] [min(a1b1,a1b2,a2b1,a2b2), max(a1b1,a1b2, a2b1,a2b2)]

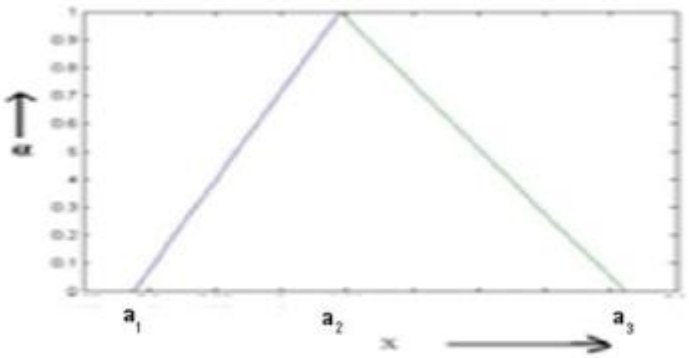


Figure: Triangular Fuzzy Number

(Source: research gate)

Fuzzy linear and Non-linear Equation

Fuzzy number is first introduced by the Lofti A in his researcher paper “Fuzzy sets”. A fuzzy set A in “X” is organized by $\mu_A(x)$, which operates to x variables in interval variables. It is also characterized by the” evaluation of Enrollment” of “X” in A matrix. Any sets can be different for Fuzzy sets (Nozari, H *et al.* 2022). Let A be a Fuzzy set that is mentioned by the universal value “X” and”U”. If take an example “ X” ; lies between 20 to 26

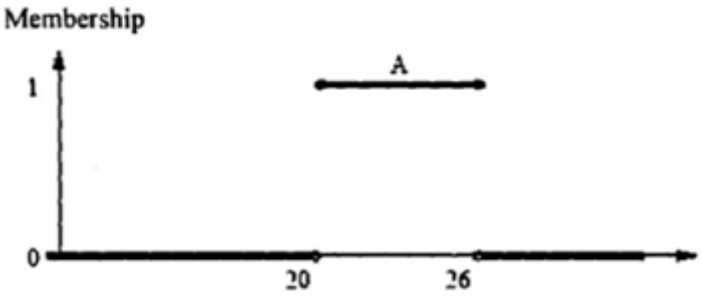


Figure: Membership Function characterizing the Crisp set

(Source: Research Gate)

For the Fuzzy set, the trademark capacity will be ranged between zero to one. The variables might have to be more trustworthy and lesser power grade

$$\mu_A(x)=\begin{cases}0 & \text{if } x\notin A \text{ and there is no ambiguity,}\\ 1 & \text{if } x\in A \text{ and there is no ambiguity,}\\ 0.5 & \text{if there is maximum ambiguity whether } x\in A \text{ or } x\notin A\end{cases}$$

Here the number 3 is avoided through the implementation of 0.02, the few numbers is between 0.09 and the zero number is between 1. It may be focused that variables in a Fuzzy set, instead of similar universal variables. Some of the participation variables might be accepted and full express with maintaining critical conditions. In this case, the natural monotonic strategic condition is a Fuzzy set of components

The operation that assigns a membership value $\mu(x)$ to a given value $x\in U$ is called fuzzification, e.g., Figure 1.2 shows the membership function of the fuzzy set $A=\{x|\ x \text{ is almost between 20 and 26}\}$ i.e., the fuzzy set representing approximately the same concept as that of the crisp set of Figure

Operation on the Fuzzy set, the main task is extending the most natural pure activities. The activities simply evaluate the basic formula (Sakthivel, R. *et al*. 2022). The fuzzy set should have to decrease itself with range values 0 and 1 , if A and B are two mandatory subsets of U under the participation modules $\mu_A(x)$ and μ such that B(x): x such that of an element of universal value U:

(i) Intersection/ AND operation is defined as

$$\mu_{A\cap B}(x)=min\{\mu_A(x),\mu_B(x)\}$$

(ii) Union/OR operation is defined as

$$\mu_{A\cup B}(x)=\max\{\mu_A(x),\mu_B(x)\}$$

(iii) Complement or Negation of any fuzzy set A is defined as

$$\mu_{\bar{A}}(x)=1-\mu_A(x).$$

Fundamental theorem of the Fuzzy Sets

Associative theorem

$(A \cap B) \cap C = A \cap (B \cap C)$; $(A \cup B) \cup C = A \cup (B \cup C)$

Distribution theorem

$(A \cap B) \cup C = (A \cup C) \cap (B \cup C)$; $(A \cup B) \cap C = (A \cap C) \cup (B \cap C)$

Absorption theorem

$A \cup (A \cap B) = A$; $A \cap (A \cup B) = A$.

Zero law

$A \cap \phi = \phi$; $A \cup U = U$.

Identity Law

$A \cup \phi = A$; $A \cap U = A$.

De morgan's law

$\overline{A \cap B} = \overline{A} \cup \overline{B}$; $\overline{A \cup B} = \overline{A} \cap \overline{B}$.

Fuzzy number and Fuzzy Interval:

A Fuzzy variable is similar to standard natural components. Numerically, the Fuzzy variables can become interval natural numbers and A symmetric triangular number has been scrutinized by the

$$\mu_{\bar{A}_j}(x) = \begin{cases} 1 - \dfrac{|c - c_j|}{r_j}, & \text{when} \quad c_j - r_j \le c \le c_j + r_j, \\ 0, & \text{otherwise} \end{cases}$$

Where Ci is denoted by the middle variables for Aj(Cj)= 1 and Rj>0 .

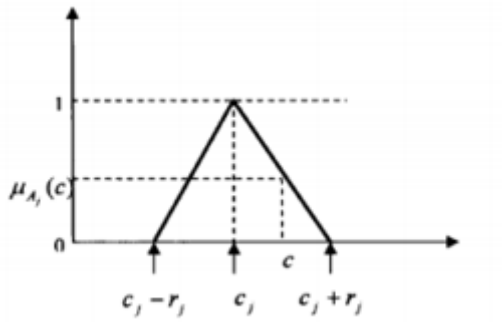


Figure: Symmetrical Triangular Fuzzy number
(Source: Research Gate)

Member Function

A calculatio0by the definite module is to be characterized by the points of gathering individual information between the limit values of 0 to 1. The prime situation and task must identify the difference anywhere without the values 0 and 1. The variable capabilities would be more comfort, speed, and efficiency. As per the topic mentioned above, the following characterized are as:

1. Triangular corresponding task is fulfilled by the common three parametric variables $\text{trim } f(x;a,b,c)=max\left(min\left(\frac{x-a}{b-a},\frac{c-x}{c-b}\right),0\right)$ and is illustrated in fig.
2. The trapezoidal theorem is determined by four parameters, $\text{trapm } f(x;a,b,c,d)=max\left(min\left(\frac{x-a}{b-a},1,\frac{d-x}{d-c}\right),0\right)$ and is illustrated in fig.
3. General capacity is mentioned by the parameters which will be organized $\text{Gaussian}(x;\delta,m)=exp\left(-\frac{(x-m)^2}{\delta^2}\right)$, where δ and m denote the width and the
4. Gaussian participation is organized by the two parameters and is mentioned by $\text{Gaussian}(x;\delta,m)=exp\left(-\frac{(x-m)^2}{\delta^2}\right)$,

Where delta and m denote the width and focusing points with the help of parameters б.

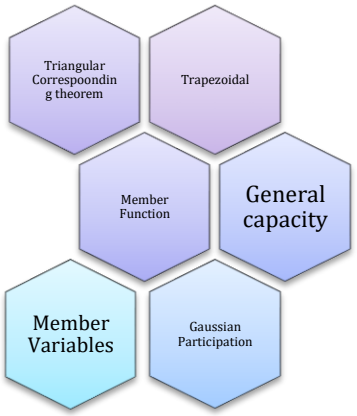


Figure: Member Function
(Source: self-created)

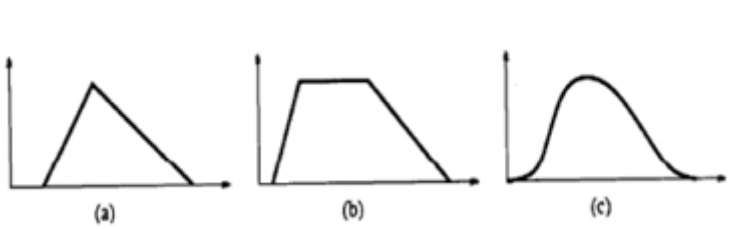


Figure: Membership functions
(Source: Research Gate)

The vital points which are to operate by the specific work

a) Fuzzy sets manufacturing differentiable concepts
b) Fuzzy sets conclude like halfway interpretation in it.
c) The power value and degree have their own value with the Fuzzy sets in the range [0,1].

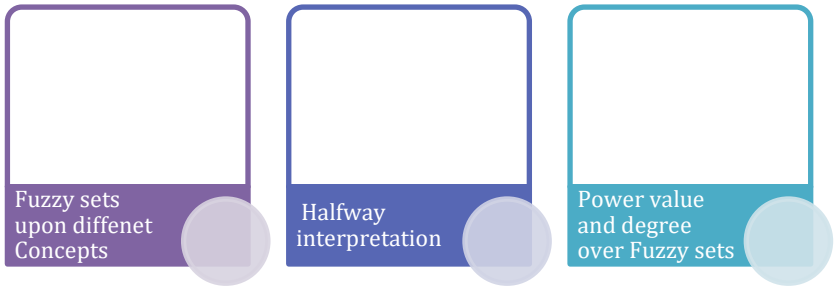


Figure: Fuzzy sets Manufacturing Process
(Source: self-created)

Fuzzy Sets and Probability

The human most considerate and demanding module is a fuzzy set with probability. The very important part of the information with the direct proportion of probabilities and the proportion of degree is called the proportion of information. The Fuzzy set and probability are both connecting technology for equivalence, probability theory can be abstract by its different probability. Let X be the discrete Random components with the specific probability distribution where X= (p1,p2,p3,.....pn).

(P-1) $H(A)$ is minimum if and only if A is a crisp set, i.e.

$\mu_A(x_i)=0$ or 1 for all $x_i : i=1,2,...n$.

(P-2) $H(A)$ is maximum if and only if A is most fuzzy set, i.e.

$\mu_A(x_i)=0.5$ for all $x_i : i=1,2,...n$.

(P-3) $H(A) \geq H(A^*)$, where A^* is sharpened version of A.

(P-4) $H(A)=H(\overline{A})$, where $\overline{A}$ is the complement of A.

Since $\mu_A(x_i)$ and $1-\mu_A(x_i)$ for all i = 1, 2,...,n, give the same degree of fuzziness, therefore, corresponding to Shannon's (1948) entropy of probability distribution Deluca and Termini (1971) defined the following measure of fuzzy entropy:

$$H(A)=-\sum_{i=1}^{n}[\mu_A(x_i)\log\mu_A(x_i)+(1-\mu_A(x_i))\log(1-\mu_A(x_i))]$$

The Role of computation Linear and nonlinear equation

It is the most complex analysis that pc and every numerical value following the advantages of nonlinear mathematics fields. The knowledge of useful materials of the arranging with the technique. Frequently, the numerical components of the Runge Kutta method are a base-point strategy, when arranging the nonlinear situation. For any obstacles situation, the Fuzzy systems can help with updated strategy and technique. Mainly, the Runge-Kutte is best for arranging the Newton technique. In the case of creating strategy, drafting policy, implementation hunt, pre-structural knowledge, and competitive problems and solving the estimated terminal value.

Conclusion

The Fuzzy linear and non-linear equation is organized like the framework. Some of the dependable variables rely on framework components. A genuine Fuzzy linear algorithm with Fuzzy parameters and new organizing factors for any polynomial equation, which is expressed as the newly oriented and straightforward function. In this topic, the different linear and nonlinear components are modified by fuzzy systems and numbers. Although, the parameters of fuzzy systems and the fuzzy solution must not be operated clearly. The co-efficient of the fuzzy solution and the fuzzy limited value not taking any disproval variables.

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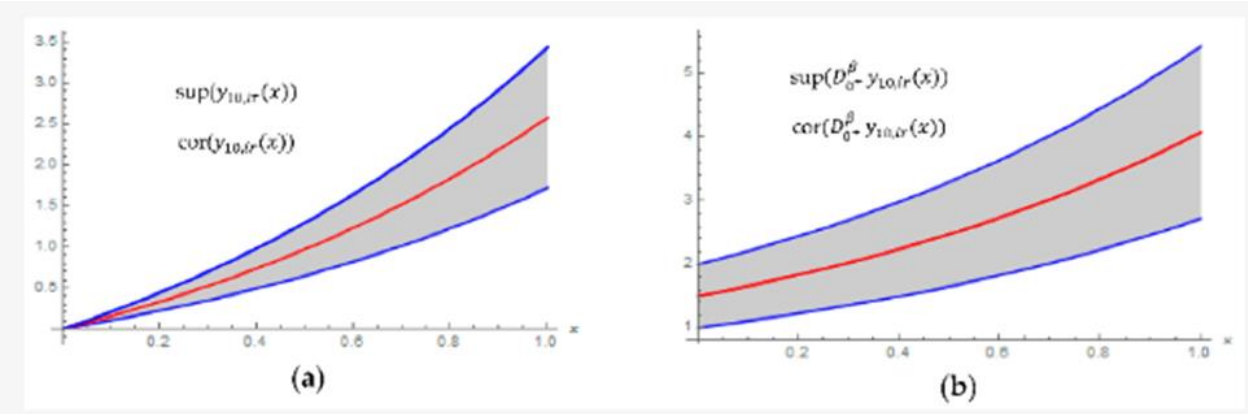
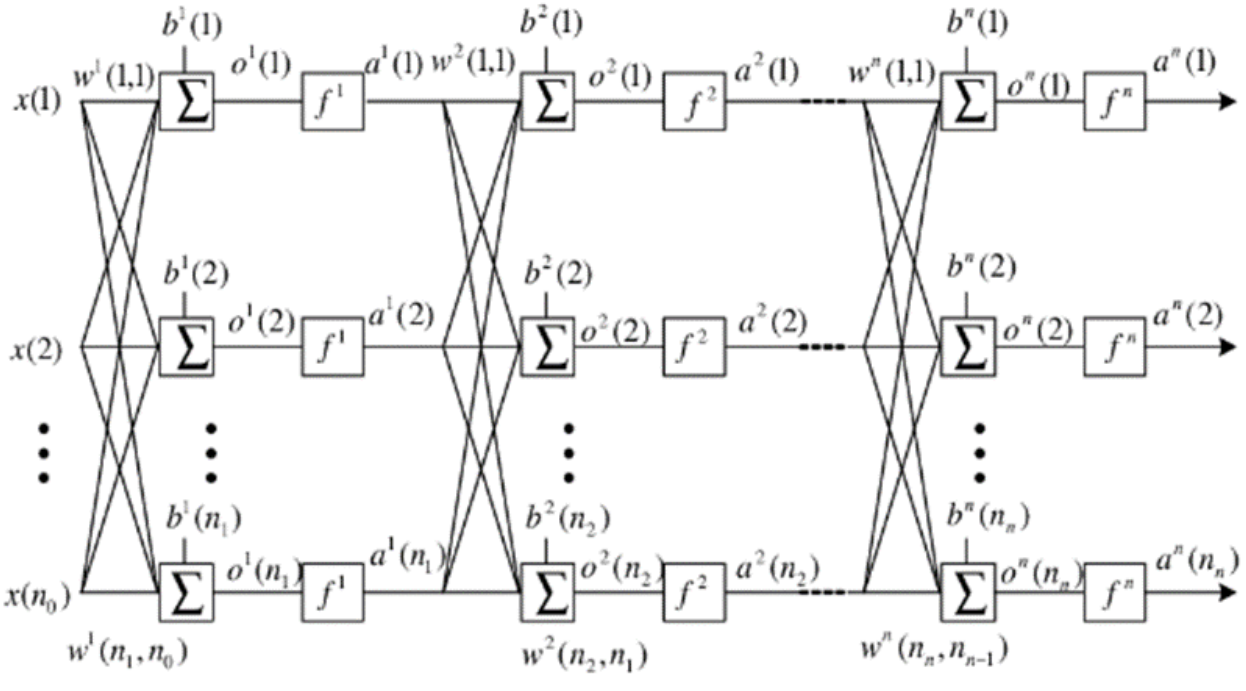
Appendices

Appendix 1: a) The Core and the support Of Fuzzy linear Solution b) The core and support of the derivative of Fuzzy.



(Source: https://www.google.com)

Appendix 2: Numerical Simulation of Fuzzy Non-linear Equation.



(Source: https://www.google.com)