



## Scientific Inquiry and Review (SIR)

Volume 4, Issue 1, January to March 2020

ISSN (P): 2521-2427, ISSN (E): 2521-2435

Journal DOI: <https://doi.org/10.32350/sir>

Issue DOI: <https://doi.org/10.32350/sir.41>

Homepage: <https://journals.umt.edu.pk/index.php/SIR/Home>

Journal QR Code:



Article **A Best Way to Access Gas Station using Fuzzy Logic Controller in Neutrosophic Environment**

Author(s) **Muhammad Naveed Jafar Asma Riffat  
Muhammad Saqlain Aasia Mansoob**

Online Published January to March 2020

Article DOI <https://doi.org/10.32350/sir.41.03>

QR Code of Article



M. Naveed Jafar

To cite this Article  
Jafar MN, Saqlain M, Mansoob A, Riffat A. A best way to Access gas station using fuzzy logic controller in neutrosophic environment. *Sci Inquiry Rev.* 2020;4(1): 30–45.  
[Crossref](#)

Copyright Information This article is open access and is distributed under the terms of Creative Commons Attribution – Share Alike 4.0 International License.

Indexing Agency



A publication of the  
School of Science, University of Management and Technology  
Lahore, Pakistan.

# The Best Way to Access Gas Stations using Fuzzy Logic Controller in a Neutrosophic Environment

Muhammad Naveed Jafar\*, Muhammad Saqlain, Aasia Mansoob,  
Asma Riffat

Department of Mathematics,  
Lahore Garrison University, Lahore, Pakistan

\*[naveedjafar@lgu.edu.pk](mailto:naveedjafar@lgu.edu.pk)

## Abstract

*These days, Google Map is used to find any location and/or to define the route to any given place. Its accuracy is up to 30 meters but if neutrosophic numbers are used, it gives more accuracy. To check the implementation of neutrosophic numbers in Google Map, a system is developed based on Fuzzy Logic Controller (FLC) using neutrosophic numbers to find the gas station which is nearest, less parking car units and with few traffic signals on the way. In this way, it takes less time to reach the available gas station. This system enables the driver to find a fuel station with more accuracy. We took five linguistic inputs including distance, gas availability, parking car unit, amount of gas, and the number of traffic signals to get one output, that is, time. We assigned different neutrosophic soft sets to each linguistic input. FLC inference was designed using 108 rules based on if-then statements to select time to reach the gas station. The results were verified by MATLAB's Fuzzy Logic Toolbox.*

**Keywords:** FLC, neutrosophic numbers, fuzzy toolbox, linguistic inputs, accuracy function

## Introduction

In 1965, the concept of fuzzy set was proposed by Zadeh [1]. Fuzzy Logic (FL) is linked with the fuzzy set theory which is an extension of the crisp set theory. Crisp sets or classical sets follow a bi-valued logic (Boolean logic). Crisp logic deals with exact or precise information. The crisp set  $C$  of universe  $Y$  is defined by a function called membership function or characteristic function  $\mu_C(y)$  such that

$$\mu_C(y): Y \rightarrow \{0,1\}$$

where

$$\mu_C(y) = \begin{cases} 1 & \text{if } y \in C \\ 0 & \text{if } y \notin C \end{cases}$$

Fuzzy logic deals with vague, uncertain and/or imprecise information rather than exact information. The basic concept of fuzzy logic comprises linguistic variables and the values of these variables are words instead of numbers [2, 3, 4]. These are represented by fuzzy sets and are characterized by a membership function. Fuzzy logic is a form of multi-valued logic and it may have truth values between 0 and 1 (including 0 and 1) [5, 6, 7]. A fuzzy set  $\tilde{F}$  of  $Y$  is defined by a function known as the characteristic function or membership function  $\mu_{\tilde{F}}(y)$  of fuzzy set  $\tilde{F}$  such that

$$\mu_{\tilde{F}}(y): Y \rightarrow [0,1]$$

where

$$\begin{aligned} \mu_{\tilde{F}}(y) &= 1 \text{ if } y \text{ is totally in } F \\ \mu_{\tilde{F}}(y) &= 0 \text{ if } y \text{ is not in } F \\ 0 < \mu_{\tilde{F}}(y) < 1 &\text{ if } y \text{ is partly in } F \end{aligned}$$

The applications of fuzzy sets in various fields are discussed by George J. Klir and Bo Yuan [8] and Timothy [9]. In 1974, Mamdani conducted the first fuzzy logic based control experiment for a steam engine [10]. Fuzzy logic systems are used in traffic, medical science, securities, transportation, and electronic devices such as cameras, rice cookers, dishwashers, air conditioners, washing machines, microwave ovens and many other home appliances, as well as in the industrial sector. Many home appliances have been improved using fuzzy logic to conserve electricity and to save time. Fuzzy set theory and its application in decision making have been studied by many researchers [11, 12, 13, 14, 15, 16, 17, 18, 19, 20].

Fuzzy controller is a control system based on fuzzy logic. A Fuzzy Logic Controller (FLC) is a mathematical system that takes on continuous values between 0 and 1 and it examines analog input values in terms of logical variables [21, 22]. It mainly consists of three parts: fuzzifier, fuzzy inference engine and defuzzifier.

Sometimes, it becomes very difficult to assign membership value to fuzzy sets. Consequently, researchers have devised many other tools to avoid difficulties in handling ambiguous and uncertain data. Some of these tools include intuitionist fuzzy numbers [23] and rough sets [24]. Intuitionist fuzzy sets only deal with incomplete information by considering both membership function (truth membership) and non-membership function (falsity membership) [25]. While dealing

with some real life problems in information system, belief system and expert system, we need to work with indeterminate and incomplete information. Neutrosophic set is defined by Smarandache [26]. It is a mathematical tool for handling problems involving indeterminate, imprecise and inconsistent data. In the universe of discourse  $X$ , a neutrosophic set  $A$  is defined as

$$A = \{ \langle x, T_A(x), I_A(x), F_A(x) \rangle : x \in X \}$$

where the functions  $T, I, F : X \rightarrow [0,1]$

and

$$0 \leq T_A(x) + I_A(x) + F_A(x) \leq 3$$

where  $T_A(x), F_A(x), I_A(x)$  defines the degree of membership, degree of non-membership and the degree of indeterminacy respectively of each element to the set  $A$ .

Maji [27] combined soft set with neutrosophic set and introduced the theory of neutrosophic soft set. The author described the equality of two super sets and super soft sets, super set and subset of a neutrosophic soft set, complement of a neutrosophic soft set, null neutrosophic soft set and absolute neutrosophic soft set. Binary operations such as OR, AND, union, intersection and De Morgan's Law with examples were applied on neutrosophic soft set.

The researcher identified the location of fuel station and designed a smart system that automatically indicates the quantity of fuel in the tank. It also indicates the nearest fuel station when there is a low amount of fuel left in the tank through digital displays embedded in vehicles and maps. Jafar et al. [28, 29, 30] worked on decision-making problems within a neutrosophic environment. Saqlain et al. [31, 32, 33] worked on neutrosophic and neutrosophic hypersoft environment.

In this research, a new method is developed based on FLC using neutrosophic numbers to identify the location of a particular fuel station in unfamiliar areas which takes less time to reach.

## 2. Statement of Problem

These days, Google Map is used to find the location and/or to define the route to any given place. It has an accuracy of up to 30 meters. This accuracy can be improved by designating neutrosophic numbers as membership values.

### 2.1. Case Study

Driver / user may forget to check the fuel tank before the start of a long journey or while travelling to distant places. The driver may not know the location of petrol pump in an unknown locality. Other issues regarding vehicles (breakdown, puncture) may also cause the driver to panic while travelling.

### 2.2. Objective

To check the implementation of this number in Google Map, a system is developed based on FLC using neutrosophic numbers. The objective of this research is to bring more accuracy in locating a fuel station that takes less time to reach.

### 2.3. Proposed Model

A model based on FLC is designed in this research which relies on five linguistic inputs and one linguistic output to locate a fuel station.

Linguistic inputs include the following:

1. Distance
2. Gas availability
3. Parking Car Unit (PCU)
4. Amount of gas
5. Number of traffic signals

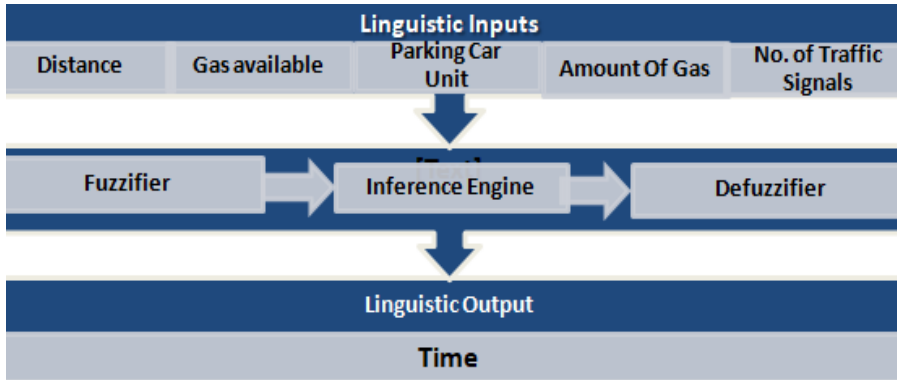
**Table 1.** Linguistic Inputs

<b>Linguistic Inputs</b>					
<b>No.</b>	<b>Distance</b>	<b>Gas Availability</b>	<b>Parking Car Unit</b>	<b>Amount of Gas</b>	<b>Number of Traffic Signals</b>
1	Small	Yes	Less	Yes	1
2	Medium	No	Medium	No	2
3	Large		High		3

Linguistic output comprises time.

Figure 1 shows the basic approach to FLC. This system is based on FLC and it consists of three parts, that is, fuzzifier, inference engine (fuzzy rule selector) and defuzzifier. FLC inference engine was designed using 108 rules based on if-then statements to select time to

reach the gas station. We assigned different neutrosophic soft sets to each linguistic input.



**Figure 1.** Basic approach to FLC

**Table 2.** Neutrosophic Inputs

	Representation	Symbol	Neutrosophic Soft Sets
<b>Distance</b>			
1	Small	S	(0.2,0.4,0.6)
2	Medium	M	(0.3,0.1,0.9)
3	Large	L	(0.7,0.9,0.3)
<b>Gas Availability</b>			
1	Yes	Y	(0.9,0.6,0.2)
2	No	N	(0.1,0.8,0.9)
<b>Parking Car Unit (PCU)</b>			
1	Less	L	(0.4,0.6,0.5)
2	Medium	M	(0.6,0.7,0.8)
3	High	H	(0.8,0.1,0.4)
<b>Amount of Gas</b>			
1	Yes	Y	(0.7,0.2,0.9)
2	No	N	(0.8,0.1,0.4)
<b>Number of Traffic Signals</b>			
1	1		(0.7,0.8,0.5)
2	2		(0.5,0.7,0.6)
3	3		(0.4,0.6,0.7)

108 rules were formed using linguistic inputs to obtain the said linguistic output, that is, time. It was analyzed in terms of conditional statements (if-then statement) given below,

**Rule 1**

If (distance is S) and (gas availability is Y) and (PCU is L) and (amount of gas is Y) and (number of traffic signals is 1) then (time is X).

**Rule 2**

If (distance is S) and (gas availability is Y) and (PCU is L) and (amount of gas is Y) and (number of traffic signals is 2) then (time is X).

**Rule 3**

If (distance is S) and (gas availability is Y) and (PCU is L) and (amount of gas is Y) and (number of traffic signals is 3) then (time is X).

•  
•  
•

**Rule 108**

If (distance is H) and (gas availability is Y) and (PCU is H) and (amount of gas is Y) and (number of traffic signals is 3) then (time is XXXXXXXXXXX).

By assigning neutrosophic soft sets to each linguistic variable, we solved the above 108 rules using the following formula of the intersection of two neutrosophic soft sets:

$$T_{K(e)}(m) = \min (T_{H(e)}(m), T_{G(e)}(m))$$

$$I_{K(e)}(m) = \frac{I_{H(e)}(m) + I_{G(e)}(m)}{2}$$

$$F_{K(e)}(m) = \max (F_{H(e)}(m), F_{G(e)}(m)), \forall e \in C$$

**Rule 1**

$$\overbrace{[(0.2,0.4,0.6) \cap (0.9,0.6,0.2)]}^A \cap \overbrace{[(0.4,0.6,0.5) \cap (0.7,0.2,0.9)]}^B \cap (0.7,0.8,0.5) \quad (1)$$

$$F_{h e}(x) \cap F_{g e}(x) = [(0.2,0.4,0.6) \cap (0.9,0.6,0.2)]$$

$$\min (0.2,0.9) = 0.2$$

$$\frac{0.4 + 0.6}{2} = \frac{0.10}{2} = 0.5$$

$$\max (0.6,0.2) = 0.6$$

$$F_l e(x) = [(0.2,0.4,0.6) \cap (0.9,0.6,0.2)] = (0.2,0.5,0.6)$$

(A)

$$F_i e(x) \cap F_j e(x) = [(0.4,0.6,0.5) \cap (0.7,0.2,0.9)]$$

$$\min(0.4,0.7) = 0.4$$

$$\frac{0.6 + 0.2}{2} = \frac{0.8}{2} = 0.4$$

$$\max(0.5,0.9) = 0.9$$

$$F_m e(x) = [(0.4,0.6,0.5) \cap (0.7,0.2,0.9)] = (0.4,0.4,0.9)$$

(B)

Put (A) and (B) in (1)

$$(0.2,0.5,0.6) \cap (0.4,0.4,0.9) \cap (0.7,0.8,0.5)$$

(2)

$$F_l e(x) \cap F_m e(x) = [(0.2,0.5,0.6) \cap (0.4,0.4,0.9)]$$

$$\min(0.2,0.4) = 0.2$$

$$\frac{0.5 + 0.4}{2} = \frac{0.9}{2} = 0.45$$

$$\max(0.6,0.9) = 0.9$$

$$F_n e(x) = [(0.2,0.5,0.6) \cap (0.4,0.4,0.9)] = (0.2,0.45,0.9)$$

(2) becomes

$$F_n e(x) \cap F_k e(x) = [(0.2,0.45,0.9) \cap (0.7,0.8,0.5)]$$

$$\min(0.2,0.7) = 0.2$$

$$\frac{0.45 + 0.8}{2} = \frac{1.25}{2} = 0.625$$

$$\max(0.9,0.5) = 0.9$$

$$F_o e(x) = [(0.2,0.45,0.9) \cap (0.7,0.8,0.5)] = (0.2,0.625,0.9)$$

$$F_o e(x) = (0.2,0.4,0.6) \cap (0.9,0.6,0.2) \cap (0.4,0.6,0.5) \cap (0.7,0.2,0.9) \cap (0.7,0.8,0.5)$$

$$= (0.2,0.625,0.9)$$

Then, we converted this neutrosophic number to crisp number using the accuracy function given below:

$$\begin{aligned} \text{Accuracy Function} &= A_F(N) \\ &= \frac{T(x) + I(x) + F(x)}{3} \\ &= \frac{0.2 + 0.625 + 0.9}{3} \\ &= 0.58 \end{aligned}$$

Similarly, we solved all other rules



**Table 3.** Application of Accuracy Function

Sr.#	Distance	Gas Available	Parking Car Unit (PCU)	Amount of Gas	Number of Traffic Signals	Output	Accuracy
							Function = $A_F(N)$ $T(x) + I(x) + F(x)$ =
1	(0.2,0.4,0.6)	(0.9,0.6,0.2)	(0.4,0.6,0.5)	(0.7,0.2,0.9)	(0.7,0.8,0.5)	(0.2,0.63,0.9)	0.58
2	(0.2,0.4,0.6)	(0.9,0.6,0.2)	(0.4,0.6,0.5)	(0.7,0.2,0.9)	(0.5,0.7,0.6)	(0.2,0.58,0.9)	0.56
3	(0.2,0.4,0.6)	(0.9,0.6,0.2)	(0.4,0.6,0.5)	(0.7,0.2,0.9)	(0.4,0.6,0.7)	(0.2,0.53,0.9)	0.54
4	(0.2,0.4,0.6)	(0.9,0.6,0.2)	(0.4,0.6,0.5)	(0.8,0.1,0.4)	(0.7,0.8,0.5)	(0.2,0.61,0.9)	0.47
5	(0.2,0.4,0.6)	(0.9,0.6,0.2)	(0.4,0.6,0.5)	(0.8,0.1,0.4)	(0.5,0.7,0.6)	(0.2,0.56,0.6)	0.45
6	(0.2,0.4,0.6)	(0.9,0.6,0.2)	(0.4,0.6,0.5)	(0.8,0.1,0.4)	(0.4,0.6,0.7)	(0.2,0.51,0.7)	0.47
7	(0.2,0.4,0.6)	(0.9,0.6,0.2)	(0.6,0.8,0.7)	(0.7,0.2,0.9)	(0.7,0.8,0.5)	(0.2,0.65,0.7)	0.58
8	(0.2,0.4,0.6)	(0.9,0.6,0.2)	(0.6,0.8,0.7)	(0.7,0.2,0.9)	(0.5,0.7,0.6)	(0.2,0.6,0.9)	0.57
9	(0.2,0.4,0.6)	(0.9,0.6,0.2)	(0.6,0.8,0.7)	(0.7,0.2,0.9)	(0.4,0.6,0.7)	(0.2,0.55,0.9)	0.55
10	(0.2,0.4,0.6)	(0.9,0.6,0.2)	(0.6,0.8,0.7)	(0.8,0.1,0.4)	(0.7,0.8,0.5)	(0.2,0.64,0.7)	0.51
11	(0.2,0.4,0.6)	(0.9,0.6,0.2)	(0.6,0.8,0.7)	(0.8,0.1,0.4)	(0.5,0.7,0.6)	(0.2,0.59,0.7)	0.5
12	(0.2,0.4,0.6)	(0.9,0.6,0.2)	(0.6,0.8,0.7)	(0.8,0.1,0.4)	(0.4,0.6,0.7)	(0.2,0.54,0.7)	0.48
13	(0.2,0.4,0.6)	(0.9,0.6,0.2)	(0.8,0.1,0.4)	(0.7,0.2,0.9)	(0.7,0.8,0.5)	(0.2,0.56,0.9)	0.55
14	(0.2,0.4,0.6)	(0.9,0.6,0.2)	(0.8,0.1,0.4)	(0.7,0.2,0.9)	(0.5,0.7,0.6)	(0.2,0.51,0.9)	0.54
15	(0.2,0.4,0.6)	(0.9,0.6,0.2)	(0.8,0.1,0.4)	(0.7,0.2,0.9)	(0.4,0.6,0.7)	(0.2,0.46,0.9)	0.52
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
108	(0.7,0.9,0.3)	(0.9,0.6,0.2)	(0.8,0.1,0.4)	(0.7,0.2,0.9)	(0.4,0.6,0.7)	(0.4,0.53,0.9)	0.61

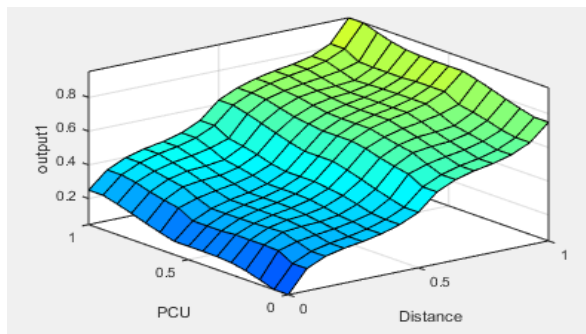
## 2.4. Significance

The use of neutrosophic numbers instead of fuzzy numbers in Google Map gives more accuracy in locating the desired place. A system based on FLC which uses neutrosophic numbers enables us to get more accuracy in locating a fuel station that takes less time to reach.

## 3. Achievements

### 3.1. Comparison of MATLAB Results with Calculated Results

We calculated results from MATLAB Fuzzy Toolbox and compared them with calculated results.



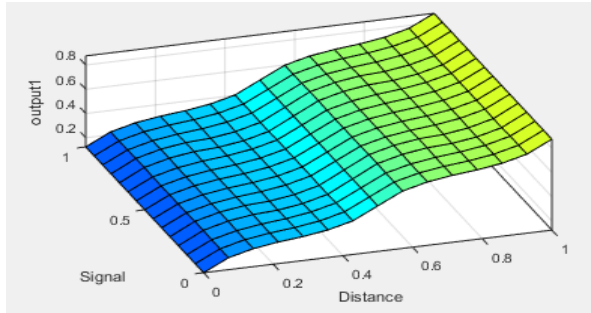
**Figure 2.** Relation between distance and PCU MATLAB fuzzy toolbox view

The above graph shows the relationship of distance and PCU with time. As we move away from the origin, distance and PCU increase and time also increases.

A direct relationship between PCU and distance verification of the above graph can be seen below based on calculated results.

**Table 4.** Relation between Distance and PCU MATLAB Fuzzy Toolbox Linguistic View

Distance	Gas Availability	Parking Car Unit (PCU)	Amount of Gas	Number of Traffic Signals	Output
S	Y	L	Y	1	0.58
M	Y	M	Y	1	0.6



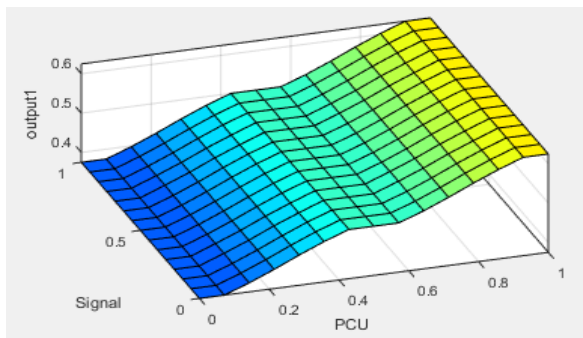
**Figure 3.** Relation between distance and signal MATLAB fuzzy toolbox view

The above graph shows the relationship between distance and signal with time. As we move away from the origin, distance and signal increase and time also increases.

A direct relationship between PCU and distance verification of the above graph can be seen below based on calculated results.

**Table 5.** Relation between Distance and Signal MATLAB Fuzzy Toolbox View

Distance	Gas Availability	Parking Car Unit (PCU)	Amount of Gas	Number of Traffic Signals	Output
S	Y	H	Y	1	0.55
L	Y	H	Y	3	0.61



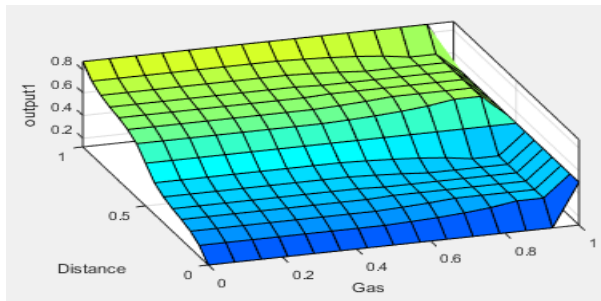
**Figure 4.** Relation between PCU and signal MATLAB fuzzy toolbox view

The above graph shows the relationship between PCU and signal with time. As we move away from the origin, PCU and signal increase and time also increases.

A direct relationship between PCU and distance verification of the above graph can be seen below based on calculated results.

**Table 6.** Relation between PCU and Signal MATLAB Fuzzy Toolbox View

Distance	Gas Availability	Parking Car Unit (PCU)	Amount of Gas	Number of Traffic Signals	Output
M	Y	L	Y	1	0.58
M	Y	M	Y	2	0.59



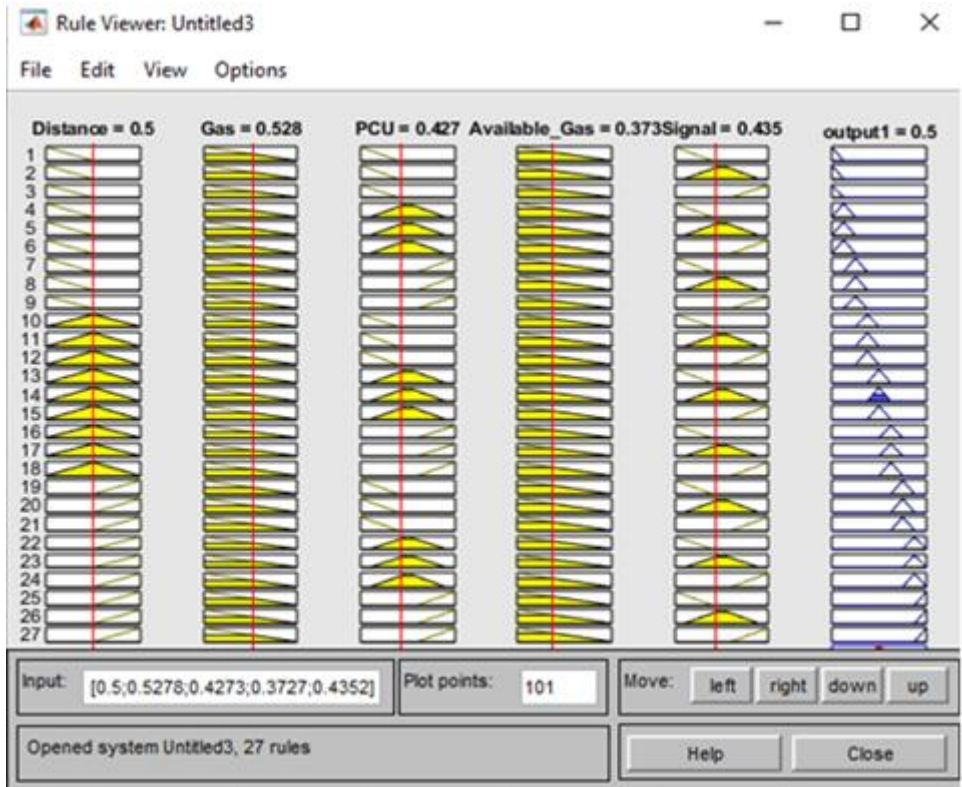
**Figure 5.** Relation between gas and distance MATLAB fuzzy toolbox view

The above graph shows the relationship of the amount of gas and signal with time. As we move away from the origin, distance and signal increase and time also increases.

A direct relationship with PCU and distance verification of the above graph can be seen below based on calculated results.

**Table 7.** Relation between Gas and Distance MATLAB Fuzzy Toolbox View

Distance	Gas Availability	Parking Car Unit (PCU)	Amount of Gas	Number of Traffic Signals	Output
M	Y	L	Y	1	0.58
L	Y	L	Y	1	0.66



**Figure 6.** MATLAB’s rule viewer

When we select Distance  $M = 0.5$ , Amount of Gas  $Y = 0.528$ , PCU  $M = 0.427$ , Gas Availability  $Y = 0.373$ , Number of Traffic Signals  $2 = 0.435$ , then Output is 0.5.

Also from the calculation,

**Table 8.** MATLAB Results and Neutrosophic Soft Set Results

Distance	Gas Availability	Parking Car Unit (PCU)	Amount of Gas	Number of Traffic Signals	Output
S	Y	M	N	2	0.5

MATLAB results and neutrosophic soft set results are approximately the same.

## 4. Conclusion

We used Neutrosophic numbers to calculate the output, that is, time. Neutrosophic numbers were used as membership values in FLC and the results were calculated in MATLAB's Fuzzy Logic Toolbox. Also, these results were verified by taking neutrosophic soft numbers as membership functions and manually calculated by applying aggregate operators of neutrosophic numbers. So, in the future, neutrosophic numbers can be used as membership values in FLC to obtain accuracy.

## References

- [1] Zadeh LA. Fuzzy sets. *Inf Control*. 1965;8(3): 338–353.
- [2] Novák V. Fuzzy sets in natural language processing. In *An introduction to Fuzzy logic applications in intelligent systems* (pp. 185-200). Springer, Boston, MA: Springer; 1992.
- [3] Godjevac J. *Idées nettes sur la logique floue*. Godjevac, Jelena: PPUR presses polytechniques; 1999.
- [4] Gupta MM. Fuzzy logic and neural systems. In *Fuzzy Set Theory and Advanced Mathematical Applications* (pp. 225-244). Springer, Boston, MA: Springer; 1995
- [5] Zadeh LA. The concept of a linguistic variable and its application to approximate reasoning-I. *Inf Sci*. 1975:8(3); 199–249.
- [6] Zadeh LA. The concept of a linguistic variable and its application to approximate reasoning-II. *Inf Sci*. 1975:8(4); 301–357.
- [7] Zadeh LA. The concept of a linguistic variable and its application to approximate reasoning-III. *Inf Sci*. 1975:9(1); 43–80.
- [8] Klir GJ, Yuan B. *Fuzzy sets, fuzzy logic, and fuzzy systems: selected papers* (vol. 6). New Jersey: World Scientific; 1996.
- [9] Timothy R. *Fuzzy logic with engineering applications*. vol. 2. New York: Wiley; 2004.
- [10] Mamdani EH. Application of fuzzy algorithms for control of simple dynamic plant. In *Proceedings of the Institution of Electrical Engineers* (vol. 121, no. 12, pp. 1585-1588). IET; 1974.
- [11] *Fuzzy Logic*. The free encyclopedia from Wikipedia website. <http://En.Wikipedia.Org/Wiki/Fuzzy Logic>

- [12] Zadeh LA. The role of fuzzy logic in modeling, identification and control. In: George JK, Bo Y, *Fuzzy sets, Fuzzy logic, and Fuzzy systems: selected papers by Lotfi A Zadeh* (pp. 783-795). New Jersey: World Scientific Publishing; 1996.
- [13] Zadeh LA. Understanding Fuzzy logic: an interview with Lotfi Zadeh. *IEEE Signal Process Mag.* 2007;5: 101–105.
- [14] Han H, Su CY, Stepanenko Y. Adaptive control of a class of nonlinear systems with nonlinearly parameterized fuzzy approximators. *IEEE Trans Fuzzy Syst.* 2001;9(2): 315–323.
- [15] Abbas SE, Hebeshi MA, Taha IM. On upper and lower continuous Fuzzy multifunctions. *Punjab Univ J Math.* 2015;47: 105–117.
- [16] Akram M, Shahzadi G. Certain characterization of m-polar Fuzzy graphs by level graphs. *Punjab Univ J Math.* 2017;49: 1–12.
- [17] Kamacı H, Atagün AO, Aygün E. Difference operations of soft matrices with applications in decision making. *Punjab Univ J Math.* 2019;51(3): 1–21.
- [18] Khan MA, Sumitra. Common fixed point theorems for converse commuting and OWC maps in Fuzzy metric spaces. *J Math.* 2012;44, 57–63.
- [19] Kumar D, Haider Y. Fuzzy logic based control system for washing machines. *Int J Comput Sci Technol.* 2013;4(2): 198–200.
- [20] Mahmood T, Mehmood F, Khan Q. Some generalized aggregation operators for cubic hesitant fuzzy sets and their applications to multi criteria decision making. *Punjab Univ J Math.* 2017;49: 31–49.
- [21] Shakeel M, Abdullah S, Fahmi A. Triangular cubic power aggregation operators and their application to multiple attribute group decision making. *Punjab Univ J Math.* 2018;50: 75–99.
- [22] Shakeel M, Abdullah S, Khan MSA, Rahman K. Averaging aggregation operators with interval Pythagorean trapezoidal fuzzy numbers and their application to group decision making. *Punjab Univ J Math.* 2018;50(2): 147–170.

- [23] Voskoglou MG. Application of Fuzzy numbers to assessment of human skills. *Punjab Univ J Math*. 2018;50: 85–96.
- [24] Pedrycz W. *Fuzzy control and Fuzzy systems* (2<sup>nd</sup> ed.). Somerset, England: Research Studies Press Ltd; 1993.
- [25] Hájek P. *Metamathematics of Fuzzy logic* (Vol. 4). London: Springer Science & Business Media; 2013.
- [26] Smarandache F. Neutrosophic set: a generalization of the intuitionistic fuzzy set. *Int J Pure Appl Math*. 2005;24(3): 287.
- [27] Maji PK. Neutrosophic soft set. *Ann Fuzzy Math Inform*. 2013;5(1), 157–168.
- [28] Jafar NM, Farooq A, Javed K, Nawaz N. (2020), Similarity measures of tangent, cotangent and cosines in neutrosophic environment and their application in selection of academic programs. *Int J Comput Appl*. 177(46): 17–24
- [29] Jafar NM, Imran R, Hassan S, Riffat A, Shuaib R. medical diagnosis using neutrosophic soft matrices and their compliments. *Int J Adv Res Comput Sci*, 2020;11(1): 1–3.
- [30] Jafar NM, Saqlain M, Shafique AR, Khalid M, Akbar H, Naveed A. New Technology in Agriculture Using Neutrosophic Soft Matrices with the Help of Score Function. *Int J Neutrosophic Sci*. 2020;3(2): 78–88.
- [31] Saqlain M, Jafar NM, Riaz M. (2020), A new approach of neutrosophic soft set with generalized Fuzzy TOPSIS in application of smart phone selection. *Neutrosophic Sets Syst*. 2020;32: 307–316.
- [32] Saqlain M, Moin S, Jafar NM, Saeed M, Samandrache F. Aggregate operators of neutrosophic hypersoft set. *Neutrosophic Sets Syst*. 2020;32: 294–306.
- [33] Saqlain M, Jafar N, Moin S, Saeed M, Broumi S. (2020), Single and multi-valued neutrosophic hypersoft set and tangent similarity measure of single valued neutrosophic hypersoft sets. *Neutrosophic Sets Syst*. 2020;32: 317–329.