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Towards Intelligent Road Traffic Management Based on Neutrosophic Logic: A Brief Review

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Abstract: Road traffic management has been a serious concern in the transportation sector for many years now. The explosion of the number of cars along with the inability of creating new high-capacity road infrastructures in big cities makes mitigating this danger a problem for the scientific research community. Traffic congestion contributes to increased pollution, economic loss, and a general deterioration in the quality of life. As a result, researchers are being asked to cope with the complexity of establishing effective and smooth traffic flow. However, as in traffic congestion control, real-world decision-making problems are always fraught with uncertainty and indeterminacy. The neutrosophic environment has been applied successfully to deal with these problems and recently, researchers tried to use various neutrosophic approaches to tackle the traffic congestion problem. This paper provides a brief overview of the most recently used neutrosophic techniques to handle traffic congestion and transportation problems in general. The aim of the investigation is to summarize the available neutrosophic traffic flow problems and their progress to enable future researchers to differentiate the major problems to be manipulated and identify conditions to be optimized.

Keywords: Road traffic control; Intelligent Traffic Management System; Neutrosophic environment; Neutrosophic logic; Neutrosophic approaches.

1. Introduction

Transport researchers have long worked to improve traffic management on urban roads. Congestion is a critical issue affecting negatively road users and traffic controllers. Despite the important attempts and research that have been made to minimize traffic congestion, this serious problem continues to worsen [1]. The direct reason for this is the slow development of transportation systems and road capacity as well as the explosive growth of urban and rural population rates, which causes an increase in vehicle demand and hence the vehicles' number on the roads. Thus, traffic congestion is a serious matter that should be urgently addressed in order to offer a safe and healthy environment for people [1].

In order to manage the traffic flow, the road traffic management system takes various real-time decisions [3]. As existing practical situation traffic flow parameters involve vagueness due to several uncontrolled factors so that the developed models unable to tackle such conditions [4]. For instance, the number of vehicles in a specific lane in real-time is always unknown precisely. Furthermore, the non-recurrent traffic congestion sources, which are special incidents that happen suddenly as shown in Figure 1, cannot be accurately managed. This gives rise for the use of fuzzy logic controllers in traffic management endeavor. The concept of fuzzy set, which is initialized by Zadeh in 1965 [5], has been widely applied in problems that include uncertainty and vagueness since it imitates human perception and thinking based on linguistic information.

Neutrosophic concept was initialized by Florentin Smarandache in 1995 as an extension of the fuzzy logic and its derivatives. It goes beyond the fuzzy set and fuzzy logic by expressing the false membership information and beyond the intuitionistic fuzzy set and intuitionistic fuzzy logic by handling the indeterminacy of information. Neutrosophic logic is a logic in which each proposition is estimated to have a degree of truth (T), a degree of indeterminacy (neutrality) (I), and a degree of falsity (F). It can then handle the uncertainty and impreciseness related to the road traffic flow that the fuzzy logic may fail to properly address.

The forthcoming part of the study is arranged as follows. In Section 2, an introduction of the basic concepts that we focus on in this paper is provided. In Section 3, some of the available methods in the scientific literature that tackle road traffic problems based on the Neutrosophic sets are presented. In Section 4, a comparative analysis is provided for the different presented methods. Finally, section 5, introduces the main challenges and future perspectives and concludes our brief review.

Figure 1: Non-recurrent traffic congestion sources.

2. Basic concepts

This section introduces some of the fundamental principles covered in this paper as shown in Figure 2.

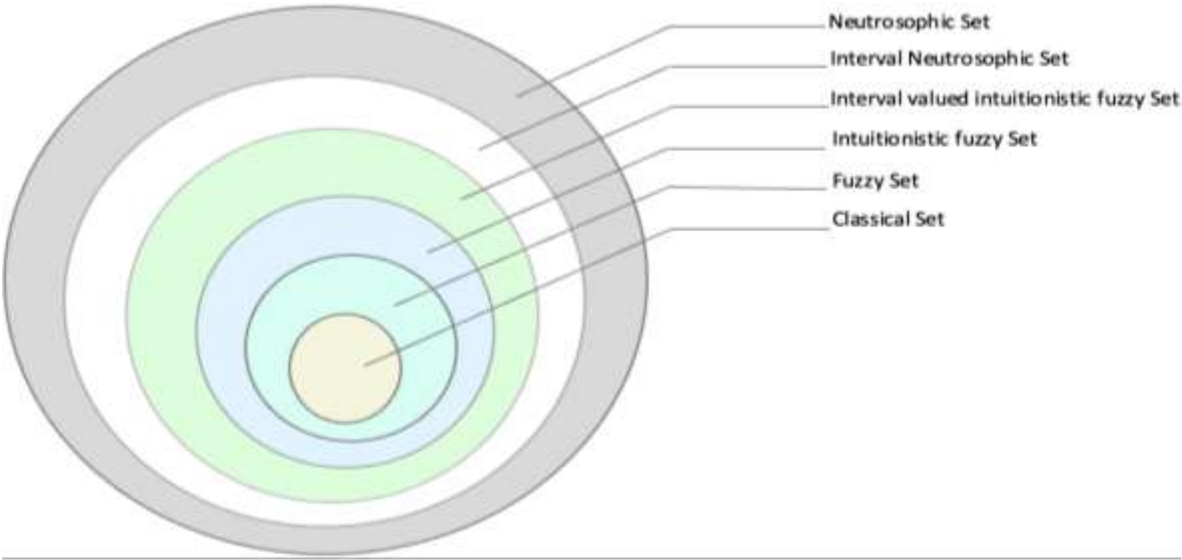

Figure 2: Relationship between classical, fuzzy, intuitionistic fuzzy, interval-valued intuitionistic fuzzy, interval neutrosophic sets, and neutrosophic sets.

2.1 Fuzzy set (FS)

When we encounter vagueness in our daily life activities fuzzy theory is the right tool to overcome it. It is often applicable transportation engineering and planning. In classical set theory if an element belongs to a set its membership degree is simply 1 and if it does not belong to a set its membership degree is 0. In contrast, in the theory of vagueness the degree to which the element belongs to a set is not clearly known, instead we use values in the interval [0,1]. This type of set is called fuzzy sets. So, a fuzzy set is identified by its membership degree alone.

2.2 Intuitionistic fuzzy set (IFS)

Let X be the universe of discourse. A set $A \in X$ that can be written in the form $A = \{\langle X, \mu_A(x), \upsilon_A(x), \rangle;\ x \in X$ is called an intuitionistic fuzzy set where, $\mu_A(x)$, $\upsilon_A(x)$ are degree of acceptance and degree of rejection of the element x in A respectively are each subsets of [0,1] such that, $0 \le \mu_A(x) + \upsilon_A(x) \le 1$.In addition, for A in X , $\pi_A(x) = 1 - \mu_A(x) - \upsilon_A(x)$ is called the intuitionistic fuzzy set index or the degree of indeterminacy of x∈ X and for every $x \in X$, $0 \le \pi_A \le 1$.

2.3 Neutrosophic logic

In Neutrosophic logic each statement has a truth degree (T), an indeterminacy degree (neutrality) (I), and a falsity degree(F), where T, I, F ⊆ [0, 1] and $0 \le T + I + F \le 3$. The degrees T, I, F are nondependent to each other.

2.4 Single valued neutrosophic set (SVNS)

If in a set A every member of A has a degree of belongingness ($\mu_A(x)$), a degree of indeterminacy ($\upsilon_A(x)$) and a degree of non-belongingness ($\omega_A(x)$), with $\mu_A(x), \upsilon_A(x), \omega_A(x) \in [0,1]$,then the set is a single valued neutrosophic set and $x \equiv x(\mu_A(x), \upsilon_A(x), \omega_A(x))$ is a single valued neutrosophic element of A such that we have the following relations between the three degrees

$$0 \le \mu_A(x), \upsilon_A(x), \omega_A(x) \le 1 \text{ and}$$

$$0 \leq \mu_A(x) + \upsilon_A(x) + \omega_A(x) \leq 3 \;\; \forall x \in X$$

2.5 Interval valued neutrosophic set

If in a set A every member of A has a degree of belongingness $\mu_A(x)$, a degree of indeterminacy $\upsilon_A(x)$ and a degree of non-belongingness $\omega_A(x)$, with $\mu_A(x), \upsilon_A(x), \omega_A(x)$ are all elements of the closed interval $[0,1]$, and $\mu_A(x) = [\underline{\mu}_A(x), \overline{\mu}_A(x)]$, $\upsilon_A(x) = [\underline{\upsilon}_A(x), \overline{\upsilon}_A(x)]$, $\omega_A(x) = [\underline{\omega}_A(x), \overline{\omega}_A(x)]$ are respectively upper and lower degree of belongingness , upper and lower degree of indeterminacy and upper and lower degree non-belongingness , then A is an interval valued neutrosophic set.

2.1 Soft Set

Neutrosophic sets may be combined with other types of sets to get another hybrid structure which can be applicable in transport engineering. One of such type of set is a soft set which is initiated for the first time by Molodtsov in 1999 and defined as follows.

Let X be a universe of discourse and P be a set of parameters. Let $P(X)$ denote the power set of X and $A \subseteq P$. A combination (F, A) is called a soft set over X, where F is a mapping given by $F: A \rightarrow P(X)$. In other words, a soft set over U is a parameterized family of subsets of the universe X. For $e \in A$, $F(e)$ may be considered as the set of e-approximate elements of the soft set (F, A). Clearly, a soft set is not a set in a classical sense.

3. The Application of Neutrosophic Theory in Intelligent Traffic Management Systems

This section outlines some of the suggested Neutrosophic logic-based solutions for managing traffic flow and transportation problems in general. Table 1 summarizes these approaches.

Jun Ye introduced in [6] the neutrosophic linear equations, the neutrosophic matrix and the neutrosophic matrix operations relying on the Neutrosophic Numbers concept. Then, he chose the traffic flow case study to apply the neutrosophic linear equations system in a real scenario and demonstrate its efficiency in handling the indeterminacy problem of a real environment.

For traffic management, El Bendadi et al. suggested in [7] two clustering strategies namely, Credal C-Means clustering (CCM) and Neutrosophic C-Means clustering (NCM). When overlapping items are found, both proposed techniques have a comparable propensity to construct a novel cluster that determines the imprecision object. The indeterminacy cluster is interpreted differently by each approach. The CCM algorithm forms a number of meta-cluster that is proportionate to the number of singleton clusters, while the NCM approach represents all indeterminate items with a single indeterminacy cluster.

In [8], Muhammad Akram created a traffic-monitoring road network model based on the notion of bipolar neutrosophic planar graphs. The suggested approach may be used to compute and track the yearly accident proportion. The overall number of accidents can be reduced by monitoring and installing additional security measures.

Nagarajan et al. studied in [9] a triangular interval type-2 Schweizer, Sklar weighted arithmetic (TIT2SSWA) operator, a triangular interval type-2 Schweizer and Sklar weighted geometric (TIT2SSWG) operator based on Schweizer and Sklar triangular norms. Afterward, the validity of these operators was examined based on a numerical example, and then an interval neutrosophic Schweizer and Sklar weighted arithmetic (INSSWA) and interval neutrosophic Schweizer and Sklar weighted geometric (INSSWG) operators were proposed in order to extend these operators to an interval neutrosophic environment. Moreover, a new traffic flow approach is introduced based on the presented operators as well as an improved score function. The score function was used to analyze the traffic flow based on TIT2SSWA and INSSWA operators as well as TIT2SSWG and INSSWG operators. Both used methods identified the same intersection as the more congested one.
In another paper [10], Nagarajan et al. used the Gauss Jordan method to examine the flow of traffic in a neutrosophic environment and under various indeterminacy ranges.
In another paper, Nagarajan et al. proposed [11] Dombi Single valued Neutrosophic Graph and Dombi Interval-valued Neutrosophic Graph. Furthermore, the Cartesian product and composition of the suggested graphs were extracted and then verified with the numerical example. The Neutrosophic Controllers' importance and their use in managing traffic are theoretically emphasized. It has been pointed out that the triangular norms T Norm and T-Conorm can be utilized rather than minimum and maximum operations in control systems like traffic management systems. Finally, the pros and cons of some fuzzy logic methods and neutrosophic logic methods have been discussed.
Finally, In another paper, Nagarajan et al. [12] examined the traffic flow control in a neutrosophic environment under diverse ranges of indeterminacy and then proposed a road traffic study based on Crisp, Fuzzy, and Neutrosophic.

Phillip Smith introduced in [13] a Multiple Attribute Decision-Making (MADM) method for picking out sustainable public transportation systems under uncertainty, which means using incomplete information involving single-valued neutrosophic sets (SVNSs) which means in turn a generalization of a classical set, a fuzzy set, and an intuitionistic fuzzy set. In the context of the Public Transit Sustainable Mobility Analysis Tool (PTSMAT) SVNSs and SVNS connectives are demonstrated and used with a composite (multiple attributes) sustainability index. The results of the presented case study of PTSMAT for the UBC Corridor study in Vancouver, Canada are identical to those of the original study despite the fact that neutrosophic formalism opens a wide range of possibilities for recognition of uncertainty in sustainability assessment. The results of the presented case study of PTSMAT for the UBC Corridor study in Vancouver, Canada are similar to those obtained in the original study despite the fact that to recognize the uncertainty in sustainability assessment, neutrosophic formalism opens a wide range of possibilities.

In [14], R. Sujatha et al. used Fuzzy Cognitive Map and Induced Fuzzy Cognitive Map to examine road traffic flow patterns at a congested intersection in Chennai, India's biggest city.

A new emergency transport model that simulates emergency transport from the logistics center to each incident area as well as between incident locations was created by Lin Lu and Xiaochun Luo in [15]. The emergency transshipment problem was transformed into a multiattribute decision-making problem using the SVNS concept in indeterminate and uncertain circumstances. The suggested technique was applied in an emergency operation scenario to rank and select effective transportation routes.

In developing countries, to control traffic flow at signaled crossroads, The fixed-time traffic light control method is used. However, this method does not allow congested intersections to identify their level of congestion and therefore allows vehicles to cross the intersection. To deal with this challenge, road managers must set their opinions and create an intelligent automated decision-making system to replace them. The manager's decision process might be analyzed utilizing the approach of Interval-Valued Neutrosophic Soft Set (IVNSS) theory to take advantage of fuzziness in traffic flow and determine efficient timings and optimal phase change. Enalkachew Teshome Ayele et al. [16] suggested an IVNSS traffic management system that can ameliorate traffic congestion control. It evaluates the different phases and timings of the traffic light based on the real-time traffic density at the intersection rather than a fixed phase and duration.

Under neutrosophic statistics, Muhammad Aslam created a control chart for neutrosophic exponentially weighted moving average (NEWMA) using recurrent sampling in [17]. To track traffic collisions on the highway (RTC), the author employed a NEWMA chart. The proposed NEWMA chart goes beyond the previously proposed control charts for tracking the RTC, according to a simulated study and a real-world example. According to the comparative study, the presented NEWMA chart might be utilized to successfully regulate RTC. The new chart will allow changes in accidents and injuries to be detected faster than previous charts.

In [18], Rayees et al. identified four different kinds of Plithogenic hypersoft sets (PHSS) relying on the application-specific features number used, the type of alternatives, or the degree of attribute value appurtenance. These four PHSS categories cover the fuzzy and neutrosophic situations that may have neutrosophic applications in symmetry. They then proposed a new multi-criteria decision-making (MCDM) technique based on PHSS (TOPSIS) as an extension of the method for order preference by similarity to an ideal solution. Uncertainty complicates a variety of real-world MCDM scenarios, necessitating the division of each selection criterion or attribute into attribute values and the independent evaluation of all options against each attribute value. The suggested PHSS-based TOPSIS may be utilized to tackle real MCDM challenges that are precisely defined by the PHSS notion depending on the provided criteria. The proposed PHSS-based TOPSIS resolves a parking space Choosing issue in a fuzzy neutrosophic environment in a real-world application, and it is verified by comparing it to fuzzy TOPSIS.

In [19], Simic et al. expanded the CRITIC and MABAC approaches to type-2 neutrosophic sets for the selection of public transportation pricing systems, and Pamucar et al. proposed in [20] a hybrid model that comprised fuzzy FUCOM and neutrosophic fuzzy MARCOS for assessing alternative fuel vehicles for sustainable road transportation in the United States.

For controlling road accidents and injuries when the smoothing constant is uncertain Muhammad Aslam and Mohammed Albassam [21] proposed an S2N NEWMA control chart to track road accidents and injuries by employing repeated sampling. The tables and control chart figures are generated using the neutrosophic Monte Carlo simulation. This chart identifies changes in accidents and injuries quicker than prior charts, lowering and pinpointing the causes of traffic accidents and injuries.

In [22], M. Abdel-Basset et al. stated that autonomous vehicles play an important role in the intelligent transportation system; nonetheless, these vehicles pose a number of risks. As a result, a novel hybrid model is proposed for recognizing these hazards. This process contains uncertainty and foggy data. The neutrosophic hypothesis is used to deal with uncertainty. The neutrosophic theory provides three membership functions: true, indeterminacy, and false (T, I, F). In this study, the concept of MCDM is combined with neutrosophic theory since autonomous vehicles have several contradictory criteria. First, the Analytic Hierarchy Process defines the weights of criteria (AHP). Second, to assess the dangers of autonomous cars, approaches such as Multi-Attributive Border Approximation Area Comparison (MABAC) and Preference Ranking Organization Method for Enrichment Evaluations II are utilized (PROMETHEE II). In the case study, ten distinct choices were used. An understanding and a sensitivity analysis of this process in an uncertain environment are given to demonstrate the robustness of the suggested model.

In [23], F. Xiao et al. introduced a method that ameliorates the multi-valued neutrosophic MULTIMOORA method relying on prospect theory. The suggested approach is utilized to select a suitable subway building scheme. Firstly, Multi-valued neutrosophic sets (MVNNs) were utilized to offer evaluations of subway building. Secondly, the IGMVNWHM operator is added, which takes into account the inputs interactions. Thirdly, a new distance measure between two MVNNs is determined. The fourth approach is an IMVN-PT-MULTIMOORA technique.

Nasrullah Khan et al. presented in this article [24] neutrosophic multiple dependent state sampling control chart for the neutrosophic EWMA statistic. The control chart coefficients were set by the neutrosophic statistical interval method for different process settings. The neutrosophic average run lengths and the neutrosophic standard deviation have been estimated by the Monte Carlo simulation to verify the efficiency of the suggested chart. A comparison of this chart with existing charts has been done. As result, this chart is comparatively robust in monitoring the incomplete, and unclear quality characteristics. However, the production process should adhere to the normal distribution, which represents a limitation of this study. The presented chart could be used in the chemical, packing, and electronic industries.

In [25], Fayed et al. introduced a robust occupancy detection system that relies on a novel fusion approach for merging heterogeneous sensor data that significantly enhances occupancy detection efficiency. The suggested method is suitable for use in traffic management.

Table 1. An overview of the most Neutrosophic approaches that deal with the problem of road traffic congestion

Year	Ref	Scope	Contributions and Methods used	Topics
2017	Jun Ye [6]	Traffic Flow	A traffic flow problem application example is	▪ Neutrosophic Numbers and Their Operational Laws.

			offered to demonstrate the application and efficacy of employing the system of neutrosophic linear equations to solve the indeterminate traffic flow problem.	▪ Neutrosophic Linear Equations and Neutrosophic Matrices. ▪ A Neutrosophic Linear Equations System Solving. ▪ A Traffic Flow Problem Application.
2018	El Bendadi et al. [7]	Road Safety	The Credal C-means (CCM) and Neutrosophic C-means (NCM) algorithms describe the credal clustering and neutrosophic clustering respectively. To demonstrate their behavior and efficacy, real-world road safety data were tested and their results compared.	▪ CCM working Principle. ▪ NCM working Principle. ▪ Comparison of the CCM and NCM algorithms for different datasets based on different criteria namely, error rate, imprecision rate, intra class inertia.
	Muhammad Akram [8]	Traffic Monitoring	Some applications of bipolar neutrosophic graphs were described.	▪ Bipolar Neutrosophic Graphs. ▪ Applications to MCDM. ▪ Bipolar Neutrosophic Planar Graphs. ▪ Applications of Neutrosophic Planar Graphs. ▪ Bipolar Neutrosophic Line Graphs. ▪ Application of Bipolar Neutrosophic Line Graphs.
2019	Nagarajan et al. [9]	Traffic Flow	To control traffic flow that has been analyzed by determining the intersection with more vehicles, an improved score function for interval neutrosophic numbers (INNs) is proposed.	▪ Basic concepts of a traffic control system, fuzzy logic' role, output methods from fuzzy linguistic terms and structure of the fuzzy control system. ▪ Operational laws. ▪ Neutrosophic perspective. ▪ Traffic flow using proposed operators.
	Nagarajan et al.[10]	Traffic Flow Control	MATLAB is used to investigate traffic flow control in a neutrosophic environment using Gauss Jordan method.	▪ Bipolar Neutrosophic Line Graphs. ▪ Basic concept: Single Valued Neutrosophic Set, Gauss Jordan Method.

				▪ Description of the proposed methodology
	Nagarajan et al.[11]	Traffic Control	Dombi Single valued Neutrosophic Graph and Dombi Interval valued Neutrosophic Graph have been suggested. As well as the theoretical significance of Neutrosophic Controllers and their application in traffic control management.	▪ Basic Concepts: Graph, Fuzzy Graph, Dombi Fuzzy Graph, Single Valued Neutrosophic Graph, Interval Valued Neutrosophic Graph, Triangular Norms, Dombi Triangular Norms, Hamacher Triangular Norms, Dombi and Hamacher Triangular Norms Special Cases, Standard Products of graphs, Neutrosophic Controllers. ▪ Proposed Dombi Interval Valued Neutrosophic Graph. ▪ Traffic Control Comparison based on divers types of set and Graph theory.
	Nagarajan et al.[12]	Traffic Flow	The Jordan approach is used in this study to evaluate traffic flow control in a neutrosophic environment.	▪ Neutrosophic number. ▪ Application: at analyzing the traffic flow
	Phillip Smith [13]	Transportation Sustainability Assessment	A multi-attribute decision-making method for selecting sustainable public transportation systems in the uncertainty, represented by SVNSs and their connectives.	▪ Neutrosophic sets. ▪ Single-valued neutrosophic averages. ▪ Score functions ▪ Cross-entropy. ▪ Application to sustainable transport.
	R Sujatha et al. [14]	Crowded junction in Chennai	Some traffic congestion causes are unknown and indeterminate, Thus, Neutrosophic Cognitive Maps is employed in this paper to identify a solution.	▪ Fundamental concepts of Fuzzy Cognitive Maps and Neutrosophic Cognitive Maps. ▪ Description of the traffic congestion problem. ▪ Comparison of expert' opinion.
2020	Lin Lu and Xiaochun Luo [15]	Emergency Transportation Problem	In confusing and uncertain environments, the SVNS is used to turn the emergency transshipment problem into a	▪ Methods: The Basic Concept of Single-Valued Neutrosophic Set.

			multiattribute decision-making problem.	▪ A new emergency transport model is presented.
	Enalkachew Teshome Ayele [16]	Traffic light Control	To manage both phase change and green time extension / termination based on the traffic circumstances at any time, an algorithm is proposed in this paper.	▪ Preliminary concepts: Soft Set, Single valued neutrosophic set, Interval Valued Neutrosophic Set. ▪ The proposed two stage IVNSS traffic light control model and its verification.
	Muhammad Aslam [17]	Road traffic crashes monitoring	The suggested Neutrosophic Exponentially Weighted Moving Average (NEWMA) chart is used to monitor traffic accidents.	▪ Neutrosophic EWMA chart using repetitive sampling. ▪ Comparative study based on Road Traffic Crashes simulation data. ▪ Using real-time data to monitor road traffic accidents.
	Muhammad Rayees Ahmad [18]	Solve a parking problem	In a real-world application, the suggested Plithogenic fuzzy hypersoft set (PHSS)-based TOPSIS solves a parking place selection problem in a fuzzy neutrosophic environment.	▪ The Four Classifications of PHSS. ▪ The Proposed PHSS-Based TOPSIS Applied to a Parking Issue.
2021	Simic et al. [19]	Public transportation pricing system selection	The public transport services pricing is a complicated problem that authorities must handle since numerous elements must be observed when deciding on a pricing scheme. A two-stage hybrid MCDM model based on type-2 neutrosophic numbers (T2NNs) is presented to offer researchers and practitioners a simple and flexible decision-making tool.	–
	Pamucar et al. [20]	Assessment of alternative fuel vehicles for sustainable	The goal of this research is to create a multi-criteria decision-making (MCDM) framework that combine fuzzy FUCOM and	▪ AFV assessment methodology. ▪ Case study in the New Jersey.

	road transportation	neutrosophic fuzzy MARCOS for prioritizing various Alternative Fuel Vehicles (AFVs) for sustainable transportation.	
Muhammad Aslam and Mohammed Albassam [21]	Reducing and identifying the causes of traffic accidents and injuries	The use of a neutrosophic statistical approach for road safety.	▪ The Proposed S2N −NEW M A Chart. ▪ The Proposed Control Chart
M. Abdel-Basset et al. [22]	Risk Management in Autonomous Vehicles	To represent and handle uncertainty and incomplete risk information consistently and reliably, the proposed model combines the single-valued neutrosophic sets, the AHP, MABAC, and PROMETHEE II methodologies.	▪ Neutrosophic linguistic information. ▪ Suggested hybrid MCDM approach.
Fei Xiao et al. [23]	Traffic flow and its application in a multi-valued way	This paper improves the multi-valued neutrosophic MULTIMOORA method.	▪ Preliminaries: Multi-valued neutrosophic sets (MVNNs), Heronian Mean (HM) operators, The MULTIMOORA method, Prospect theory. ▪ IGMVNWHM operator, Distance measure between two MVNNs and IMVN-PT-MULTIMOORA method. ▪ Solution framework for MVN-MCGDM problem.
Nasrullah Khan [24]	Tracking Traffic Accidents and Injuries	The Use of Neutrosophic Exponentially Weighted Moving Average Statistics in Tracking Road Accidents and Injuries	▪ Methodology of the Proposed Chart. ▪ The Proposed NEWMA X-Bar Control Chart Based on Multiple Dependent State Sampling. ▪ The Proposed Neutrosophic Control Chart Simulation Study.

2022	Noha S. Fayed [25]	Improving occupancy Detection system.	The suggested approach addresses sensor data uncertainty using Neutrosophy. It also enhances reliability by combining data from various sensors. Training and testing time is decreased since it only employs one feature created by fusing input from many sensors.	▪ The efficient occupancy detection system and its evaluation.

4. Comparative Analysis

Table 2 below gives a comparative analysis of the different neutrosophic methods used recently in the literature for traffic management and transportation system improvement in general, in order to understand each method's key role, advantages, and limitations.

Table 2. Comparison of different neutrosophic methods used for traffic management.

Types	Advantages	Limitations
Neutrosophic Sets	▪ In neutrosophic theory, we use neutrosophic numbers -> $a + Ib$ where $a, b \in R$. ▪ Addresses uncertainty as well as uncertainty caused by unpredictable environmental disturbances ▪ The Neutrosophic set presents the degrees of membership, indeterminacy, and non-membership of the element $x \in$ S. For instance: μ(0.5,0.1,0.4) ∈ S means probability of 50% $'x'$ belong to the set S 10% $'x'$ is not in S and 40% is undecided. ▪ The operations are entirely different.	▪ Calculations errors can't be rounded up and down.
Interval Valued Neutrosophic Sets	▪ Adaptability and flexibility. ▪ handles more uncertainty and indeterminacy. ▪ Calculations errors can be rounded up and down. ▪ Can handle problems with one number or a group of numbers in the real unit interval.	▪ Can't handle criterion incomplete weight information.

Neutrosophic Graphs	▪ An optimized output is possible if the paths and the terminal points are uncertain.	▪ Can't deal with more uncertainty.
Interval Valued Neutrosophic Graphs	▪ Can address additional uncertainty discovered in terminal points (vertices) and paths (edges).	▪ Can't handle incomplete criterion weight information.
Dombi Neutrosophic Graphs	▪ Can handle indeterminacy.	▪ Can't handle uncertainty for interval values.
Dombi Interval Valued Neutrosophic Graphs	▪ Can handle uncertainty well for interval values.	▪ Can't handle incomplete criterion weight information.
Type 2 fuzzy and interval neutrosophic	▪ Based on a rule that fully accepts uncertainties. ▪ Adaptability.	▪ The membership functions are fuzzy thus computational complexity is high.
Single valued neutrosophic sets (SVNSs)	▪ Can handle uncertain and inconsistent information.	▪ Not flexible and practical than interval valued neutrosophic sets
Neutrosophic Cognitive Maps	▪ Provide the ability to treat the relation between two vertices as indeterminate.	▪ No comparative work has been done with respect to the existing models in relation to waiting time ▪ Applicability for other types of traffic junction is not clear
Neutrosophic Markov	▪ Can handle the occurred indeterminacy in a system. ▪ The neutrosophic Markov chain's equilibrium state demonstrates the ability of traffic states transitions accurately in order to predict the traffic.	▪ Applicable only for T-shaped traffic junction ▪ Applicability for other types of traffic junction is not clear

Interval valued neutrosophic soft sets	▪ Regarding the stability of traffic states, verification of ergodicity can be achieved in a minimum of steps. ▪ Applied parameterization tools in which others techniques lack ▪ The method is verified with numerical example	▪ The model is not validated. ▪ Other parameters like pedestrian movements and emission of pollutants are not considered

5. Conclusion and Future Challenges

For many years, road traffic control has been a major problem in the transportation field. Traffic jam adds to increased pollution and an overall decline in life quality. Real-world decision-making challenges, such as controlling traffic congestion, are always vague and indeterminate. Therefore, the neutrosophic environment has been effectively used to address these problems, and lately, researchers attempted to employ several neutrosophic techniques to address transportation problems.

In this paper, we have conducted a brief review that deal with the use of neutrosophic logic in the field of traffic control. The review concentrated on several methods for describing and optimizing traffic flow. The review looked at several traffic management approaches in a neutrosophic environment and analyzed the benefits and limitations of the offered models. Many research conducted comparisons with real data sets and demonstrated the benefits of using neutrosophic sets and neutrosophic logic.

According to the literature review, there are still unresolved concerns and issues that need to be addressed in future investigations. The issues include (i) controlling a large number of junctions at the same time to maintain uninterrupted traffic flow, especially during traffic jams, (ii) A comparative study between the developed models and the existing models should be made to test the efficiency of the developed model with respect to the average vehicle delay which is the major measure of effectiveness for the flow of traffic at traffic junction. (iii) The theory of neutrosophic sets is currently advancing quickly. However, there is a problem in determining membership, falsity and indeterminacy degrees in in traffic flow parameters. The nature of determining those degrees is extremely individual. The cause of these challenges might be the theory's parameterization tool's inadequacy. (v) No approach for analyzing the stability of neutrosophic controller systems has yet been created. (vi) The majority of neutrosophic logic-based results that deliver increased performance are simulation-based.

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