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Similarity Measures for Analyzing Medical Diagnostic Problems and Hamlet's Amenities with Intuitionistic Fuzzy Set

Abstract
The survey's validity is determined by the dependability and correctness of the data collected. Conventional models surveys usually ask people who responded to select a single number within zero and one. Furthermore, this kind of approach may not correctly express human views, particularly when questions incorporate linguistics phrases such as "high," "moderate," or "low." The human evaluations are typically vague, unreliable, and lacking of assurance or certainty. To overcome this constraint, Intuitionistic Fuzzy Sets (IFS) provide an effective reasoning. As opposed to traditional fuzzy sets, IFS consider three factors: the degree of membership, the degree of non-membership, and the degree of hesitation. This approach allows various individuals to communicate what they think both casually and clearly, expressing the uncertainty that comes with making real-life decisions. In this study, an Intuitionistic fuzzy approaches is combined by using a Modified Cosine similarity metric to evaluate a village facilities and essential amenity. This methodology helps the respondents to identify not only their degree of consent or disapproval, but it also indicates their ambiguity while comparing several features. Therefore an outcome, it provides a better and more reliable measurement than the conventional assessment methods. The proposed method provides in identifying most of the essential facilities and fundamental amenities required for community growth. Furthermore, the same concept can be used efficiently to solve medical diagnosis difficulties involving uncertainty and ambiguity. The Modified Cosine Similarity Measure increases making decisions with accuracy by clearly showing the difference between various options.

1. Introduction

The decision-making process under uncertainty has arisen as a major research area in mathematics, engineering, health, and the social sciences. Real-life decision-making challenges are usually marked by ambiguity, inadequate knowledge, and subjective analysis. Traditional set theory, this only allows binary membership, is frequently insufficient for representing such complications. Zadeh's [1] in 1965 creation of fuzzy set theory was a huge step forward in uncertainty modeling since it provided an analytical foundation for gathering ambiguous and unreliable information. Atanassov [2] later expanded on this idea that have been by creating Intuitionistic fuzzy sets (IFSs), that are incorporate membership, non-membership, and hesitation degrees, allowing for a more comprehensive portrayal of uncertainty. This concept increased flexibility enables IFSs to more effectively emulate reasoning by humans in situations involving inadequate and inaccurate input. IFSs have been widely used in decision-making, pattern recognition, clustering, image processing, expert systems, and engineering analysis due to their significant capacity to deal with uncertainty. Similarity measures for IFSs,[3][4][5][6][7] in particular, have grown in popularity as a research area because they assess the degree of similarities among different possibilities or groups while accounting for membership, non-membership, and hesitation data. Cosine similarity[8][9][10] is one of the most popular similarity measures because of its a conceptual simplicity, efficiency of computation, and consistent performance. It calculates the similarity by taking a cosine expression of an angle between two vectors. An assessment relatively close to one implies great similarity, while a score around zero indicates dissimilarity. Various modified cosine-based and distance-related similarity assessments are being developed over time to increase discriminating and flexibility in unpredictable contexts. According to these advancements, traditional cosine similarity measures may have difficulties while handling weighting based characteristics, limited information, insufficient observations, and changing levels of featured relevance. In order to resolve these constraints, new cosine similarity measurements were proposed. Normalization, weighting strategies, and biased elimination procedures are among the measures used to achieve reliable, consistent, and precise similarity estimates in complex decision-making environments.

These approaches have a broad range of applications, demonstrating their practical value. In medical diagnosis, Intuitionistic fuzzy similarity metrics [1][12][13][14] are being successfully used to identify diseases, classify patients, diagnose medical situations, provide clinical decision-making, and analyze mixed medical images[15][16]17][18][19]. The medical records frequently contain uncertainty, insufficient data, and repetitive disease symptom patterns, finding Intuitionistic-based fuzzy analysis very useful. Nephrotic disease [20][21] is a medical disorder defined by severe proteinuria, hypoalbuminemia, edema, and hyperlipidemia. Because its diagnosis frequently relies on ambiguous, inaccurate, and inconsistent clinical signs, it is a suitable option for Intuitionistic fuzzy similarity analysis. IFS-based approaches can greatly increase accuracy in diagnosis and clinical choice-making by including reluctance in addition to membership or non-membership facts. Rural environment assessment [[22][23] and the village development strategy are also key areas of application. The infrastructure factors which include water consumption availability, energy access, roadway connectivity, healthcare amenities, educational organizations, sanitary conditions, networks of communication, and financial resources can all be successfully expressed using an Intuitionistic fuzzy based model. Similarity-oriented research allows for comparative analysis of areas based on their levels of development, which aids decision-makers in detecting infrastructure shortages and optimizing allocation of resources.

The survey sample helps to improve the performance of rural infrastructure appraisal. Since people who responded frequently deliver the linguistic or personal judgments, Intuitionistic fuzzy sets provides an appropriate way for capturing ambiguity and hesitation in survey results. This results in more consistent and more understandable evaluation results. This paper creates a modified cosine similarity measure within an Intuitionistic fuzzy framework and applies it to two significant real-life challenges: medical diagnostics and the rural infrastructure analysis. Particularly, proposed technique is utilized to diagnose Nephrotic disease and assess village infrastructure facilities. In all instances, the given data contains doubt, vagueness, and hesitancy.In general, the combination of Intuitionistic fuzzy sets along with the modified cosine similarity measure creates a strong, adaptable, and effective approach to dealing with complicated decision-making scenarios in the face of uncertain situations. The suggested method provides greater precision, predictability, and a more accurate depiction of person judgment, thus making it ideal for use in healthcare diagnostics, development in rural areas planning, and other related domains with inaccurate and uncertainty.

The primary goals of this paper to investigate the basic ideas of fuzzy sets and Intuitionistic fuzzy sets, examine existing cosine similarity measures and create a modified cosine similarity measure for Intuitionistic fuzzy sets, successfully implement hesitate and weighting data into a similarity analysis, and apply the proposed method to medical diagnosis and rural infrastructure evaluation based problems. The suggested approach will also be compared with existing similarity measures using numerical examples and comparative analysis.

This analysis applies the suggested modified cosine similarity metric to two significant real-life problems: medical diagnostics and rural infrastructure analysis. Considering both cases, the available data comprises uncertainty, ambiguity, reluctance, and incomplete data The merging of Intuitionistic fuzzy sets with the recommended modified cosine similarity measure yields a powerful, adaptive, and effective design for dealing with complex decision-making situations in uncertain contexts. The proposed approach enhances precision as well as stability while also depicting human judgment more clearly, making it excellent for medical field diagnostics, rural development strategies, and other areas with uncertain information.

The remaining sections of this work are organized as follows. Section 2 covers over the basics of fuzzy sets, Intuitionistic fuzzy sets, and existing similarity measures. Section 3 discusses the proposed enhanced cosine similarity measure. Sections 4 and 5 discuss its applications in medical diagnosis and rural infrastructure assessment, respectively. Section 6 includes numerical illustrations and comparisons. Section 7 closes the report by outlining the possibility of future research directions.

2.Preliminaries

2.1 **Definition (Fuzzy set)**

A Fuzzy set defined as A $=\{(x,\ \mu_{\tilde{A}}(x))/x\in X\}$, where $\mu_{\tilde{A}}: X \to [0,1]$ is called membership value of x in A .

2.2 Definition (Intuitionistic fuzzy set)

Let X be a non-empty set, an IFS A in X is defined as A= $\{(\boldsymbol{\alpha}_A(x),\gamma_A(x))/x\in X\}$ which is characterized by a membership value $\boldsymbol{\alpha}_A(x)$:X→[0,1] and the non-membership value $\gamma_A(x)$:X→[0,1] and satisfying following condition

(i) $0\leq \alpha_A(x)+\gamma_A(x) \leq 1, \forall x\in X$

(ii) 0≤ $\alpha_A(x),\gamma_A(x),\beta_A(x)$ ≤1,∀x∈X

(iii) $\beta_A(x)$ =1-($\alpha_A(x)$+ $\gamma_A(x)$)

Where $\beta_A(x)$ is called the hesitation value.

2.3 Cosine Similarity Measure (CSM) in Intuitionistic Fuzzy set

The cosine similarity metric is an important mathematical tool for determining the level of similarity between membership and non-membership information. It measures the angle between two Intuitionistic fuzzy vectors.

For two Intuitionistic fuzzy sets A and B defined on X = {x₁, x₂, ..., xₙ}, the cosine similarity measure is defined as

$$C(A,B) = \frac{\sum_{i=1}^{n} \mu_A(x_i)\mu_B(x_i) + \vartheta_A(x_i)\vartheta_B(x_i)}{\sqrt{\sum_{i=1}^{n}(\mu^2{}_A(x_i)+\vartheta^2{}_A(x_i)}\sqrt{\sum_{i=1}^{n}(\mu^2{}_B(x_i)+\vartheta^2{}_B(x_i)}}$$

Set A contains $\mu_A(x_i)$, $\tau_A(x_i)$, $\sigma_A(x_i)$

$\mu_A(x_i)$∈[0,1] Membership value

$\vartheta_A(x_i)$∈[0,1] Non Membership value

Set B contains $\mu_A(x_i)$, $\tau_A(x_i)$, $\sigma_A(x_i)$

$\mu_B(x_i)$∈[0,1] Membership value

$\beta_B(x_i)$∈[0,1] Non Membership value

3.Modified Cosine Similarity Measure (MCSM)

The modified cosine similarity includes hesitation degree and attribute weights, making it more suitable for clinical data. The hesitation degree can also be integrated into the metric for a more accurate similarity rating.

3.1 MCSM in Intuitionistic Fuzzy set

For two Intuitionistic fuzzy sets A and B defined on X = {x₁, x₂, ..., xₙ}, the modified cosine similarity measure is defined as

$$MCS_{IFS}(A,B) = \sum_{i=1}^{n}\frac{1}{S_i}\left\{\frac{\mu_A(x_i)\mu_B(x_i)+\tau_A(x_i)\tau_B(x_i))+\sigma_A(x_i)\sigma_B(x_i)}{\sqrt{\mu_A(x_i)+\tau_A(x_i)+\sigma_A(x_i)}\sqrt{\mu_B(x_i)+\tau_B(x_i)+\sigma_B(x_i)}}\right\}$$

Set A contains

$\mu_A(x_i)$∈[0,1] Membership value

$\tau_A(x_i)$∈[0,1] Hesitation value

$\sigma_A(x_i)$∈[0,1] Non Membership value

Set B contains

$\mu_B(x_i)$∈[0,1] Membership value

$\tau_A(x_i)$∈[0,1] Hesitation value

$\sigma_A(x_i)$∈[0,1] Non Membership value

4. Applications in Medical Diagnosis and Rural infrastructure assessment

4.1 Nephrotic Syndrome Diagnosis problem in Intuitionistic Fuzzy set with MCSM

Using Modified Cosine Similarity Measure,

$$MCS_{IFS}(A,B) = \sum_{i=1}^{n}\frac{1}{S_i}\left\{\frac{\mu_A(x_i)\mu_B(x_i)+\tau_A(x_i)\tau_B(x_i))+\sigma_A(x_i)\sigma_B(x_i)}{\sqrt{\mu_A(x_i)+\tau_A(x_i)+\sigma_A(x_i)}\sqrt{\mu_B(x_i)+\tau_B(x_i)+\sigma_B(x_i)}}\right\}$$

From the Blood test report,

Set A contains $\mu_A(x_i)$, $\tau_A(x_i)$, $\sigma_A(x_i)$

$\mu_A(x_i)$ is the membership values of HB, Proteinuria, Creatinine ratio, Serum albumin and Blood Cholesterol level.

$\tau_A(x_i)$ is the hesitation value of HB, Proteinuria, Creatinine ratio, Serum albumin and Blood Cholesterol level.

$\sigma_A(x_i)$ is the non-membership value of HB, Proteinuria, Creatinine ratio, Serum albumin and Blood Cholesterol level.

Set B contains $\mu_B(x_i)$, $\tau_B(x_i)$, $\sigma_B(x_i)$

$\mu_B(x_i)$ is the membership values of Patient's symptoms

$\tau_B(x_i)$ is the hesitation value of Patient's symptoms

$\sigma_B(x_i)$ is the non-membership value of Patient's symptoms .

S_i is number of symptoms.

4.2 Rural Infrastructure assessment problem in Intuitionistic Fuzzy set with MCSM

Using Modified Cosine Similarity Measure

$$MCS_{IFS}(A,B) = \sum_{i=1}^{n}\frac{1}{S_i}\left\{\frac{\mu_A(x_i)\mu_B(x_i)+\tau_A(x_i)\tau_B(x_i))+\sigma_A(x_i)\sigma_B(x_i)}{\sqrt{\mu_A(x_i)+\tau_A(x_i)+\sigma_A(x_i)}\sqrt{\mu_B(x_i)+\tau_B(x_i)+\sigma_B(x_i)}}\right\}$$

From the Survey report,

Set A contains $\mu_A(x_i)$, $\tau_A(x_i)$, $\sigma_A(x_i)$

$\mu_A(x_i)$is the membership values of Anganwadi, Primary school, Middle School, Secondary school, Diploma institute.

$\tau_A(x_i)$ is the hesitation value of Anganwadi, Primary school, Middle School, Secondary school, Diploma institute.

$\sigma_A(x_i)$ is the non-member ship value of Anganwadi, Primary school, Middle School, Secondary school, Diploma institute.

Set B contains $\mu_B(x_i)$, $\tau_B(x_i)$, $\sigma_B(x_i)$

$\mu_B(x_i)$ is the membership values of Bank ATM, Post office, Gas Agency, EB Office, Health care center.

$\tau_B(x_i)$ is the hesitation value of Bank ATM, Post office, Gas Agency, EB Office, Health care center.

$\sigma_B(x_i)$ is the non-member ship value of Bank ATM, Post office, Gas Agency, EB Office, Health care center.

S_i is minimum important amenites.

5. Algorithm MCSM with IFS

5.1 Proposed Algorithm for Nephrotic Syndrome diagnosis

Step 1

Collect the patient's clinical and test information, which includes:

- Hemoglobin level,
- Proteinuria,
- Creatinine ratio,
- Serum albumin,
- Blood cholesterol level.

Step 2

Generate the Intuitionistic fuzzy representation of the patient's condition by classifying:

- membership degree,
- non-membership degree,

- hesitation degree for each diagnostic parameter and symptom.

Step 3
Create the Intuitionistic fuzzy data for Nephrotic syndrome using specialized medical skills.
Step 4
Determine the Modified Cosine Similarity Measure between the patient's Intuitionistic fuzzy analysis and the conventional Nephrotic Syndrome Analysis.
Step 5
Identify the similarity value.

- A number near 1 suggests a high risk of Nephrotic syndrome.
- An average value indicates partial similarity and requires additional examination.
- A low level suggests a decreased risk of Nephrotic syndrome.

5.2 Proposed Algorithm for Rural Infrastructure assessment using MCSM with IFS

1. Gather the data on infrastructure for the specified areas.
2. Rewrite the obtained data into Intuitionistic fuzzy values.
3. Create Intuitionistic fuzzy sets for learning and vital facilities.
4. Calculate the adjusted cosine similarity measure.
5. Sort the villages according to similarity ratings.
6. Choose villages that require urgent infrastructure improvement.

6. Numerical Example

6.1Application I: Medical Diagnosis of Nephrotic Syndrome

Nephrotic syndrome is a kidney condition identified by significant proteinuria along with hypoalbuminemia, edema, and hyperlipidemia. The uncertainty arises from symptoms that overlap and different diagnostic test results, making a proper diagnosis more difficult. The nephrologist examines ten patients suspected of having Nephrotic Syndrome. Because medical data and diagnostic results generally involve uncertainty and mismatches among both normal and abnormal situations, an Intuitionistic fuzzy set (IFS) technique is utilized to help assist in diagnosis.

Diagnostic Factors

- Hemoglobin level
- Proteinuria
- Creatinine ratio
- Serum albumin
- Cholesterol level

Clinical Symptoms

- Severe swelling
- Foamy urine
- Weight gain due to fluid retention
- Fatigue
- Loss of appetite

Every diagnostic criteria and symptom can be expressed by an Intuitionistic fuzzy number, for each of the parameters are merged to produce an overall diagnostic a result pertaining to all the identified patients. On the basis of this analysis, patients are put into one of the following categories:
 High chance of Nephrotic Syndrome.
 Marginal risk (needs further investigation).
 Low chances of having the syndrome.

Objective
To develop an intelligent medical decision-support framework that improves diagnostic accuracy for Nephrotic Syndrome by incorporating uncertainty, incomplete information, and expert judgment through Intuitionistic Fuzzy Set theory.

Table 1 shows the conversion of the patient's diagnosing factors into Intuitionistic fuzzy values.

Diagnosing Factors / Patients	HB $(\mu_A, \tau_A, \sigma_A)$	Proteinuria >3-3.5g/24 hour	Creatinine ratio>300-350 mg/mmol	Serum albumin <20-25g/l	Severe Hyperlipidemia
1	(0.5,0.3,0.2)	(0.6,0.1,0.3)	(0.4,0.3,0.2)	(0.3,0.2,0.5)	(0.6,0.2,0.2)
2	(0.7,0.1,0.2)	(0.7,0.0,0.3)	(0.6,0.2,0.2)	(0.6,0.1,0.3)	(0.7,0.2,0.1)
3	(0.8,0.1,0.1)	(0.9,0.1,0.0)	(0.7,0.1,0.2)	(0.6,0.2,0.2)	(0.9,0.1,0.0)
4	(0.7,0.1,0.2)	(0.6,0.2,0.2)	(0.8,0.0,0.2)	(0.7,0.1,0.2)	(0.7,0.2,0.1)
5	(0.6,0.2,0.1)	(0.7,0.1,0.2)	(0.7,0.0,0.3)	(0.6,0.1,0.3)	(0.7,0.1,0.1)
6	(0.7,0.1,0.2)	(0.4,0.3,0.3)	(0.3,0.3,0.4)	(0.5,0.3,0.2)	(0.2,0.3,0.5)
7	(0.6,0.1,0.3)	(0.9,0.0,0.1)	(0.8,0.1,0.1)	(0.7,0.1,0.2)	(0.9,0.1,0.0)
8	(0.5,0.3,0.2)	(0.6,0.2,0.2)	(0.6,0.2,0.2)	(0.5,0.4,0.1)	(0.5,0.2,0.3)

9	(0.8,0.1,0.1)	(0.6,0.2,0.2)	(0.7,0.2,0.1)	(0.8,0.1,0.1)	(0.6,0.1,0.3)
10	(0.5,0.3,0.2)	(0.4,0.3,0.3)	(0.5,0.2,0.3)	(0.6,0.2,0.2)	(0.5,0.2,0.3)

Table 2 shows the conversion of the patient's symptoms into Intuitionistic fuzzy values.

Symptoms / **Patients**	**Severe Swelling (μ_B, τ_B, σ_B)**	**Urine with Foamy**	**Fluid retention caused Weight gain**	**Exhaustion**	**Loss of appetite**
1	(0.5,0.2,0.3)	(0.4,0.2,0.4)	(0.3,0.3,0.4)	(0.2,0.3,0.5)	(0.4,0.3,0.3)
2	(0.6,0.1,0.3)	(0.7,0.2,0.1)	(0.5,0.3,0.2)	(0.5,0.2,0.3)	(0.6,0.2,0.2)
3	(0.7,0.0,0.3)	(0.7,0.1,0.2)	(0.6,0.2,0.2)	(0.8,0.1,0.1)	(0.7,0.2,0.1)
4	(0.5,0.2,0.3)	(0.7,0.1,0.2)	(0.7,0.1,0.2)	(0.6,0.2,0.2)	(0.5,0.3,0.2)
5	(0.6,0.2,0.2)	(0.7,0.0,0.2)	(0.6,0.1,0.3)	(0.5,0.3,0.2)	(0.6,0.1,0.2)
6	(0.6,0.3,0.1)	(0.4,0.5,0.1)	(0.5,0.2,0.3)	(0.6,0.2,0.2)	(0.6,0.3,0.1)
7	(0.6,0.2,0.2)	(0.7,0.2,0.1)	(0.6,0.3,0.1)	(0.7,0.2,0.1)	(0.5,0.3,0.2)
8	(0.4,0.2,0.4)	(0.7,0.2,0.1)	(0.7,0.2,0.1)	(0.4,0.4,0.2)	(0.6,0.2,0.2)
9	(0.7,0.2,0.1)	(0.5,0.2,0.3)	(0.6,0.2,0.3)	(0.4,0.3,0.3)	(0.5,0.3,0.2)
10	(0.7,0.1,0.2)	(0.6,0.2,0.2)	(0.3,0.4,0.3)	(0.5,0.3,0.2)	(0.6,0.1,0.3)

Table 3 displays the Modified Cosine Similarity measure solutions in IFS.

Village	**Solutions**
1.	0.3540
2.	0.4600
3.	**0.5360**
4.	0.4840
5.	0.4600
6.	0.3600
7.	**0.5220**
8.	0.3800
9.	0.4480
10.	0.3820

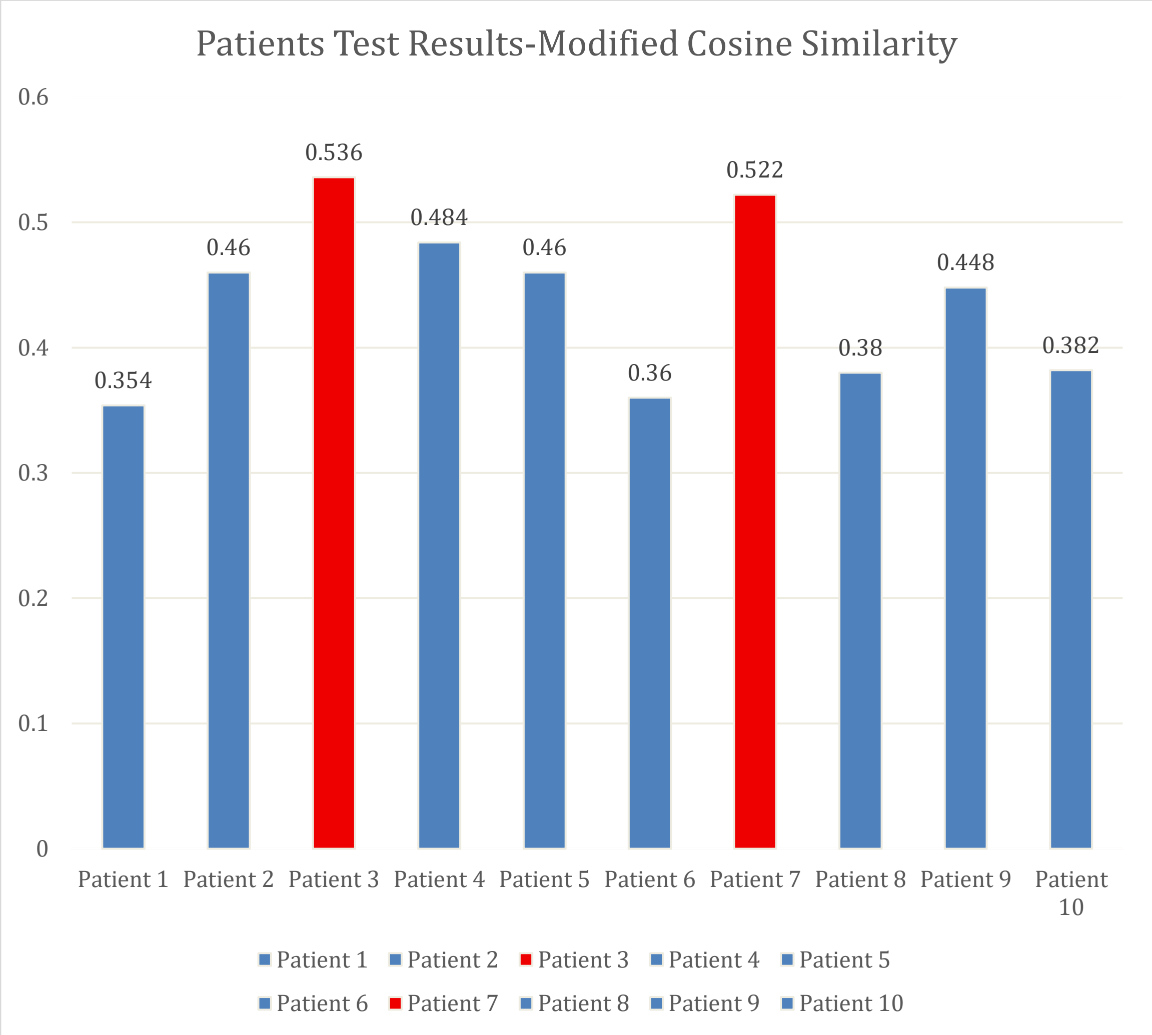
Numerical Results

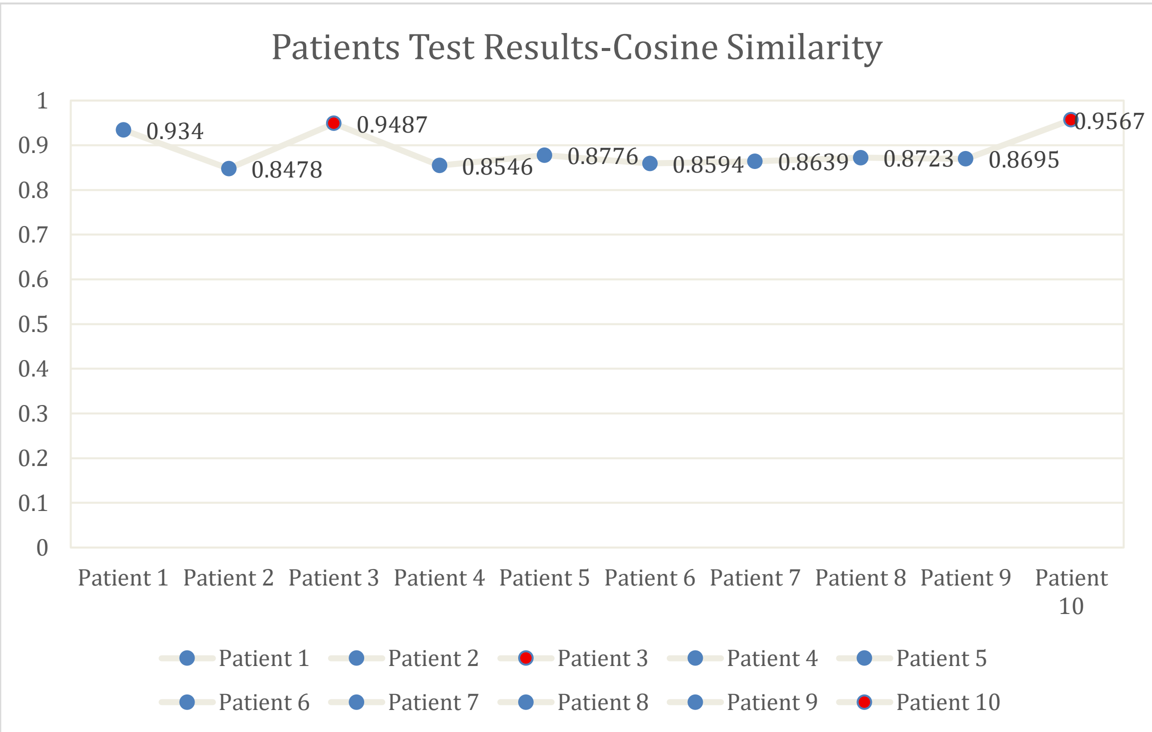
The computed similarity values for ten patients indicate that:

- Patient 3: 0.5360
- Patient 7: 0.5220

These two patients exhibit the highest similarity values and are therefore identified as the most likely cases of Nephrotic syndrome.

Bar Diagram's survey report results:





6.2 Application II: Evaluation of Rural Infrastructure Deficiencies

Development in rural areas requires a comprehensive assessment of facilities and essential services. The

responses to the survey frequently contain ambiguity and hesitancy, providing Intuitionistic fuzzy modeling a suitable fit.Each infrastructure amenity is represented by an Intuitionistic fuzzy number
The ten villages will be categorized into two distinct groups:
Group I includes villages with acceptable and satisfactory amenities.
 Group II includes villages with little or inadequate amenities.
Using a modified cosine similarity measure and Intuitionistic fuzzy sets, the information mentioned above can be separated into two sets of analytical items. The goal is to figure out how many villages have the least amount of amenities.

Educational Infrastructure Criteria

- Anganwadi
- Primary school
- Middle school
- Secondary school
- College/ITI/Diploma institute

Essential Public Amenities

- Bank ATM
- Post office
- Gas agency
- Electricity board office
- Healthcare center

Villages Under Study

1. Ponmar
2. Vengadamangalam
3. Polacherry
4. Mambakkam
5. Kulathur
6. Pooluppai
7. Pulipakkam
8. Muthukadu
9. Mullipakkam
10. Vengaleri

Evaluation Criteria

Each hamlet will be rated based on the availability as well as the quality of the ten basic fundamental amenities:

1. Anganwadi Centre
2. Primary Educational Institution
3. Intermediate School
4. Post-Secondary Educational Facility
5. ITI / College / Diploma Institute
6. Bank with ATM Facility
7. Post Office
8. Gas Agency
9. Electricity Board (EB) Office
10. Medical Clinic / Primary Health Facility

Objective

Use the Modified Cosine Similarity Measure in the context of Intuitionistic Fuzzy sets to analyze and categorize the ten communities based on their availability of basic amenities and infrastructure. Determine which communities have the lowest level of infrastructure development and how many villages have low amenities.

Table 1 shows the conversion of the infrastructure amenities analyzing factors into Intuitionistic fuzzy membership values.

Village	Anganwadi	Primary school	Middle school	Secondary school	College/ITI /Diploma Institute
1	(0.6,0.3,0.1)	(0.1,0.1,0.8)	(0.1,0.1,0.8)	(0.1,0.2,0.7)	(0.1,0.1,0.8)
2	(0.7,0.1,0.2)	(0.4,0.2,0.4)	(0.3,0.3,0.4)	(0.1,0.2,0.7)	(0.1,0.1,0.8)
3	(0.4,0.3,0.3)	(0.5,0.2,0.3)	(0.1,0.1,0.8)	(0.2,0.1,0.7)	(0.0,0.1,0.9)
4	(0.1,0.1,0.8)	(0.5,0.1,0.4)	(0.2,0.2,0.6)	(0.5,0.2,0.3)	(0.1,0.0,0.9)
5	(0.6,0.2,0.2)	(0.3,0.2,0.5)	(0.3,0.2,0.5)	(0.3,0.1,0.6)	(0.1,0.0,0.9)
6	(0.6,0.3,0.1)	(0.4,0.5,0.1)	(0.5,0.2,0.3)	(0.6,0.2,0.2)	(0.6,0.3,0.1)
7	(0.6,0.2,0.2)	(0.7,0.2,0.1)	(0.6,0.3,0.1)	(0.7,0.2,0.1)	(0.5,0.3,0.2)
8	(0.4,0.2,0.4)	(0.7,0.2,0.1)	(0.7,0.2,0.1)	(0.4,0.4,0.2)	(0.6,0.2,0.2)
9	(0.7,0.2,0.1)	(0.5,0.2,0.3)	(0.6,0.2,0.3)	(0.4,0.3,0.3)	(0.5,0.3,0.2)
10	(0.7,0.1,0.2)	(0.6,0.2,0.2)	(0.3,0.4,0.3)	(0.5,0.3,0.2)	(0.6,0.1,0.3)

Table 2 shows the conversion of the infrastructure amenities analyzing factors into Intuitionistic fuzzy membership values.

Village	Bank ATM	Post Office	Gas Agency	EB Office	Health care center
1	(0.1,0.1,0.8)	(0.3,0.2,0.5)	(0.1,0.1,0.8)	(0.1,0.1,0.9)	(0.1,0.1,0.9)
2	(0.4,0.2,0.4)	(0.2,0.1,0.7)	(0.5,0.1,0.4)	(0.1,0.1,0.9)	(0.1,0.1,0.8)
3	(0.1,0.1,0.8)	(0.1,0.0,0.9)	(0.1,0.0,0.9)	(0.1,0.1,0.8)	(0.1,0.0,0.9)
4	(0.6,0.2,0.2)	(0.2,0.1,0.7)	(0.6,0.1,0.3)	(0.5,0.3,0.2)	(0.1,0.1,0.8)
5	(0.6,0.1,0.3)	(0.5,0.1,0.4)	(0.1,0.2,0.7)	(0.5,0.2,0.3)	(0.1,0.1,0.8)
6	(0.7,0.1,0.2)	(0.4,0.3,0.3)	(0.3,0.3,0.4)	(0.5,0.3,0.2)	(0.2,0.3,0.5)
7	(0.6,0.1,0.3)	(0.9,0.0,0.1)	(0.8,0.1,0.1)	(0.7,0.1,0.2)	(0.9,0.1,0.0)

8	(0.5,0.3,0.2)	(0.6,0.2,0.2)	(0.6,0.2,0.2)	(0.5,0.4,0.1)	(0.5,0.2,0.3)
9	(0.8,0.1,0.1)	(0.6,0.2,0.2)	(0.7,0.2,0.1)	(0.8,0.1,0.1)	(0.6,0.1,0.3)
10	(0.5,0.3,0.2)	(0.4,0.3,0.3)	(0.5,0.2,0.3)	(0.6,0.2,0.2)	(0.5,0.2,0.3)

Table 3 displays the Modified Cosine Similarity measure solutions in IFS.

Village	**Solutions**
1.	**0.534**
2.	0.484
3.	**0.552**
4.	0.410
5.	0.462
6.	0.360
7.	**0.522**
8.	0.380
9.	0.448
10.	0.382

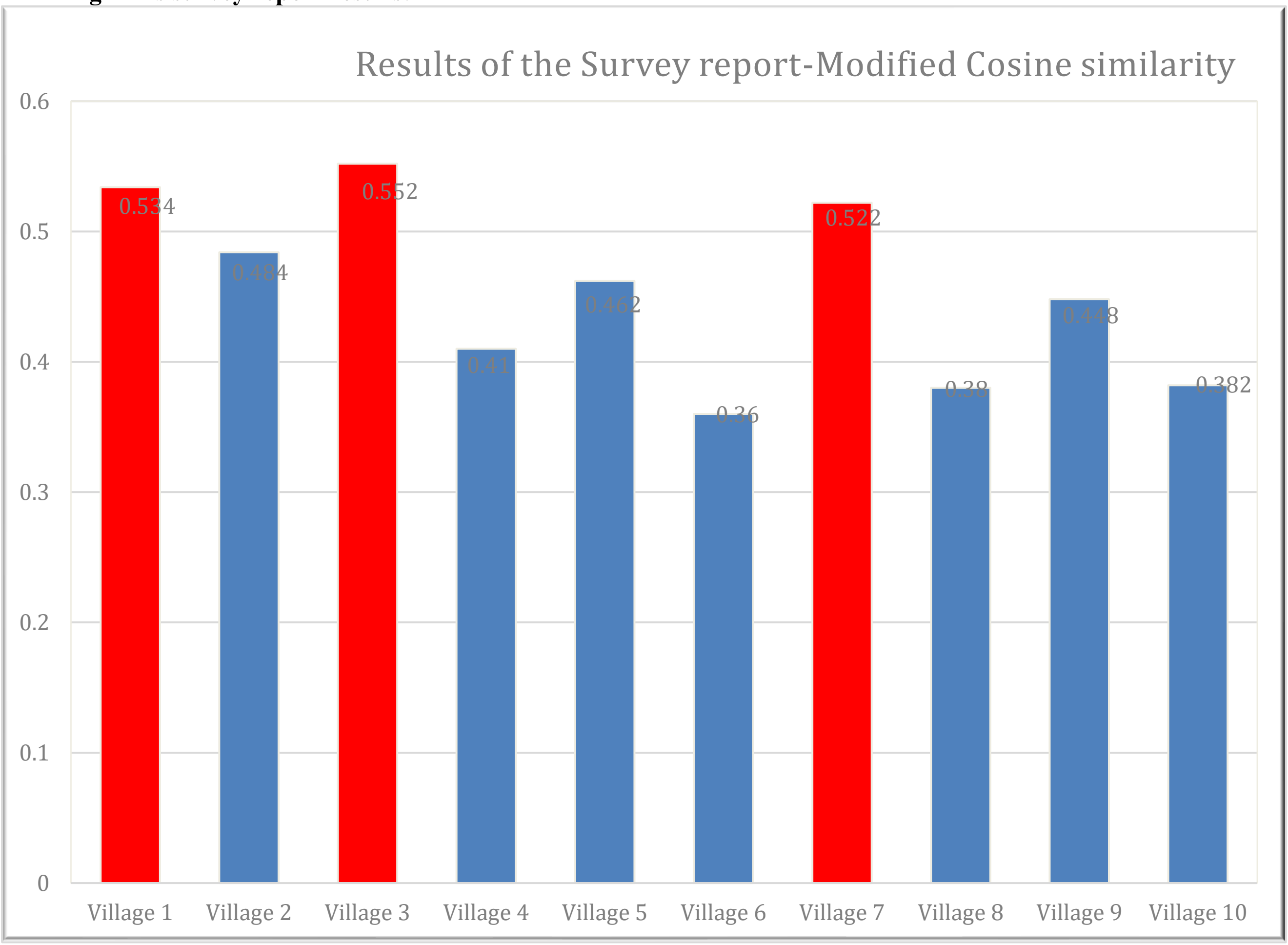
Numerical Results

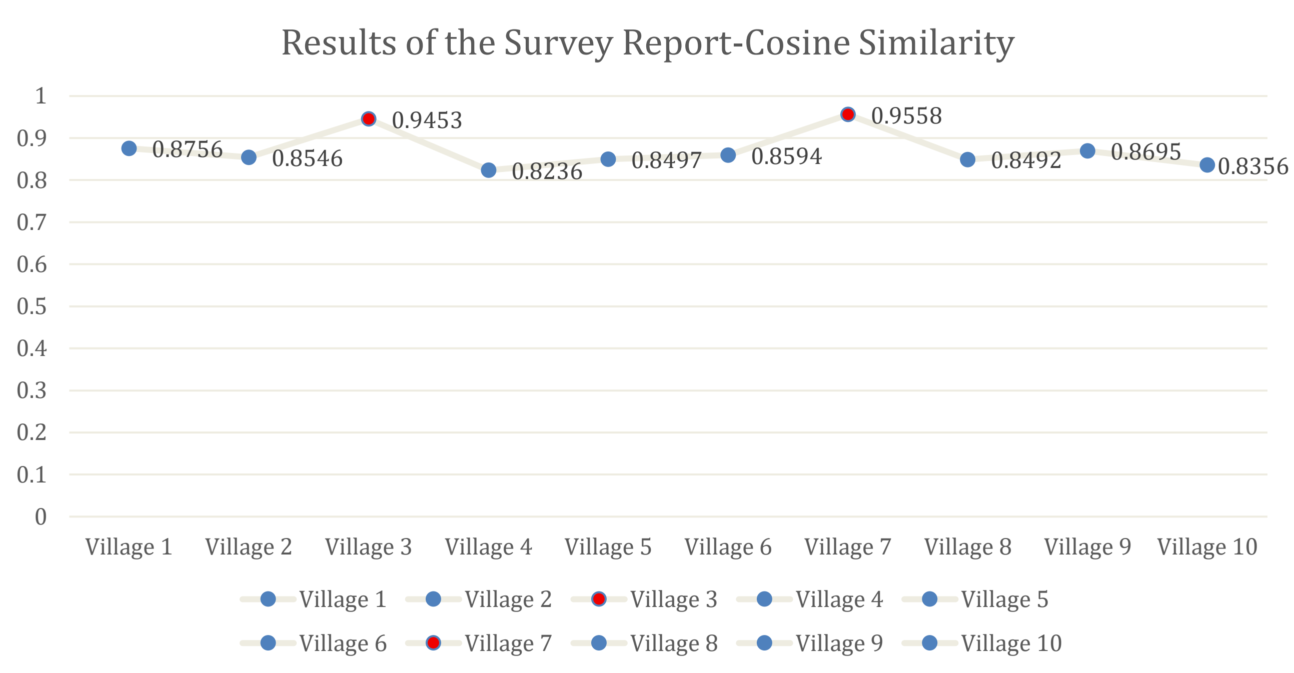
The computed similarity values for ten villages indicate that:

- Village 1: 0.534
- Village 3: 0.552
- Village 7: 0.522

These villages require immediate attention for infrastructure improvement.

Bar Diagram's survey report results:





7. Comparative Analysis of Cosine and Modified Cosine Similarity Measures in IFS

Application 1: Nephrotic syndrome

In medical diagnosis, especially for diseases such as Nephrotic syndrome, patient symptoms and laboratory findings are often uncertain, incomplete, and imprecise. Intuitionistic fuzzy set provides an effective framework to model this uncertainty. Similarity measures are then used to compare a patient's symptom profile with known disease patterns.

Traditional cosine similarity measures used in fuzzy decision models mainly consider membership and non-membership values, while the hesitation component is ignored. As a result, part of the diagnostic uncertainty is lost, leading to possible confusion in classification and reduction in diagnostic accuracy.

Clinical Interpretation

Consider two diseases provide identical membership and non-membership results for a patient. Traditional cosine similarity can generate virtually identical similarity values. On the other hand, if one condition has a lower level of hesitation, the modified cosine similarity indicates that it is a more reliable diagnosis.

Application 2: Rural Infrastructure Assessment

In rural infrastructure evaluation, decision-makers often assess villages based on multiple criteria such as education, healthcare, banking, transportation, sanitation, and public services. These indicators are frequently uncertain, incomplete, and subjective. An Intuitionistic fuzzy set framework is therefore highly suitable for modeling such data.

Traditional cosine similarity measures generally utilize only membership and non-membership information, while ignoring the hesitation component. As a result, uncertainty present in the survey responses is lost, which may lead to inaccurate prioritization of village development needs.

As a result, incorporating the hesitation factor into similarity analysis improves the reliability, efficacy, and successful outcomes of making decisions in rural survey research. The suggested technique may be used by decision makers, local administrative bodies, development and growth agencies to plan long-term rural infrastructure and improve that the quality of life in villages surrounding Chennai.

Practical Interpretation

Two villages might have comparable fundamental amenity scores. The traditional cosine similarity can rank them equally. On the other hand, if one town has greater uncertainty about healthcare or education availability, the adjusted measure represents that uncertainty and produces a more realistic score.

8.Discussion

This proposed modified cosine similarity measure successfully addresses lack of certainty, non-membership, and hesitancy. Compared to conventional fuzzy similarity measures, that provides a more accurate overview of everyday uncertainty. In the field of medical diagnosis, this technique efficiently identify those who are at a higher risk of Nephrotic syndrome. In an analysis of rural infrastructure, it correctly determines the villages that require an an upgrade.

9.Conclusion

For Application 1 (medical diagnosis of Nephrotic syndrome), the modified cosine similarity measure is superior because the suggested Intuitionistic fuzzy technique, which includes hesitation degree, enhances illness identification by maintaining the uncertainty information associated with laboratory reports. The inclusion of hesitation improves sensitivity in borderline instances and lowers misdiagnosis of Nephrotic and Non-Nephrotic renal diseases. As a result, including hesitation margin into similarity measurements provides a more reliable mathematical model for medical diagnosis and improves the accuracy of identifying Nephrotic syndrome from laboratory blood and urine test results.

For Application 2, the modified cosine similarity measure is superior to the classical cosine similarity measure because the suggested Intuitionistic fuzzy technique, which includes a hesitation buffer, considerably increases the accuracy of rural development analyses. While retaining hesitant information, the model delivers a more accurate estimate of the urgency and priority of basic facilities necessary in various villages. The reluctance degree is especially useful in recognizing moderately pleased communities that require rapid attention from the government.Thus, incorporating the hesitation margin into similarity analysis improves the accuracy, transparency, and effectiveness of decision-making in rural survey investigations. The suggested approach may help policymakers, local governments, and development agencies plan sustainable rural infrastructure and improve the quality of life in communities near Chennai.

Scope for Future work

This strategy is capable of being improved by including Neutrosophic sets, Pythagorean fuzzy sets, spherical fuzzy sets, and q-rung ortho pair fuzzy sets. The suggested healthcare technique may be utilized to diagnose chronic medical conditions such as diabetes, cardiovascular disorders, liver problems, and cancer. It has several applications in the social sciences and public affairs, such as resource allocation, quality assessment, and regional development.

References

1. Zadeh, L. A. (1965). Fuzzy sets. *Information and Control*, 8, 338–353.
2. Atanassov, K. T. (1986). Intuitionistic fuzzy sets. *Fuzzy Sets and Systems*, 20, 87–96.
3. Liu, Z. (2025). A new sine similarity measure based on evidence theory for conflict management. *Communications in Statistics-Theory and Methods*, *54*(11), 3350-3366.
4. Dhanasekaran, P., & Kalidasan, S. (2025). A distance based similarity measure on trapezoidal intuitionistic fuzzy numbers and its applications: P. Dhanasekaran, S. Kalidasan. *Soft Computing*, *29*(2), 1107-1119.48.
5. Chen, Z., & Liu, P. (2022). Intuitionistic fuzzy value similarity measures for intuitionistic fuzzy sets. *Computational and Applied Mathematics*, *41*(1), 45.
6. Bhatia, M., Arora, H. D., Kumar, V., & Naithani, A. (2025). Novel Distance–Similarity Measures for Intuitionistic Fuzzy Sets: A Comparative Analysis from Medical Diagnosis and Pattern Recognition Perspective. In *Fuzzy Logic Concepts in Computer Science and Mathematics* (pp. 273-289). Apple Academic Press.
7. Li, H., Zhu, S., & Liu, Z. (2025). New distance and similarity measures of picture fuzzy sets and applications. *Intelligent Decision Technologies*, *19*(2), 1158-1181.
8. Ahemen, S., Ujah, R., & Ejegwa, P. A. (2024). New cosine similarity measures for intuitionistic fuzzy sets with application in decision-making. In *Optimization and computing using intelligent data-driven approaches for decision-making* (pp. 55-68). CRC Press.
9. Yang, J., & Su, W. (2023). A New Approach to Intuitionistic Fuzzy Decision Making Based on Projection Technology and Cosine Similarity Measure. *arXiv preprint arXiv:2311.11539*.
10. Sajid, M., Khan, K. A., Frnda, J., & Rahman, A. U. (2025). A novel multi-attribute decision-making method for supplier selection in the health care industry using cosine similarity measures of single-valued neutrosophic cubic hypersoft sets. *IEEE Access*, *13*, 16603-16622.
11. Palanisamy, S., & Periyasamy, J. (2024). Interval-Valued Intuitionistic Fuzzy Cosine Similarity Measures for Real World Problem Solving. *International Journal of Robotics & Control Systems*, *4*(2).
12. Ahemen, S., Ujah, R., & Ejegwa, P. A. (2024). New cosine similarity measures for intuitionistic fuzzy sets with application in decision-making. In *Optimization and computing using intelligent data-driven approaches for decision-making* (pp. 55-68). CRC Press.
13. Bernwal, S., Sahni, M., Mellado-Cid, C., & Castro, E. L. (2025). Novel Similarity Measure for Pythagorean and Intuitionistic Fuzzy Sets. *Journal of Multiple-Valued Logic & Soft Computing*, *45*.
14. Selvakumari K ,and Pathmavathi V.R.,(2020) Similarity Measure in Dengue Diagnosis Problem Using Intuitionistic Fuzzy Set, The Journal of Research on the Lepidoptera volume 51 (2), pg.no: 73-79 .
15. Kaur, P., & Gupta, A. N. (2025). A Medical Diagnosis of Cataract Using Intuitionistic Fuzzy Sets. *Risk Assessment and Management Decisions*, *2*(2), 88-94.
16. Qayyum, A., Mushtaq, N., Shaheen, T., Ali, W., & Smarandache, F. (2024). Some similarity measures on generalized interval-valued intuitionistic fuzzy soft expert sets and their applications in medical diagnosis. *ollected apers*, 743.
17. Shao, Z., Kosari, S., Rashmanlou, H., & Mofidnakhaei, F. (2023). Fuzzy Decision Making in Medical Diagnosis Using Vague Sets. *Journal of Multiple-Valued Logic & Soft Computing*, *40*.
18. Khalaj, F., & Khalaj, M. (2022). Developed cosine similarity measure on belief function theory: An application in medical diagnosis. *Communications in Statistics-Theory and Methods*, *51*(9), 2858-2869.
19. Riaz, M., Saba, M., Khokhar, M. A., & Aslam, M. (2022). Medical diagnosis of nephrotic syndrome using m-polar spherical fuzzy sets. *International Journal of Biomathematics*, *15*(02), 2150094.
20. Pathmavathi V.R. and Selvakumari K.(2019), Solving medical diagnostic problem in intuitionistic fuzzy sets using new distance

measure ,International Journal of Pharmaceutical Research ,Volume 11(1).
21. Mima, A., Saito, Y., Matsumoto, K., Nakamoto, T., & Lee, S. (2024). Effect of finerenone on nephrotic syndrome in patients with diabetic kidney disease. *Metabolism open*, *22*, 100294.
22. Vijayan, V. M. A. (2024). Rural Infrastructure Development: Challenges, Opportunities and Future Directions. *Shikshan Sanshodhan: Journal of Arts, Humanities and Social Sciences*, *7*(06), 28-32.
23. Myvizhi, M., Swapna, G., Suresh, B., Venukumar, S., Dabral, U., & Vatin, N. I. (2025, April). Application of fuzzy inference system for the development of rural health diagnosis system. In *AIP Conference Proceedings* (Vol. 3157, No. 1, p. 130008). AIP Publishing LLC.