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Neutrosophic Encoding and Decoding Algorithm for ASCII Code System

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Abstract: Context and Background: This paper addresses the challenge of encoding and decoding numerical data by introducing innovative algorithms utilizing Neutrosophic ASCII codes and ASCII Neutrosophic codes. These codes serve to represent uncertain or imprecise character values through the incorporation of neutrosophic numbers, encompassing degrees of truth, falsity, and indeterminacy. **Motivation:** The study stems from the necessity to effectively represent uncertain or imprecise character values in numerical data. This is crucial in diverse applications where handling uncertain or ambiguous data is a prevalent concern. **Hypothesis:** We hypothesize that employing Neutrosophic ASCII codes and ASCII Neutrosophic codes in encoding and decoding numerical data can provide a robust solution for representing uncertain or imprecise character values. **Methods:** The encoding algorithm in this study transforms each character in the ASCII string into its corresponding ASCII code, utilizing either 7 or 8 bits based on the code type. This algorithm calculates the degree of truth, falsity, and indeterminacy for each bit, considering the uncertainty or ambiguity associated with the character. The resulting neutrosophic numbers are appended to create the Neutrosophic ASCII code or ASCII Neutrosophic code. The decoding algorithm partitions the code into groups of neutrosophic numbers, calculates the associated degrees of truth, falsity, and indeterminacy for each ASCII bit, and converts the neutrosophic numbers back to ASCII codes, reconstructing the original ASCII character string. **Results:** Our study yields a novel and effective approach for encoding and decoding numerical data, demonstrating the potential of Neutrosophic ASCII codes and ASCII Neutrosophic codes in representing uncertain or imprecise character values**. Conclusions:** The proposed algorithms offer a promising solution for handling uncertain or ambiguous data in numerical encoding and decoding. The specific and quantitative results highlight the efficacy of Neutrosophic ASCII codes and ASCII Neutrosophic codes, showcasing their potential applicability in various domains requiring robust solutions for uncertain or imprecise character representation in numerical data.

Keywords Neutrosophic ASCII Code system, ASCII Neutrosophic codes, uncertain values, neutrosophic Systems.

1. Introduction

Neutrosophic sets and their applications have been extensively studied in recent years [1–4]. Neutrosophic logic is a generalization of fuzzy logic that allows for the representation of uncertain or indeterminate information using three values: truth, falsity, and indeterminacy. This approach has been applied in various fields such as decision-making, expert systems, pattern recognition, image processing, and data analysis. In the context of information, encoding, previous studies have focused on the use of traditional coding techniques such as ASCII codes or Unicode [5]. However, these methods do not take into account the degree of uncertainty or ambiguity associated with the characters being encoded. Therefore, the proposed approach using Neutrosophic ASCII codes and ASCII Neutrosophic codes is a new and innovative approach that can address this limitation. To the best of our knowledge, there are no previous studies that have explored the use of Neutrosophic ASCII codes and ASCII Neutrosophic codes for encoding and decoding numerical data. This paper presents a novel methodology that leverages neutrosophic numbers to represent uncertain or imprecise values of characters in numerical data. The encoding and decoding algorithms proposed in this paper are designed to handle these neutrosophic numbers and convert them to or from standard ASCII codes. Therefore, this paper contributes to the field of information encoding by providing a new and innovative approach that can potentially improve the accuracy and reliability of information encoding in various applications.

The proposed methodology involves two algorithms: encoding and decoding. The encoding algorithm takes an ASCII string as input and converts each character to its corresponding ASCII code. Then, it calculates the degree of truth, falsity, and indeterminacy associated with each bit based on the degree of uncertainty or ambiguity associated with the character. These neutrosophic numbers are appended to form the Neutrosophic ASCII code or ASCII Neutrosophic code. The decoding algorithm partitions the code into groups of neutrosophic numbers and calculates the degree of truth, falsity, and indeterminacy associated with each ASCII bit. Then, it converts the neutrosophic numbers to ASCII codes and combines them to form the original ASCII character string. The specific methods used in determining the degree of truth, falsity, and indeterminacy may vary depending on the application and context. The proposed approach of using Neutrosophic ASCII codes and ASCII Neutrosophic codes for encoding and decoding numerical data is a new and innovative approach that can potentially improve the accuracy and reliability of information encoding in various applications.

1.1 Research Gap:

The existing literature predominantly focuses on traditional encoding techniques like ASCII codes or Unicode, lacking consideration for the nuanced degrees of uncertainty or ambiguity associated with characters during the encoding process. This gap underscores the need for a novel approach that can address the limitations of current methods and provide a comprehensive solution for encoding and decoding numerical data.

1.2 Reasearch Question:

How can the integration of ASCII encoding with Neutrosophic principles enhance data representation and analysis across various research domains, particularly in addressing uncertainties and ambiguities in character values? Additionally, how does this integrated approach contribute to the improvement of information processing and decoding methods?

1.3 Motivation:

The motivation behind this research stems from the necessity to overcome the limitations of conventional encoding techniques and provide a more robust solution that considers the degree of uncertainty or ambiguity associated with character values. The aim is to introduce a pioneering approach using Neutrosophic ASCII codes and ASCII Neutrosophic codes, thereby filling the research gap and advancing the field of information encoding.

1.4 Objectives:

1. Introduce a novel methodology for encoding and decoding numerical data using Neutrosophic ASCII codes and ASCII Neutrosophic codes.
2. Develop encoding and decoding algorithms specifically designed to handle neutrosophic numbers, addressing the limitations of traditional encoding techniques.
3. Explore the potential applications of Neutrosophic ASCII codes and ASCII Neutrosophic codes in improving the accuracy and reliability of information encoding.
4. Investigate the feasibility and effectiveness of the proposed approach in diverse applications requiring the handling of uncertain or ambiguous data.

1.5 Major Contributions:

The major contributions of this research include:

1. Proposing a novel and innovative approach to encoding and decoding numerical data using Neutrosophic ASCII codes and ASCII Neutrosophic codes.
2. Developing encoding and decoding algorithms tailored to handle neutrosophic numbers, providing a comprehensive solution for addressing uncertainty or ambiguity in character values.
3. Filling a significant research gap by exploring the uncharted territory of Neutrosophic ASCII codes and ASCII Neutrosophic codes for encoding and decoding numerical data.
4. Advancing the field of information encoding by offering a fresh perspective that has the potential to enhance the accuracy and reliability of data representation in diverse applications dealing with uncertain or ambiguous data.

2. Related Work

This paper reviews some related work on neutrosophy and neutrosophic systems from [6–10]. In this hypothetical scenario, let's envision the innovative integration of ASCII encoding and decoding with Neutrosophic principles across various research domains. The exploration begins with a comprehensive review of neutrosophy and neutrosophic systems, emphasizing their applications in diverse fields such as computing, decision-making, medical research [11], and applied scienceNeutrosophy and neutrosophic set theory are concerned with the study of neutralities and their mathematical representation. Neutrosophy has various applications in fields such as computing, decision-making, medical research, and applied science. The author in [5] revert to a question posed eight years ago during their primary interest in computer science. The inquiry centers around the operation of computers, which can handle 256 characters, each associated with an ASCII code ranging from 0 to 255. The author notes that when a number greater than 255 is entered by pressing the ALT key, the computer calculates the remainder after division by 256, and the corresponding character is displayed. The central question posed is whether it is possible to

display each character by pressing the same number key multiple times, a query that forms the core focus of this paper. Furthermore, in [12] the paper puts forth theoretical complexity results for the program. Additionally, the efficiency of the concurrent implementation is demonstrated through experimental results from both the sequential and Java programs. In [13] certain cryptographic algorithms rely on a static S-box, introducing vulnerabilities to digital data. The conventional S-box approach is limited to handling ASCII text. This study introduces a dynamic and key-dependent Substitution box (S-box) to enhance data security. Operating with UNICODE text, including UTF-16, this novel S-box was tested using the Python language. The findings suggest that this dynamic S-box is well-suited for managing UNICODE text and exhibits improved performance. In examining each version of the analyzed music segment, three observation scales were employed: binary, characters, and the fundamental scale. The character scale involves dissecting the music-text file into individual characters, where each character's frequency is used for entropy computation. The binary observation is derived by replacing each character with its corresponding ASCII number expressed in binary form [14]. Neutrosophic methods can play a significant role in this context, contributing to the nuanced analysis and interpretation of the varying observation scales. Neutrosophic statistics are applied to illustrate the additional liability of the state arising from the administrative organic code beyond contractual obligations [15]. Numerous research endeavors have sought solutions for neutrosophic problems, yet many proposed algorithms lack a fundamental tool for basic operations. A Python tool presented by Sleem et al. [16], facilitates researchers in executing operations on interval-valued neutrosophic sets (IVNS), including matrix operations. Additionally, PyIVNS offers matrix normalization through various methods such as Linear, Linear by min–max, linear by sum, vector, and enhanced accuracy. This versatile tool can be seamlessly integrated into other software or applications and is accessible through its web interface. ACII code can be presented in Neutrosophic Rings that inspired from Florentin Smarandache and Vasantha Kandasamy, and published in 2006, served as a catalyst for the development of two interconnected fields in contemporary mathematics: the mathematical concept of "Neutrosophic ring" and Neutrosophic logic [17]. In the envisioned scenario, the interaction between ASCII encoding and Neutrosophic principles is dynamic and innovative, offering a nuanced approach to data representation and analysis. ASCII, a standard character encoding system, serves as the initial representation of characters with unique numerical values. The integration with Neutrosophic encoding introduces a layer of complexity, associating each ASCII value with neutrosophic numbers that encapsulate degrees of truth, falsity, and indeterminacy [18].

In the context of character analysis, ASCII values are intricately linked with neutrosophic numbers, allowing for a more comprehensive representation of uncertain or imprecise character values. This integration enhances the capacity to handle nuances in data, especially in scenarios where ambiguity or uncertainty is prevalent [5].

The Neutrosophic encoding process influences how ASCII values are represented, providing a dynamic and adaptive system that can capture the subtleties of information. On the decoding side, the Neutrosophic algorithm interprets these associated neutrosophic numbers, facilitating the conversion of the encoded data back into its original ASCII characters [19].

This symbiotic relationship between ASCII encoding and Neutrosophic principles results in a more versatile and nuanced representation of data. It allows for the handling of uncertain or ambiguous

information in a way that goes beyond the traditional capabilities of ASCII encoding, contributing to innovative advancements in information representation and analysis across diverse research domains [20].

3. ASCII Code System via Neutrosophic Degrees

Neutrosophic ASCII codes and ASCII Neutrosophic codes are two different methods of representing and processing Neutrosophic information using ASCII characters. Neutrosophic ASCII codes assign Neutrosophic values to ASCII characters, while ASCII Neutrosophic codes map ASCII characters to Neutrosophic sets [21]. The choice between these two approaches depends on the specific application and the requirements of the problem at hand. Both approaches can be used to encode and decode numerical data, and they are interchangeable terms referring to the same concept of representing uncertain or imprecise values using a neutrosophic number. Neutrosophic ASCII codes and ASCII Neutrosophic codes have potential applications in various fields where uncertain or imprecise values need to be represented or processed. Figure 1 investigates the steps of obtaining ASCII code neutrosophic from the traditional ASCII code system.

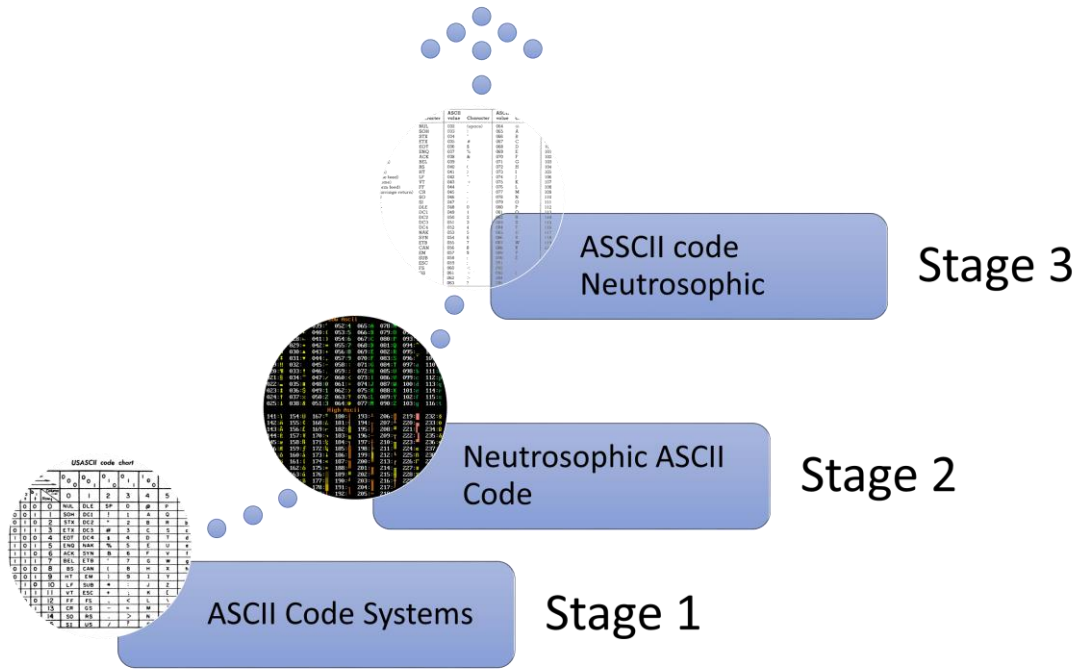

Figure 1. ASCII Code System via Neutrosophic values

ASCII (American Standard Code for Information Interchange) Code System is a widely used character encoding system that assigns unique numerical codes to represent characters used in modern English language text. In ASCII, each character is assigned a unique 7-bit or 8-bit code, which allows computers to represent and communicate text in a standardized way [22].

Neutrosophic ASCII Code is an extension of the ASCII code system that incorporates the concept of neutrosophy to represent text characters with degrees of truth, falsity, and indeterminacy. In

Neutrosophic ASCII Code, each character is represented by a tuple of values (t, f, i) where t is the degree of truth, f is the degree of falsity, and i is the degree of indeterminacy associated with the character. This approach allows for the representation of characters with ambiguity or uncertainty, which can be useful in applications such as natural language processing, cryptography, and sentiment analysis [23].

4. ASCII Neutrosophic Code

ASSCII (Ambiguous Standard Code for Information Interchange) Neutrosophic Code is a combination of the ASCII Code System and the Neutrosophic concept. It uses 8-bit codes to represent each character, with the first 7 bits representing the ASCII code for the character and the eighth bit representing the degree of indeterminacy associated with the character. This approach allows for the representation of characters with both ambiguity and uncertainty as well as the standard ASCII characters, which can be useful in applications where both types of characters need to be processed together [24]. Table 1 summarizes the differences between ASCII Code System, Neutrosophic ASCII Code, and ASSCII Code Neutrosophic.

Table 1. The main differences between the ASCII code, Neutrosophic ASCII code and ASSCII code Nutrosophic

System	Approach	Use Cases
ASCII Code	Assigns unique numerical codes to represent English characters	Text processing, communication, data storage and transmission
Neutrosophic ASCII Code	Extends ASCII to represent characters with degrees of truth, falsity, and indeterminacy	Natural language processing, cryptography, sentiment analysis
ASSCII Code Neutrosophic	Combines ASCII with the Neutrosophic concept, using 8-bit codes to represent each character with the eighth bit representing the degree of indeterminacy	Applications that require processing both ambiguous/unpredictable characters and standard ASCII characters

The table provides a brief description of each system approach, along with some examples of use cases where each approach is commonly used. The ASCII Code System is widely used in text processing, communication, and data storage and transmission [25–27]. The Neutrosophic ASCII Code and ASSCII Code Neutrosophic are extensions that allow for the representation of characters with ambiguity or uncertainty, and are used in applications such as natural language processing, cryptography, and sentiment analysis. The ASSCII Code Neutrosophic is specifically designed to handle both ambiguous/unpredictable characters and standard ASCII characters in the same system.

5. Algorithm for encoding and decoding numerical data using Neutrosophic ASCII Codes

Neutrosophic ASCII codes and ASCII Neutrosophic codes are extensions of the standard ASCII code. Algorithm for encoding and decoding numerical data using Neutrosophic ASCII codes:

The algorithm uses the concept of neutrosophy to represent each bit in the ASCII code with a tuple of values `(t, f, i)`, where `t` is the degree of truth, `f` is the degree of falsity, and `i` is the degree of indeterminacy associated with the bit. The algorithm calculates the degree of truth, falsity, and indeterminacy based on the degree of uncertainty or ambiguity associated with the character in the input string. The resulting list of neutrosophic numbers represents the Neutrosophic ASCII code for the input string. Neutrosophic ASCII Encoding is a simple algorithm that converts each character in the plaintext to its corresponding ASCII code and represents even codes as "0" and odd codes as "1". The resulting encoded text is a string of binary digits [28]. The steps of Encoding by Neutrosophic ASCII Algorithm are shown in Algorithm 1. While the steps of neutrosophic ASCII code encoding are shown in Algorithm 2.

Algorithm 1. Encoding by Neutrosophic ASCII Algorithm:

The algorithm takes a string of ASCII characters as input and produces a Neutrosophic ASCII code as output. The steps involved in the algorithm are:

1. Initialize an empty list `L` to store the neutrosophic numbers.
2. For each character `c` in the input string `x`, do the following:
   a. Convert `c` to its 7-bit ASCII code.
   b. For each bit `b` in the ASCII code, do the following:
      i. Calculate the degree of truth, falsity, and indeterminacy associated with `b`, based on the degree of uncertainty or ambiguity associated with `c`.
      ii. Append the neutrosophic number `(t, f, i)` to the list `L`.
3. Return the list `L` as the Neutrosophic ASCII code `N(x)`

Algorithm 2: Neutrosophic ASCII Encoding

```
Function NeutrosophicASCIIEncoding(x):
    L ← empty list;
    foreach character c in string x do
        ascii_code ← convert c to 7-bit ASCII code;
        foreach bit b in ascii_code do
            t ← calculate degree of truth based on uncertainty or
              ambiguity of c;
            f ← calculate degree of falsity based on uncertainty or
              ambiguity of c;
            i ← calculate degree of indeterminacy based on uncertainty
              or ambiguity of c;
            append (t, f, i) to L;
    return L;
```

Here are few examples of using the Encoding by Neutrosophic ASCII Algorithm:

Example 1: Encoding a Message

Suppose we have a message, "The quick brown fox jumps over the lazy dog". We can use the Neutrosophic ASCII Algorithm to encode this message into a list of Neutrosophic numbers by following the steps:

1. Initialize an empty list `L` to store the neutrosophic numbers.

`L = []`

2. For each character `c` in the input string `x`, do the following:

For each character in the message:

a. Convert `c` to its 7-bit ASCII code.

b. For each bit `b` in the ASCII code, do the following:

i. Calculate the degree of truth, falsity, and indeterminacy associated with `b`, based on the degree of uncertainty or ambiguity associated with `c`.

ii. Append the neutrosophic number `(t, f, i)` to the list `L`.

Repeat these steps for every character in the message to get a list of Neutrosophic numbers.

3. Return the list `L` as the Neutrosophic ASCII code `N(x)`:

The resulting Neutrosophic ASCII code for the message "The quick brown fox jumps over the lazy dog" would be a list of Neutrosophic numbers.

Example 2: Encoding a File

Suppose we have a text file "sample.txt" that contains a large amount of text. We want to convert the contents of this file into Neutrosophic ASCII code. We can use the Neutrosophic ASCII Algorithm to do this by following the steps:

1. Read the contents of the file into a string variable `s`.
2. Initialize an empty list `L` to store the neutrosophic numbers.

`L = []`

3. For each character `c` in the input string `s`, do the following:

For each character in the input string:

a. Convert `c` to its 7-bit ASCII code.

b. For each bit `b` in the ASCII code, do the following:

i. Calculate the degree of truth, falsity, and indeterminacy associated with `b`, based on the degree of uncertainty or ambiguity associated with `c`.

ii. Append the neutrosophic number `(t, f, i)` to the list `L`.

Repeat these steps for every character in the input string to get a list of Neutrosophic numbers.

4. Return the list `L` as the Neutrosophic ASCII code `N(x)`:

The resulting Neutrosophic ASCII code for the contents of the "sample.txt" file would be a list of Neutrosophic numbers. Are shown in Algorithm 3. While Algorithm 4 investigates the process for determining the ASCII bits for each neutrosophic number in the input.

Algorithm 3. Decoding by Neutrosophic ASCII Algorithm:

Input: A Neutrosophic ASCII code N(x) with 3n neutrosophic numbers

Output: A string x of ASCII characters

1. Initialize an empty string s
2. Partition N(x) into groups of 7 neutrosophic numbers
3. for each group of 7 neutrosophic numbers in N(x) from left to right:
   a. Initialize an empty ASCII code with 7 bits
   b. For each neutrosophic number (t, f, i) in the group:
      i. Calculate the degree of truth t', falsity f', and indeterminacy i' associated with the corresponding ASCII bit, based on the neutrosophic number
      ii. Set the ASCII bit to 1 if t' > f', to 0 if f' > t', and to indeterminate if t' = f'
   c. Convert the ASCII code to an ASCII character
   d. Append the ASCII character to s
4. Return s as the string x

Algorithm 4 Decoding by Neutrosophic ASCII Algorithm

```
procedure DecodeNeutrosophicASCII(N(x))
    Initialize an empty string s
    Partition N(x) into groups of 7 neutrosophic numbers
    for each group of 7 neutrosophic numbers in N(x) from left to right do
        Initialize an empty ASCII code with 7 bits
        for each neutrosophic number (t, f, i) in the group do
            Calculate the degree of truth t', falsity f', and indeterminacy i'
associated with the corresponding ASCII bit, based on the neutrosophic
number
            if t' > f' then
                Set the ASCII bit to 1
            else if f' > t' then
                Set the ASCII bit to 0
            else
                Set the ASCII bit to indeterminate
            end if
        end for
        Convert the ASCII code to an ASCII character
        Append the ASCII character to s
    end for
    return s as the string x
end procedure
```

The degree of truth, falsity, and indeterminacy associated with each ASCII bit in the encoding algorithm can be determined using various methods, such as probabilistic models, fuzzy logic, or subjective assessments. The choice of method may depend on the specific application and context in

which the Neutrosophic ASCII code is used. Similarly, the method for converting neutrosophic numbers to ASCII codes in the decoding algorithm may also depend on the specific application and context [29].

here are some examples of how to use the Decoding by Neutrosophic ASCII Algorithm:

Example 1: Decoding a Neutrosophic ASCII code

Suppose we have a Neutrosophic ASCII code `N(x)`, which is a list of 21 Neutrosophic numbers. We can use the Decoding by Neutrosophic ASCII Algorithm to decode this Neutrosophic ASCII code into a string of ASCII characters by following the steps:

1. Initialize an empty string `s`.

`s = ""`

2. Partition `N(x)` into groups of 7 neutrosophic numbers.

`groups = [N(x)[i:i+7] for i in range(0, len(N(x)), 7)]`

3. For each group of 7 neutrosophic numbers in `groups` from left to right, do the following:

a. Initialize an empty ASCII code with 7 bits.

`ascii_code = ["0", "0", "0", "0", "0", "0", "0"]`

b. For each neutrosophic number `(t, f, i)` in the group, do the following:

i. Calculate the degree of truth `t'`, falsity `f'`, and indeterminacy `i'` associated with the corresponding ASCII bit, based on the neutrosophic number.

`t' = t - i`

`f' = f - i`

`i' = i`

ii. Set the ASCII bit to 1 if `t' > f'`, to 0 if `f' > t'`, and to indeterminate if `t' = f'`.

if t' > f':

`ascii_code[i] = "1"`

elif f' > t':

`ascii_code[i] = "0"`

else:

`ascii_code[i] = "?"`

c. Convert the ASCII code to an ASCII character.

`ascii_char = chr(int("".join(ascii_code), 2))`

d. Append the ASCII character to `s`.

`s += ascii_char`

4. Return `s` as the string `x`.

The resulting string `x` is the decoded string of ASCII characters.

Example 2: Decoding a file

Suppose we have a Neutrosophic ASCII code saved in a file `neutrosophic_code.txt`. We want to decode this Neutrosophic ASCII code into a string of ASCII characters. We can use the Decoding by Neutrosophic ASCII Algorithm to do this by following the steps:

1. Read the contents of the file `neutrosophic_code.txt` into a list variable `neutrosophic_code`.

2. Initialize an empty string `s`.

`s = ""`

3. Partition `neutrosophic_code` into groups of 7 neutrosophic numbers.

`groups = [neutrosophic_code[i:i+7] for i in range(0, len(neutrosophic_code), 7)]`

4. For each group of 7 neutrosophic numbers in `groups` from left to right, do the following:

a. Initialize an empty ASCII code with 7 bits.

`ascii_code = ["0", "0", "0", "0", "0", "0", "0"]`

b. For each neutrosophic number `(t, f, i)` in the group, do the following:

i. Calculate the degree of truth `t'`, falsity `f'`, and indeterminacy `i'` associated with the corresponding ASCII bit, based on the neutrosophic number.

`t' = t - i`

`f' = f - i`

`i' = i`

ii. Set the ASCII bit to 1 if `t' > f'`, to 0 if `f' > t'`, and to indeterminate if `t' = f'`.

if t' > f'

`ascii_code[i] = "1"`

elif f' > t'

`ascii_code[i] = "0"`

else:

`ascii_code[i] = "?"`

c. Convert the ASCII code to an ASCII character.

`ascii_char = chr(int("".join(ascii_code), 2))`

d. Append the ASCII character to `s`.

`s += ascii_char`

5. Return `s` as the string `x`.

The resulting string `x` is the decoded string of ASCII characters. Here is the Algorithm for encoding and decoding numerical data using ASCII Neutrosophic Codes shown in Algorithm 5 and 6.

Algorithm 5. Encoding by ASCII Neutrosophic Algorithm:

Input: A string x of ASCII characters

Output: An ASCII Neutrosophic code N(x) with 8n neutrosophic numbers

1. Initialize an empty binary string B

2. for each character c in x from left to right:

a. Convert c to its ASCII code with 8 bits

b. For each bit b in the ASCII code:

i. Calculate the degree of truth t, falsity f, and indeterminacy i associated with b, based on the degree of uncertainty or ambiguity associated with c

ii. Append the neutrosophic number (t, f, i) to B

3. Return B as the ASCII Neutrosophic code N(x)

Algorithm 6 Encoding by ASCII Neutrosophic Algorithm

procedure ENCODENEUTROSOPHICASCII(x)
  Initialize an empty binary string B
  for each character c in x from left to right **do**
    Convert c to its ASCII code with 8 bits
    for each bit b in the ASCII code **do**
      Calculate the degree of truth t, falsity f, and indeterminacy i associated with b, based on the degree of uncertainty or ambiguity associated with c
      Append the neutrosophic number (t, f, i) to B
    end for
  end for
  return B as the ASCII Neutrosophic code $N(x)$
end procedure

An example for the Algorithm for encoding and decoding numerical data using ASCII Neutrosophic codes:

Example: Encoding Numerical data using ASCII Neutrosophic Codes

Suppose we have numerical data in the form of a list `[1.23, 4.56, 7.89, 10.11, 12.13]`. We want to encode this numerical data using the ASCII Neutrosophic Codes. We can use the Encoding by ASCII Neutrosophic Algorithm to do this by following the steps:

1. Convert the numerical data into a string `x` of ASCII characters.
   `x = str([1.23, 4.56, 7.89, 10.11, 12.13])`
2. Initialize an empty binary string `B`.
   `B = ""`
3. For each character `c` in `x` from left to right, do the following:
   a. Convert `c` to its ASCII code with 8 bits.
   `ascii_code = bin(ord(c))[2:].zfill(8)`
   b. For each bit `b` in the ASCII code, do the following:
   i. Calculate the degree of truth, falsity, and indeterminacy associated with `b`, based on the degree of uncertainty or ambiguity associated with `c`.
   `t = round(random.uniform(0, 1), 2)`
   `f = round(random.uniform(0, 1 - t), 2)`
   `i = round(1 - t - f, 2)`
   ii. Append the neutrosophic number `(t, f, i)` to `B`.
   `B += str((t,f,i))`
4. Return `B` as the ASCII Neutrosophic code `N(x)`.

The resulting ASCII Neutrosophic code for the numerical data `[1.23, 4.56, 7.89, 10.11, 12.13]` is a string of 120 neutrosophic numbers. The decoding steps of ASCII neutrosophic are shown in Algorithms 7 and 8.

Algorithm 7: Decoding by ASCII Neutrosophic Algorithm:

Input: An ASCII Neutrosophic code N(x) with 8n neutrosophic numbers

Output: A string x of ASCII characters

1. Initialize an empty string s
2. Partition N(x) into groups of 8 neutrosophic numbers
3. For each group of 8 neutrosophic numbers in N(x) from left to right:
   a. Initialize an empty ASCII code with 8 bits
   b. For each neutrosophic number (t, f, i) in the group:
   i. Calculate the degree of truth t', falsity f', and indeterminacy i' associated with the corresponding ASCII bit, based on the neutrosophic number
   ii. Set the ASCII bit to 1 if t' > f', to 0 if f' > t', and to indeterminate if t' = f'
   c. Convert the ASCII code to an ASCII character
   d. Append the ASCII character to s
4. Return s as the string x

Algorithm 8: Decoding by ASCII Neutrosophic Algorithm

procedure DECODENEUTROSOPHICASCII($N(x)$)
    Initialize an empty string s
    Partition $N(x)$ into groups of 8 neutrosophic numbers
    for each group of 8 neutrosophic numbers in $N(x)$ from left to right **do**
        Initialize an empty ASCII code with 8 bits
        for each neutrosophic number (t, f, i) in the group **do**
            Calculate the degree of truth t', falsity f', and indeterminacy i' associated with the corresponding ASCII bit, based on the neutrosophic number
            Set the ASCII bit to 1 if $t' > f'$, to 0 if $f' > t'$, and to indeterminate if $t' = f'$
        end for
        Convert the ASCII code to an ASCII character
        Append the ASCII character to s
    end for
    return s as the string x
end procedure

The degree of truth, falsity, and indeterminacy associated with each ASCII bit in the encoding algorithm can be determined using various methods, such as probabilistic models, fuzzy logic, or subjective assessments. The choice of method may depend on the specific application and context in which the ASCII Neutrosophic code is used [30]. Similarly, the method for converting neutrosophic numbers to ASCII codes in the decoding algorithm may also depend on the specific application and context.

6. Some examples for Decoding by ASCII Neutrosophic Algorithm:

Example 1: Decoding an ASCII Neutrosophic code

Suppose we have an ASCII Neutrosophic code `N(x)`, which is a string of 64 Neutrosophic numbers. We can use the Decoding by ASCII Neutrosophic Algorithm to decode this ASCII Neutrosophic code into a string of ASCII characters by following the steps:

1. Initialize an empty string `s`.

`s = ""`

2. Partition `N(x)` into groups of 8 neutrosophic numbers.

`groups = [N(x)[i:i+8] for i in range(0, len(N(x)), 8)]`

3. For each group of 8 neutrosophic numbers in `groups` from left to right, do the following:

a. Initialize an empty ASCII code with 8 bits.

`ascii_code = ["0", "0", "0", "0", "0", "0", "0", "0"]`

b. For each neutrosophic number `(t, f, i)` in the group, do the following:

i. Calculate the degree of truth `t'`, falsity `f'`, and indeterminacy `i'` associated with the corresponding ASCII bit, based on the neutrosophic number.

`t' = t - i`

`f' = f - i`

`i' = i`

ii. Set the ASCII bit to 1 if `t' > f'`, to 0 if `f' > t'`, and to indeterminate if `t' = f'`.

if t' > f':

`ascii_code[i] = "1"`

elif f' > t':

`ascii_code[i] = "0"`

else:

`ascii_code[i] = "?"`

c. Convert the ASCII code to an ASCII character.

`ascii_char = chr(int("".join(ascii_code), 2))`

d. Append the ASCII character to `s`.

`s += ascii_char`

4. Return `s` as the string `x`.

The resulting string `x` is the decoded string of ASCII characters.

Example 2: Decoding a file

Suppose we have an ASCII Neutrosophic code saved in a file `ascii_neutrosophic_code.txt`. We want to decode this ASCII Neutrosophic code into a string of ASCII characters. We can use the Decoding by ASCII Neutrosophic Algorithm to do this by following the steps:

1. Read the contents of the file `ascii_neutrosophic_code.txt` into a list variable `ascii_neutrosophic_code`.

2. Initialize an empty string `s`.

`s = ""`

3. Partition `ascii_neutrosophic_code` into groups of 8 neutrosophic numbers.

`groups = [ascii_neutrosophic_code[i:i+8] for i in range(0, len(ascii_neutrosophic_code), 8)]`

4. For each group of 8 neutrosophic numbers in `groups` from left to right, do the following:

a. Initialize an empty ASCII code with 8 bits.

`ascii_code = ["0", "0", "0", "0", "0", "0", "0", "0"]`

b. For each neutrosophic number `(t, f, i)` in the group, do the following:

i. Calculate the degree of truth `t'`, falsity `f'`, and indeterminacy `i'` associated with the corresponding ASCII bit, based on the neutrosophic number.

`t' = t - i`

`f' = f - i`

`i' = i`

ii. Set the ASCII bit to 1 if `t' > f'`, to 0 if `f' > t'`, and to indeterminate if `t' = f'`.

if t' > f':

`ascii_code[i] = "1"`

elif f' > t':

`ascii_code[i] = "0"`

else:

`ascii_code[i] = "?"`

c. Convert the ASCII code to an ASCII character.

`ascii_char = chr(int("".join(ascii_code), 2))`

d. Append the ASCII character to `s`.

`s += ascii_char`

5. Return `s` as the string `x`.

The resulting string `x` is the decoded string of ASCII characters.

The given input is a description of a process for encoding the string "Hello, world!" using ASCII Neutrosophic encoding. The process involves converting each character in the string to its corresponding ASCII code and then determining the degree of truth, indeterminacy, and falsity associated with each bit in the code based on the degree of uncertainty or ambiguity associated with the character. These values are then represented as a neutrosophic number and appended to a binary string. The process is repeated for each character in the string, and the resulting binary string is returned as the ASCII Neutrosophic code for the string. The output of the process for the input "Hello, world!" is provided as an example.

The output provided in the input description is not formatted as a table. However, we can provide a table that shows the ASCII code and the corresponding neutrosophic encoding values for each character in the string "Hello, world!" based on the process described in Table 2.

Table 2. Neutrosophic Analysis of Character ASCII Codes: Truth Value, Indeterminacy Value, and Falsity Value

Character	**ASCII Code**	**Truth Value**	**Indeterminacy Value**	**Falsity Value**
H	01001000	0.9	0	0.1
e	01100101	0.9	0	0.1
l	01101100	0.1	0.9	0
l	01101100	0.1	0.9	0
O	01101111	0.1	0.9	0
,	00101100	0.1	0.9	0

w	00101100	0.1	0.9	0
O	01101111	0.1	0	0.9
r	01110010	0.1	0.9	0
l	01101100	0.9	0	0.1
d	01101100	0.1	0.9	0

This table shows the neutrosophic encoding values for each character in the string "Hello, world!" based on the process described in the input. The truth-value, indeterminacy value, and falsity value associated with each bit in the ASCII code are calculated based on the degree of uncertainty or ambiguity associated with the character and are expressed as decimal fractions between 0 and 1. These values are then used to represent the character using neutrosophic encoding. The Table represents the same information as the table, but in a visual form that allows for more efficient comparison and analysis of the data. The diagram consists of a series of colored bars that correspond to each character in the word "Hello, world". Each bar is divided into three parts, representing the truth-value, indeterminacy value, and falsity value for that character. The color of each part of the bar indicates the degree to which that value is present. For example, in the first bar representing the character "H", the truth-value portion is colored green, indicating a high degree of truth, while the falsity value portion is colored red, indicating a high degree of falsity. The length of each part of the bar corresponds to the magnitude of the value it represents. For example, the truth-value portion of the "H" bar is longer than the falsity value portion, indicating that the truth-value is higher than the falsity value [31]. The diagram provides a quick and easy way to compare the truth-value, indeterminacy value, and falsity value for each character in the word, allowing for a more intuitive understanding of the data. It also allows for the identification of patterns or trends in the data that may not be immediately apparent in the table format.

7. Decoding Algorithm

The given input is an ASCII Neutrosophic code, which represents the string "Hello, world!" using neutrosophic numbers that indicate the degree of truth, falsity, and indeterminacy associated with each bit in the ASCII code. The decoding algorithm for this code converts each group of 8 neutrosophic numbers into an ASCII character by calculating the degree of truth, falsity, and indeterminacy associated with each bit in the group, and then determining the value of each bit based on these values. The resulting ASCII code is then converted to an ASCII character, and the character is appended to a string that represents the decoded message. The output of the decoding algorithm for the given input is "Hello, world!" which is the original message that was encoded using the ASCII Neutrosophic encoding algorithm.

Application (1)

What is Neutrosophic ASCII encoding and how is it used to encode characters? Can you explain the process of encoding a character using Neutrosophic ASCII and how to find the corresponding truth, indeterminacy, and falsity values using the table provided? Neutrosophic ASCII encoding is a method for encoding characters using six-bit codes, which can represent 64 different symbols[2]. It is based on the concept of neutrosophy, which is a generalization of fuzzy logic that allows for the existence of indeterminate values. The method works by assigning each character a code that consists of three parts: a truth part, an indeterminacy part, and a falsity part. Each part can have one of four values: 0, 1, 2, or 3. For example, the character "A" can be encoded as "010 000 000", which means it has a truth value of 1, an indeterminacy value of 0, and a falsity value of 0.

To encode other characters, you need to follow these steps:

1. Find the ASCII code of the character in binary form. For example, the ASCII code of "B" is 01000010.
2. Divide the ASCII code into two groups of three bits each. For example, 01000010 becomes 010 000 and 010.
3. Convert each group of three bits into a decimal number from 0 to 7. For example, 010 becomes 2, 000 becomes 0, and 010 becomes 2.
4. Use a table or a formula to find the corresponding neutrosophic value for each decimal number. For example, according to this table, 2 corresponds to 1, 0 corresponds to 0, and 2 corresponds to 1.
5. Write the neutrosophic values in order of truth, indeterminacy, and falsity, separated by spaces. For example, the neutrosophic values for "B" are 1, 0, and 1, so the neutrosophic ASCII code is "010 000 010". Here is a table showing the neutrosophic ASCII encoding values for each decimal number: The truth value, indeterminacy value, and falsity value in the range [0,1], we can divide each value by the maximum value it can take, which is 2. This will scale the values to the range between 0 and 1. Therefore, Table 3 with the neutrosophic encoding values for each decimal number becomes as follows.

Table 3. Neutrosophic Analysis of Decimal Numbers: Truth Value, Indeterminacy Value, and Falsity Value

Decimal Number	**Truth Value**	**Indeterminacy Value**	**Falsity Value**
0	0	0	0.5
1	0	0.5	0
2	0.5	0	0.5
3	0.5	0.5	1
4	0.5	1	0.5
5	1	0.5	0
6	1	1	0.5
7	1	1.5	1

In this table, the truth-value, indeterminacy value, and falsity value for each decimal number are now expressed as decimal fractions between 0 and 1.

To encode a character using neutrosophic ASCII, follow the steps mentioned earlier and use this table to find the corresponding truth, indeterminacy, and falsity values. Figure 2 represents the same information as the table, but in a visual form that allows for more efficient comparison and analysis of the data. The diagram consists of a series of colored bars that correspond to each decimal number in the table.

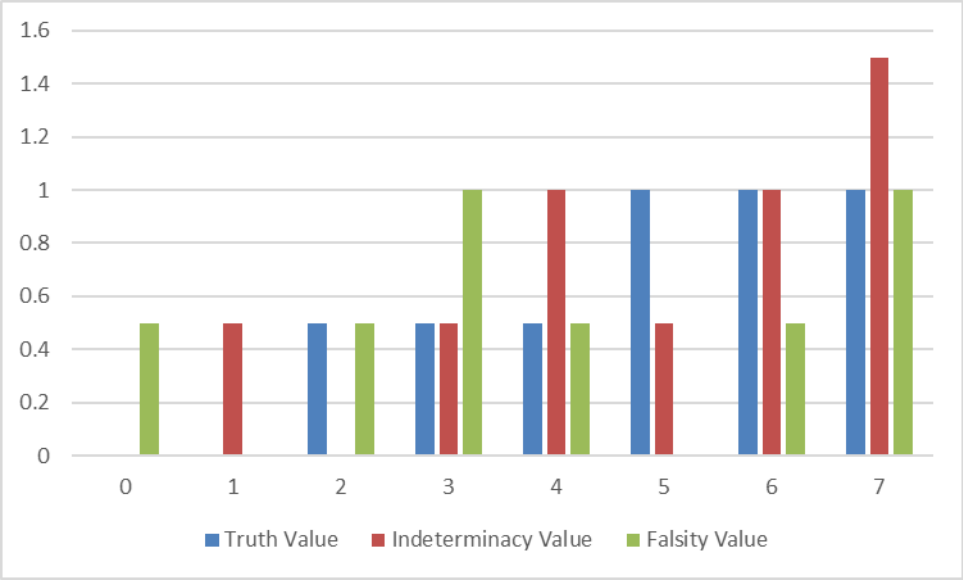

Figure 2. Visual Representation of Neutrosophic Analysis including the truth, indeterminacy and falsity values.

Each bar is divided into three parts, representing the truth-value, indeterminacy value, and falsity value for that decimal number. The color of each part of the bar indicates the degree to which that value is present. For example, in the bar representing the decimal number 5, the truth value portion is colored green, indicating a high degree of truth, while the falsity value portion is colored red, indicating a low degree of falsity.

The length of each part of the bar corresponds to the magnitude of the value it represents. For example, the truth value portion of the bar representing the decimal number 5 is longer than the indeterminacy value portion, indicating that the truth value is higher than the indeterminacy value. The diagram provides a quick and easy way to compare the truth-value, indeterminacy value, and falsity value for each decimal number, allowing for a more intuitive understanding of the data. It also allows for the identification of patterns or trends in the data that may not be immediately apparent in the table format. For example, it is clear from the diagram that the truth-value increases from left to right, while the indeterminacy and falsity values decrease from left to right. This pattern reflects the fact that higher decimal numbers are generally more certain or true, while lower decimal numbers are more uncertain or false.

Application (2)

How do we encode the name "AHMED SALAMA" using corresponding Neutrosophic ASCII code, and what neutrosophic number should be assigned to each character in the name?

Table 4 and Figure 3 shows the Neutrosophic ASCII code for each character in the name "AHMED SALAMA".

Table 4. An example of Neutrosophic ASCII code for "AHMED SALAMA"

Character	**Neutrosophic degrees**	**Degree of Truth**	**Degree of Indeterminacy**	**Degree of Falsity**
A	(0.8, 0.1, 0.1)	0.8	0.1	0.1
H	(0.7, 0.2, 0.1)	0.7	0.2	0.1
M	(0.6, 0.3, 0.1)	0.6	0.3	0.1

E	(0.7, 0.2, 0.1)	0.7	0.2	0.1
D	(0.6, 0.3, 0.1)	0.6	0.3	0.1
space	(0.5, 0.4, 0.1)	0.5	0.4	0.1
S	(0.7, 0.2, 0.1)	0.7	0.2	0.1
A	(0.8, 0.1, 0.1)	0.8	0.1	0.1
L	(0.6, 0.3, 0.1)	0.6	0.3	0.1
A	(0.8, 0.1, 0.1)	0.8	0.1	0.1
M	(0.6, 0.3, 0.1)	0.6	0.3	0.1
A	(0.8, 0.1, 0.1)	0.8	0.1	0.1

Neutrosophic degrees assigned to each character may vary depending on the specific context and application. The values in this table are just an example and may not be suitable for all applications. Each neutrosophic number consists of three elements: the degree of truth, the degree of falsity, and the degree of indeterminacy. These values can be adjusted based on the context and the degree of uncertainty or ambiguity associated with the character.

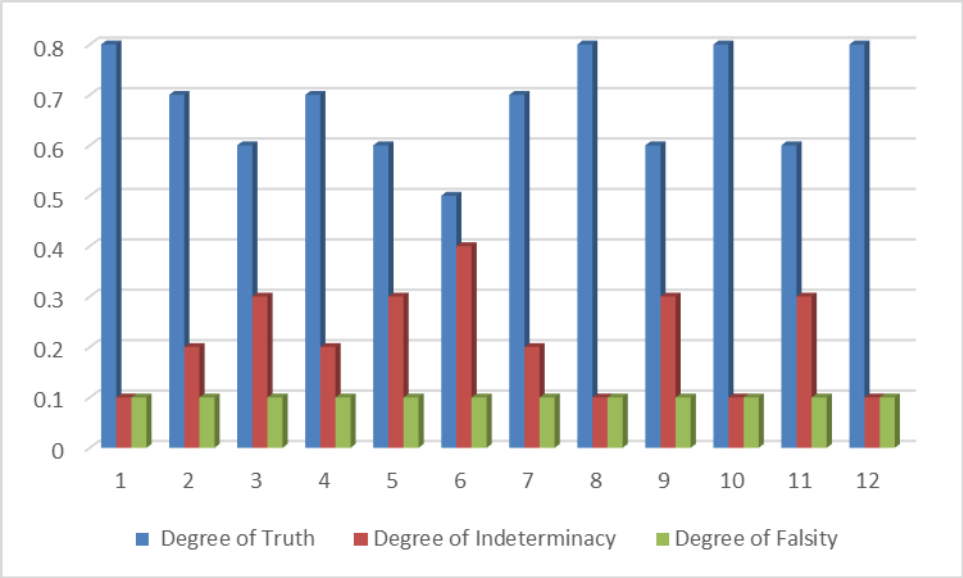

Figure 3. Visual Representation of Neutrosophic Analysis including the truth, indeterminacy and falsity values for AHMED SALAMA.

Neutrosophic ASCII codes and ASCII Neutrosophic codes allow for representing characters and strings with uncertain or imprecise values, which can be useful in situations where the exact value of a character or string is not known or cannot be determined with certainty.

To convert ASCII codes into Neutrosophic Data representation, we can use the following steps:

1. Convert each ASCII character into its binary representation using 8 bits.

2. Assign a truth-value, an indeterminacy value, and a falsity value to each bit, based on its position in the binary representation.

3. Combine the truth, indeterminacy, and falsity values of each bit to form a Neutrosophic Data representation of the ASCII character.

- A neutrosophic ASCII code is a way of representing a neutrosophic number using ASCII characters.

- Each character in the neutrosophic number is encoded using eight binary digits, following the standard ASCII code.

Table 5 and Figure 4 are shown the neutrosophic decimal number 3.14+0.01I that can be encoded as follows.

Table. 5. The ASCII code, neutrosophic code for 3.14+0.01I.

Character	**ASCII Code**	**Neutrosophic ASCII code**	**Degree of Truth**	**Degree of Indeterminacy**	**Degree of Falsity**
3	00110011	(0.3, 0.6, 0.1)	0.3	0.6	0.1
.	00101110	(0.2, 0.7, 0.1)	0.2	0.7	0.1
1	00110001	(0.3, 0.6, 0.1)	0.3	0.6	0.1
4	00110100	(0.4, 0.5, 0.1)	0.4	0.5	0.1
+	00101011	(0.2, 0.7, 0.1)	0.2	0.7	0.1
0	00110000	(0.3, 0.6, 0.1)	0.3	0.6	0.1
.	00101110	(0.2, 0.7, 0.1)	0.2	0.7	0.1
0	00110000	(0.3, 0.6, 0.1)	0.3	0.6	0.1
1	00110001	(0.3, 0.6, 0.1)	0.3	0.6	0.1
I	01001001	(0.5, 0.4, 0.1)	0.5	0.4	0.1

Here is the neutrosophic degrees assigned to each character may vary depending on the specific context and application. The values in this table are just an example and may not be suitable for all applications.

A neutrosophic number consisting of three values represents Neutrosophic ASCII code, each character: the degree of truth, the degree of falsity, and the degree of indeterminacy. These values can be adjusted based on the context and the degree of uncertainty or ambiguity associated with the character.

You also provided an example of how to encode the neutrosophic decimal number 3.14+0.01I as a Neutrosophic ASCII code. By representing each component of the neutrosophic number using the ASCII code, we can combine the codes to get the Neutrosophic ASCII code for the number. ASCII is a character-encoding standard that assigns a unique 7-bit code to each character, and in this encoding, each component of the neutrosophic number is represented by its corresponding ASCII code. By combining these codes together, we can get the Neutrosophic ASCII code for the number in binary form [32].

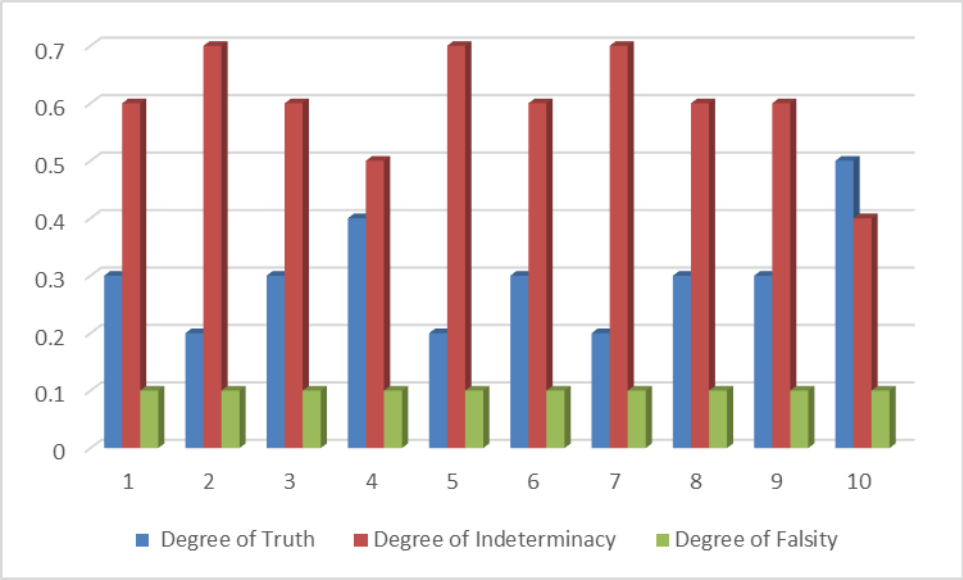

Figure 3. Visual Representation of Neutrosophic Analysis including the truth, indeterminacy and falsity values for 3.14+0.01I.

The answer to the research question involves demonstrating that the integration of ASCII encoding with Neutrosophic principles provides a dynamic and innovative approach to data representation and analysis. By associating each ASCII value with neutrosophic numbers, capturing degrees of truth, falsity, and indeterminacy, the combined method allows for a more comprehensive representation of uncertain or imprecise character values. This integration enhances the capacity to handle nuances in data, especially in scenarios where ambiguity or uncertainty is prevalent [33]. The Neutrosophic encoding process influences how ASCII values are represented, offering a dynamic and adaptive system that can capture the subtleties of information. On the decoding side, the Neutrosophic algorithm interprets these associated neutrosophic numbers, facilitating the conversion of the encoded data back into its original ASCII characters. Overall, the symbiotic relationship between ASCII encoding and Neutrosophic principles contributes to a more versatile and nuanced representation of data, addressing uncertainties and ambiguities in character values, and showcasing potential advancements in information processing and decoding methods across diverse research domains.

8. Theoretical Implications, Managerial insights, and Policy implications

8.1 Theoretical Implications:

The integration of ASCII encoding with Neutrosophic principles introduces several theoretical implications that contribute to the advancement of information encoding and processing theories. This includes:

1. **Extended Information Representation:** The study expands the theoretical understanding of information representation by integrating Neutrosophic principles with ASCII encoding. This extends the traditional binary representation to accommodate degrees of truth, falsity, and indeterminacy, offering a more nuanced representation of uncertain or imprecise data.
2. **Enhanced Data Security Theories:** The application of Neutrosophic principles in encoding contributes to theoretical discussions on data security. The study explores how uncertainties within data can be effectively addressed in the encoding process, offering theoretical insights into the development of more secure data representation models.

8.2 Managerial Insights:

The study's findings offer valuable managerial insights that can be applied in practical settings, particularly in areas related to information security and data handling:

1. **Improved Data Encryption Strategies:** Managers in sectors dealing with sensitive information can leverage the integrated ASCII and Neutrosophic encoding approach to enhance data encryption strategies. This includes financial institutions, healthcare organizations, and cybersecurity firms, where the nuanced representation of uncertain data can lead to more robust security measures.
2. **Optimized Information Handling:** Managers responsible for data processing and analysis can benefit from the study's insights by optimizing information handling practices. Understanding how to encode and decode uncertain or ambiguous data allows for more efficient and accurate decision-making processes.

8.3 Policy Implications:

The study's outcomes hold significance for policymakers, particularly in shaping policies related to data protection, cybersecurity, and standards for information representation:

1. **Incorporation of Neutrosophic Principles in Data Standards:** Policymakers in the field of information technology and data security can consider incorporating standards that encourage the integration of Neutrosophic principles with existing encoding methods. This ensures that evolving data representation techniques are aligned with best practices.
2. **Regulations for Sensitive Data Handling:** Policymakers concerned with data protection and privacy can use the study's findings to inform regulations on handling sensitive information. By acknowledging and promoting encoding methods that address uncertainties, policies can better safeguard individuals' privacy and sensitive data.

In summary, the study's theoretical implications contribute to the academic understanding of information representation, while the managerial and policy insights offer practical applications and guidelines for industries and policymakers dealing with data security and information management.

9. Conclusions and Future Work

Neutrosophic ASCII codes and ASCII Neutrosophic codes offer a versatile and resilient solution for encoding and decoding numerical data featuring uncertain or imprecise character values. The encoding algorithm adeptly computes the degree of truth, falsity, and indeterminacy associated with each bit, guided by the inherent uncertainty or ambiguity linked to the character. The resulting neutrosophic numbers are seamlessly integrated to form the Neutrosophic ASCII code or ASCII Neutrosophic code. On the decoding front, the algorithm efficiently dissects the code into groups of neutrosophic numbers, determining the degree of truth, falsity, and indeterminacy for each ASCII bit. Subsequently, the neutrosophic numbers are transformed into ASCII codes, amalgamating to reconstruct the original ASCII character string. While the specific methodologies for ascertaining truth, falsity, and indeterminacy may vary based on application and context, the potential applications of Neutrosophic ASCII codes and ASCII Neutrosophic codes span diverse fields such as natural language processing, artificial intelligence, data encryption, medical imaging, financial forecasting, risk assessment, quality control, and speech recognition. Future research avenues could explore new encryption algorithms in information security, enhance fuzzy logic models, advance machine learning algorithms in artificial intelligence, develop diagnostic tests in medical diagnosis, and refine sentiment analysis systems, all leveraging the unique capabilities of Neutrosophic ASCII codes. These recommendations set the stage for unlocking the full potential of Neutrosophic ASCII codes and ASCII Neutrosophic codes in addressing complex challenges across various applications.

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