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A TRENDING STUDY ON THE NEUTROSOPHICATION OF $\mathbb{Z}$ – TRANSFORM

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Abstract

The present study focuses on the neutrosophication of $\mathbb{Z}$ – Transform , it is developed and various properties like neutrosophic $\mathbb{Z}$ Transform linearity, neutrosophic $\mathbb{Z}$ – Transform damping rule, neutrosophic $\mathbb{Z}$ – Transform shifting theorem, neutrosophic $\mathbb{Z}$ – Transform’s initial and final value theorem are discussed under this method. The results of the properties are proposed and numerical example have been illustrated.

Keywords: A Linear Neutrosophic $\mathbb{Z}$ – Transform, Damping rule of Neutrosophic $\mathbb{Z}$ – Transform, Shifting Theorem of Neutrosophic $\mathbb{Z}$ – Transform, Initial Value Neutrosophic $\mathbb{Z}$ – Transform, Final Value Neutrosophic $\mathbb{Z}$ – Transform.

Introduction

Z- transform is useful in solving difference equation which represent a discrete system. The Z- transform plays an important role in discrete time signal analysis. In this work the Neutrosophic $\mathbb{Z}$ – Transform can be introduced, further discussing its basic properties and applications.

The Generalization of Neutrosophic Set is an Intuitionistic Fuzzy Set and Inconsistent Intuitionistic Fuzzy Set. A new branch of philosophy, Neutrosophy has been extended to Refined Neutrosophy, and consequently Neutrosophication was extended to Refined Neutrosophication. The particular cases of Neutrosophication and of Neutrosophic Probability are Regret Theory, Grey System Theory, and Three-Ways Decision. Neutrosophic Set also generalizes the paraconsistent set, intuitionistic set, etc.

Preliminary:

Neutrosophic Set: Let U be a universe of discourse, and M a set included in U . An element x from U is noted with respect to the set M as $x(T, I, F)$ and belongs to M in the following way: it is $t\%$ true in the set, $i\%$ indeterminate (unknown if it is) in the set, and $f\%$ false, where t varies in T , i varies in I , f varies in F . Statically T, I, F are subsets, but dynamically T, I, F are functions/operators depending on many known or unknown parameters.

NEUTROSOPHIC $\mathbb{Z}$ – TRANSFORM

Let the sequence of a function $f(A)$ can be defined for truth membership function, indeterminacy membership function and falsity membership function $\langle T_A(x), I_A(x), F_A(x) \rangle$, A is a single valued Neutrosophic set $x \in X$. The Neutrosophic $\mathbb{Z}$ – Transform is defined as

$$\mathbb{N}_{\mathbb{Z}}(f(A)) = \tilde{f}_{\mathbb{N}}(\mathbb{Z}) = \sum_{i=0}^{\infty} \langle T_A(x_i), I_A(x_i), F_A(x_i) \rangle \mathbb{Z}^{-i}$$

The Neutrosophic inverse $\mathbb{Z}$ – Transform $\tilde{f}_{\mathbb{N}}(\mathbb{Z}) = \mathbb{N}_{\mathbb{Z}}(\mathbf{f}(\mathbf{A}))$ is defined as

$$\mathbb{N}_{\mathbb{Z}}^{-1} \tilde{f}_{\mathbb{N}}(\mathbb{Z}) = f(A).$$

2.PROPERTIES OF NEUTROSOPHIC $\mathbb{Z}$ – TRANSFORM

2.1 The Neutrosophic $\mathbb{Z}$ – Transform is linear.

$$\mathbb{N}_{\mathbb{Z}}(af(A) + bf(B)) = a\mathbb{N}_{\mathbb{Z}}(f(A)) + b\mathbb{N}_{\mathbb{Z}}(f(B))$$

Proof:

$$\begin{aligned} \mathbb{N}_{\mathbb{Z}}(af(A) + bf(B)) &= \sum_{i=0}^{\infty} \{a \langle T_A(x_i), I_A(x_i), F_A(x_i) \rangle + b \langle T_A(x_i), I_A(x_i), F_A(x_i) \rangle\} \mathbb{Z}^{-i} \\ &= a \sum_{i=0}^{\infty} \langle T_A(x_i), I_A(x_i), F_A(x_i) \rangle \mathbb{Z}^{-i} + b \sum_{i=0}^{\infty} \langle T_A(x_i), I_A(x_i), F_A(x_i) \rangle \mathbb{Z}^{-i} \\ &= a\mathbb{N}_{\mathbb{Z}}\{f(A)\} + b\mathbb{N}_{\mathbb{Z}}\{f(B)\} \end{aligned}$$

2.2 The Neutrosophic $\mathbb{Z}$ – Transform's Damping Rule

$$\text{If } \mathbb{N}_{\mathbb{Z}}\{f(A)\} = \tilde{f}_{\mathbb{N}}(\mathbb{Z}) \text{ then } \mathbb{N}_{\mathbb{Z}}\{a^{-i}f(A)\} = \tilde{f}_{\mathbb{N}}(a\mathbb{Z}) \text{ and } \mathbb{N}_{\mathbb{Z}}\{a^i f(A)\} = \tilde{f}_{\mathbb{N}}\left(\frac{\mathbb{Z}}{a}\right)$$

Proof:

$$\begin{aligned} \tilde{f}_{\mathbb{N}}(\mathbb{Z}) &= \mathbb{N}_{\mathbb{Z}}\{f(A)\} = \sum_{i=0}^{\infty} \langle T_A(x_i), I_A(x_i), F_A(x_i) \rangle \mathbb{Z}^{-i} \\ \mathbb{N}_{\mathbb{Z}}\{a^{-i}f(A)\} &= \sum_{i=0}^{\infty} a^{-i} \langle T_A(x_i), I_A(x_i), F_A(x_i) \rangle \mathbb{Z}^{-i} \\ &= \sum_{i=0}^{\infty} \langle T_A(x_i), I_A(x_i), F_A(x_i) \rangle (a\mathbb{Z})^{-i} \\ &= \tilde{f}_{\mathbb{N}}(a\mathbb{Z}) \end{aligned}$$

Also

$$\begin{aligned} \mathbb{N}_{\mathbb{Z}}\{a^i f(A)\} &= \sum_{i=0}^{\infty} a^{-i} \langle T_A(x_i), I_A(x_i), F_A(x_i) \rangle \mathbb{Z}^{-i} \\ &= \sum_{i=0}^{\infty} \langle T_A(x_i), I_A(x_i), F_A(x_i) \rangle \left(\frac{\mathbb{Z}}{a}\right)^{-i} \end{aligned}$$

$$= \tilde{f}_{\mathbb{N}}\left(\frac{\mathbb{Z}}{a}\right)$$

2.3 Shifting Theorem of the Neutrosophic $\mathbb{Z}$ – Transform

$$\mathbb{N}_{\mathbb{Z}}\{f(A)\} = \tilde{f}_{\mathbb{N}}(\mathbb{Z}) \text{ and } C > 0 \text{ then (i) } \mathbb{N}_{\mathbb{Z}}\{f(A - C)\} = \mathbb{Z}^{-C} \tilde{f}_{\mathbb{N}}(\mathbb{Z})$$

$$(ii) \mathbb{N}_{\mathbb{Z}}\{f(A + C)\} = z^C (\tilde{f}(z) - f(0) - f(1)z^{-1} - f(z)z^{-2} - \dots - f(C - 1)z^{-(C-1)})$$

Proof:

$$(i) \mathbb{N}_{\mathbb{Z}}\{f(A)\} = \tilde{f}_{\mathbb{N}}(\mathbb{Z}) = \sum_{i=0}^{\infty} \langle T_A(x_i), I_A(x_i), F_A(x_i) \rangle \mathbb{Z}^{-i}$$

$$\mathbb{N}_{\mathbb{Z}}\{f(A - C)\} = \sum_{i=0}^{\infty} \langle T_A(x_i - C), I_A(x_i - C), F_A(x_i - C) \rangle \mathbb{Z}^{-i}$$

$$= \sum_{y=-C}^{\infty} \langle T_A(y), I_A(y), F_A(y) \rangle \mathbb{Z}^{-(y+C)}$$

$$= \sum_{y=-C}^{\infty} \langle T_A(y), I_A(y), F_A(y) \rangle \mathbb{Z}^{-y} \mathbb{Z}^{-C}$$

$$= \mathbb{Z}^{-C} \sum_{y=-C}^{\infty} \langle T_A(y), I_A(y), F_A(y) \rangle \mathbb{Z}^{-y}$$

$$= \mathbb{Z}^{-C} \tilde{f}_{\mathbb{N}}(\mathbb{Z})$$

$$(ii) \mathbb{N}_{\mathbb{Z}}\{f(A + C)\} = \sum_{i=0}^{\infty} \langle T_A(x_i + C), I_A(x_i + C), F_A(x_i + C) \rangle \mathbb{Z}^{-i}$$

$$= \mathbb{Z}^C \sum_{i=0}^{\infty} \langle T_A(x_i + C), I_A(x_i + C), F_A(x_i + C) \rangle \mathbb{Z}^{-(i+C)}$$

$$= \mathbb{Z}^C \left[\sum_{i=0}^{\infty} \langle T_A(x_i + C), I_A(x_i + C), F_A(x_i + C) \rangle \mathbb{Z}^{-i} - \sum_{i=0}^{C-1} \langle T_A(x_i + C), I_A(x_i + C), F_A(x_i + C) \rangle \mathbb{Z}^{-i} \right]$$

$$= \mathbb{Z}^C [\tilde{f}(\mathbb{Z}) - f(0) - f(1)\mathbb{Z}^{-1} - f(\mathbb{Z})\mathbb{Z}^{-2} - \dots - f(C - 1)\mathbb{Z}^{-(C-1)}]$$

Put $C = 1, 2, 3 \dots$

$$\mathbb{N}_{\mathbb{Z}}\{f(A + 1)\} = z[\tilde{f}(z) - f(0)]$$

$$\mathbb{N}_{\mathbb{Z}}\{f(A+2)\} = z^2[\tilde{f}(z) - f(0) - f(1)z^{-1}]$$

$$\mathbb{N}_{\mathbb{Z}}\{f(A+3)\} = z^3[\tilde{f}(z) - f(0) - f(1)z^{-1} - f(2)z^{-2}]$$

2.4 Initial Value Theorem of the Neutrosophic $\mathbb{Z}$ – Transform

$$\text{If } \mathbb{N}_{\mathbb{Z}}\{f(A)\} = \tilde{f}_{\mathbb{N}}(\mathbb{Z}) \text{ then } f_{\mathbb{N}}(0) = \lim_{\mathbb{Z} \rightarrow \infty} \tilde{f}_{\mathbb{N}}(\mathbb{Z})$$

Proof:

$$\begin{aligned} \tilde{f}_{\mathbb{N}}(\mathbb{Z}) &= \mathbb{N}_{\mathbb{Z}}\{f(A)\} = \sum_{i=0}^{\infty} \langle T_A(x_i), I_A(x_i), F_A(x_i) \rangle \mathbb{Z}^{-i} \\ &= \langle T_A(x_0), I_A(x_0), F_A(x_0) \rangle \mathbb{Z}^0 + \langle T_A(x_1), I_A(x_1), F_A(x_1) \rangle \mathbb{Z}^{-1} + \dots \\ &= f(0) + f(1)z^{-1} + f(2)z^{-2} + \dots \\ \therefore \lim_{\mathbb{Z} \rightarrow \infty} \tilde{f}_{\mathbb{N}}(\mathbb{Z}) &= f_{\mathbb{N}}(0) \end{aligned}$$

2.5 Final Value Theorem of the Neutrosophic $\mathbb{Z}$ – Transform

$$\text{If } \mathbb{N}_{\mathbb{Z}}\{f(A)\} = \tilde{f}_{\mathbb{N}}(\mathbb{Z}) \text{ then } \lim_{i \rightarrow \infty} \{f(A)\} = \lim_{z \rightarrow 1} (z-1) \tilde{f}_{\mathbb{N}}(\mathbb{Z})$$

Proof:

$$\mathbb{N}_{\mathbb{Z}}\{f(A)\} = \sum_{i=0}^{\infty} \langle T_A(x_i), I_A(x_i), F_A(x_i) \rangle \mathbb{Z}^{-i}$$

We Know that

$$\mathbb{N}_{\mathbb{Z}}\{f(A+1) - f(A)\} = \sum_{i=0}^{\infty} \{ \langle T_A(x_i+1), I_A(x_i+1), F_A(x_i+1) \rangle - \langle T_A(x_i), I_A(x_i), F_A(x_i) \rangle \} \mathbb{Z}^{-i}$$

$$\begin{aligned} \mathbb{N}_{\mathbb{Z}}\{f(A+1)\} - \mathbb{N}_{\mathbb{Z}}\{f(A)\} &= \sum_{i=0}^{\infty} \{ \langle T_A(x_i+1), I_A(x_i+1), F_A(x_i+1) \rangle - \langle T_A(x_i), I_A(x_i), F_A(x_i) \rangle \} \mathbb{Z}^{-i} \end{aligned}$$

$$\begin{aligned} z[\tilde{f}_{\mathbb{N}}(\mathbb{Z}) - \tilde{f}_{\mathbb{N}}(0)] - \tilde{f}_{\mathbb{N}}(\mathbb{Z}) &= \sum_{i=0}^{\infty} \{ \langle T_A(x_i+1), I_A(x_i+1), F_A(x_i+1) \rangle - \langle T_A(x_i), I_A(x_i), F_A(x_i) \rangle \} \mathbb{Z}^{-i} \end{aligned}$$

$$\begin{aligned} \tilde{f}_{\mathbb{N}}(\mathbb{Z})(z-1) - z\tilde{f}_{\mathbb{N}}(0) \\ = \sum_{i=0}^{\infty} \{\langle T_A(x_i+1), I_A(x_i+1), F_A(x_i+1) \rangle - \langle T_A(x_i), I_A(x_i), F_A(x_i) \rangle\} \mathbb{Z}^{-i} \end{aligned}$$

Taking limit as $z \rightarrow 1$

$$\begin{aligned} \lim_{z \rightarrow 1} [(z-1)\tilde{f}_{\mathbb{N}}(\mathbb{Z})] - \tilde{f}_{\mathbb{N}}(0) \\ = \lim_{z \rightarrow 1} \left[\sum_{i=0}^1 \{\langle T_A(x_i+1), I_A(x_i+1), F_A(x_i+1) \rangle - \langle T_A(x_i), I_A(x_i), F_A(x_i) \rangle\} \right] \mathbb{Z}^{-i} \\ = \sum_{i=0}^{\infty} \{\langle T_A(x_i+1), I_A(x_i+1), F_A(x_i+1) \rangle - \langle T_A(x_i), I_A(x_i), F_A(x_i) \rangle\} \\ = \lim_{i \rightarrow \infty} \left[(\tilde{f}_{\mathbb{N}}(1) - \tilde{f}_{\mathbb{N}}(0)) + (\tilde{f}_{\mathbb{N}}(2) - \tilde{f}_{\mathbb{N}}(1)) + \dots \dots \dots (\tilde{f}_{\mathbb{N}}(A+1) - \tilde{f}_{\mathbb{N}}(A)) \right] \\ = \lim_{i \rightarrow \infty} [\tilde{f}_{\mathbb{N}}(A+1) - \tilde{f}_{\mathbb{N}}(0)] \\ \therefore \lim_{z \rightarrow 1} (z-1)\tilde{f}_{\mathbb{N}}(\mathbb{Z}) = \lim_{i \rightarrow \infty} \tilde{f}_{\mathbb{N}}(A+1) \\ = \lim_{i \rightarrow \infty} \tilde{f}_{\mathbb{N}}(A) \\ \lim_{i \rightarrow \infty} \tilde{f}_{\mathbb{N}}(A) = \lim_{z \rightarrow 1} (z-1)\tilde{f}_{\mathbb{N}}(\mathbb{Z}) \end{aligned}$$

3 Results and Discussion

By the definition of Neutrosophic $\mathbb{Z}$ - Transform $\mathbb{N}_{\mathbb{Z}}(f(A)) = \tilde{f}_{\mathbb{N}}(\mathbb{Z}) = \sum_{i=0}^{\infty} \langle T_A(x_i), I_A(x_i), F_A(x_i) \rangle \mathbb{Z}^{-i}$

$$(i) \mathbb{N}_{\mathbb{Z}}(\tilde{A}^i) = \tilde{f}_{\mathbb{N}}(\mathbb{Z}) = \sum_{i=0}^{\infty} \langle T_{A^i}, I_{A^i}, F_{A^i} \rangle \mathbb{Z}^{-i}$$

$$\therefore \mathbb{N}_{\mathbb{Z}}(\tilde{A}^i) = (T^i, 1 - (1 - I)^i, 1 - (1 - F)^i), i > 0$$

$$(ii) \mathbb{N}_{\mathbb{Z}}(K\tilde{A}^i) = \tilde{f}_{\mathbb{N}}(\mathbb{Z}) = \sum_{i=0}^{\infty} K \langle T_{A^i}, I_{A^i}, F_{A^i} \rangle \mathbb{Z}^{-i}$$

$$= \langle (1 - (1 - T)^K), I^K, F^K \rangle$$

$$\therefore \mathbb{N}_{\mathbb{Z}}(K\tilde{A}^i) = \langle (1 - (1 - T)^K), I^K, F^K \rangle$$

Numerical Example

$$A = \langle (1,3,5), 0.7, 0.8, 0.9 \rangle$$

$$N_{\mathbb{Z}}(\tilde{A}^i) = \tilde{f}_{\mathbb{N}}(\mathbb{Z}) = \sum_{i=0}^{\infty} \langle T_{A^i}, I_{A^i}, F_{A^i} \rangle \mathbb{Z}^{-i}$$

$$N_{\mathbb{Z}}(\tilde{A}^i) = (T^i, 1 - (1 - I)^i, 1 - (1 - F)^i), i > 0$$

$$N_{\mathbb{Z}}(\tilde{A}^i) = (T^i, 1 - (1 - I)^i, 1 - (1 - F)^i), i > 0$$

$$N_{\mathbb{Z}}(\langle (1,3,5), 0.7, 0.8, 0.9 \rangle^i) = (2.9, 4.6, 8.2), i > 0$$

4 Conclusion

In this study an attempt has been initiated to neutrosophicate the $\mathbb{Z}$ – Transform, for the purpose of applying the concept in various fields like digital filters, system design and analysis and automatic control in telecommunication. The future study will be focused on the convolution of the neutrosophic $\mathbb{Z}$ – Transform.

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