Study Some Methods To Measure The Reliability System Neutrosophically

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Abstract

Industry has developed greatly nowadays, and it has been accompanied by great complexity in machines and devices. Researches that seeks to obtain high efficiencies for these machines have emerged , such as reliability theory. Due to the verity and complexity of the machines, we resort to using the neutrosophic reliability that includes cases excluded from classical reliability. The aim of this paper is to define the neutrosophic parallel system and study neutrosophic methods of calculating the neutrosophic reliability, where the basic concept neutrosophic adjacency matrix of system are present by defined neutrosophic adjacency matrix of neutrosophic graph. Two methods for calculate the neutrosophic reliability are defined conformity to neutrosophic logic which are neutrosophic minimal path method and neutrosophic tracing method. some applications have been introduced.

Keywords: Neutrosophic connection matrix; Neutrosophic reliability; neutrosophic probability; neutrosophic minimal path method; neutrosophic tracing method; neutrosophic parallel.

1.Introduction

In the technological world, everyone depends on the continuity functioning of the machines, tools, products, equipment of missiles, and aircraft engines, and it has been accompanied by great complexity in machines and devices. Researches that seeks to obtain high efficiencies for these machines have emerged, such as reliability theory. This theory focuses on probabilities of machine performing its work efficiently over interval time, as well as the probability of its failures. Knowing the value of the machine's reliability facilitates decision making whether to keep, replace, or maintain it. Many researchers were interested in the reliability of simple and complex systems such as Zahir [17,18]. The system of any machine consists of edge and vertices connected to each other in one way or another. Calculating the system's reliability depends on the connection of edges to the vertices, and the edges is either connected or not connected to the vertex. However, in classical reliability. if there is at least one edge that is unclear, ambiguous, or it cannot determined (whether it is connected or not) (it works or not) will be excluded or ignored. Due to the uncertainty, it is considered as ubiquitous in the real world, as in engineering, quality of products. When the design of systems radar, missiles, and aircraft engines and the quality of the machines by high reliability, the uncertainties will end. Therefore, we seek modern method to increase reliability and it neutrosophic reliability.

In neutrosophic reliability, these edges (unclear or ambiguous) will be considered in addition to other edges, and accordingly neutrosophic reliability will give amore accuracy and description of the system, that introduced by Alhasan K. and others, see[7] . The first person to work on neutrosophic approach was (Florentin in 1995)[1,2,3,4], where this approach allows dealing with the clear and unclear items, and this certainly helps to increase the reliability. In 1965, the logic fuzzy introduced by Zadeh, where the fuzzy set and fuzzy logic have been widely applied in many fields to deal with uncertain problems which represented membership of degree. Where lots of

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applications such as information fusion, the belief of systems, we noted the truth membership is not enough to the clear, however if we take against the evident that false membership. While, [19] Atnassov in 1986 introduced the intuitionistic fuzzy set that consider a generalization of fuzzy set. He included both truth membership and falsity membership functions $T_{\mathcal{A}^{\sim}}$, $F_{\mathcal{A}^{\sim}}$, respectively. $T_{\mathcal{A}^{\sim}}$, $F_{\mathcal{A}^{\sim}} \in [0,1]$, and $0 \leq T_{\mathcal{A}^{\sim}} + F_{\mathcal{A}^{\sim}} \leq 1$,where the indeterminacy in intuitionistic fuzzy set is $1 - T_{\mathcal{A}^{\sim}} - F_{\mathcal{A}^{\sim}}$. While, indeterminacy membership is dealt with as independent of truth membership and falsity membership by Florentine 1995[4,3], who introduced the neutrosophic logic. For example, the reliability of a device for 120 hours is 0. This means that out of every 100 devices that are tested, they will be valid for 120 hours. We expect one of them to be valid for work after this period of time. The neutrosophic logic is applied in many filed, such as statistical distributions and neutrosophic Weibull family, neutrosophic crisp set theory [6][10][11][12]. Additional, there are studies neutrosophic graph by S.Broumi and others [14][15][5]. In this paper, the focus was on the neutrosophic reliability system, such as neutrosophic parallel, and the methods of the neutrosophic minimum path and neutrosophic tracing methods to find neutrosophic reliability system depending on the neutrosophic adjacency matrix and neutrosophic connected matrix.

2. Important Concepts

Neutrosophic set N_eA as an matter (topic) having the form $N_eA = \{x: < T_{\mathcal{A}^{\sim}}(x), I_{\mathcal{A}^{\sim}}(x), F_{\mathcal{A}^{\sim}}(x), \in U\}$ and U be a universe of discourse. That is, there exist three functions T, I, F whose domain is , and range is $]0^-, 1^+[$, these represented by the degree of membership, the degree of indeterminacy, and the degree of non- membership, respectively. Where $0^- \leq T_{\mathcal{A}^{\sim}}(x) + I_{\mathcal{A}^{\sim}}(x) + F_{\mathcal{A}^{\sim}}(x) \leq 3^+$.

Graph $G = (V, E)$ is defined by an ordered pair (V, E), where V is nonempty set whose components, are referred to as vertices and E is a set of element of $V(E)$.

Path is a collection of components that working simultaneously, guarantee the system is working. A path set is a minimal paths set where it cannot be reduced without losing its status as path set.

Neutrosophic Graph :A graph that includes at least either one edge or one node is an indeterminacy, it is called a neutrosophic graph.

Directed graph which include at least one edge is indeterminacy, called a neutrosophic directed graph.

Neutrosophic number is the number which the form M=$c + dI$, where c and d are complex numbers or real, such that I is represent the indeterminate portion of the neutrosophy number M, such that $I^2 = I, 0.I = 0$, and $CI + DI = (C + D)I$. In general $I^n = I$.

Neutrosophic matrix is a matrix that has neutrosophic numbers.

Connection matrix (CM) is constructed from adding an adjacency matrix with the identity matrix, that is replacing the zeros in the diagonal of an adjacency matrix with ones. That is, $CM = A + AI$. Such that A is the adjacency matrix of the graph, A =(a_{ij}) with n× n matrix, and AI is the identity matrix.

3. Neutrosophic Reliability function

Let T be a Neutrosophic random variable represent the time of the system failure, and t be the interval of the operation of this system.

$N_eR(t) = \int_t^{\infty} f_{N_e}(t)dt = N_eP(T > t)$, where t is neutrosophic number contain some indeterminacy, and $f_{N_e}(t)$ is the neutrosophic probability distribution. $N_eR(t)$ called neutrosophic reliability function.[16]

System (network) is a set of components or subsystem put in order to a specific design to achieve required functions with allowable performance and reliability. Therefore, the classical reliability of system R is the probability that the system structure function equal to one.

Where $\varphi(X)$ is a binary random variable, $R = P(\varphi(X)) = 1$, and $R = [\varphi(X)]$.

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The neutrosophic reliability of system N_eR is the neutrosophic probability that the system structure function equal to one or more, standard or non-standard.

That is, $N_eR \in]0^-, 1^+[$

$$N_eR = N_eP\left(N_e\varphi(X)\right) =]0^-, 1^+[$$

Where $N_e\varphi(X)$ is a triple random variable. Thus , $N_eR = [N_e\varphi(X)]$

Structure-Function of Neutrosophic Reliability

The define of neutrosophic function is function which has elements in X for which the function is well defined, element in X for that the function is indeterminate, and elements in X for that the function is exter defined [21].

Neutrosophic structure-function is a classical function which triple subfunction (falsehood, indeterminacy, truth) that indicates the status of the system (not defective, indeterminate, defective) where the status of each component as

$\varphi(x_1, x_2, \dots, x_I \dots, x_n) = \varphi(X)$, defined as:

$$\varphi : \{0, I, 1\}^n \rightarrow \{0, I, 1\} \quad (1)$$

$$N_ex = \begin{Bmatrix} I & \text{if component i ndetermincy } [0, t] \\ 1 & \text{if component i working } [0, t] \\ 0 & \text{if component i fails } [0, t] \end{Bmatrix}$$

The fallowing equation describe the current state of the system as: $N_e\varphi(X) =$

$$\begin{Bmatrix} I & \text{system is ndetermincy } [0, t] \\ 1 & \text{system is works } [0, t] \\ 0 & \text{system is fails at } [0, t] \end{Bmatrix}$$

The triple states {0,1,I} are failure or work, or indeterminacy, respectively. [7]

4. Neutrosophic Adjacency Matrix

In classical approach the adjacency matrix of any graph A=(a_{ij}) with $n \times n$ matrix, which rows and columns are indexed by the elements of nodes $\mathcal{H}=\{\mathcal{H}_1, \mathcal{H}_2, \dots, \mathcal{H}_n\}$, the element a_{ij} is defined by

$$a_{ij} = \begin{Bmatrix} 1 \text{ if } \mathcal{H}_i \text{ and } \mathcal{H}_j \text{ are adjacent,} \\ 0 \quad \text{otherwise} \end{Bmatrix}$$

In neutrosophic approach we define the adjacency as follow:

The adjacency matrix And N_eA of neutrosophic graph (N_eG) with entrances from the set (1, I, 0) is called the neutrosophic adjacency matrix of the neutrosophic graph, and

N_ea_i = 1 when Na_i is on (effect)

N_ea_i = I when Na_i indeterminacy (effect cannot be determined, for I = 1, …, n.

N_ea_i = 0 when Na_i is off (no effect).

$$\text{Thus, } N_eA = (N_ea_1, N_ea_2, \dots, N_ea_n) \; ; N_ea_i \in \{1, I, 0\}. \quad (2)$$

5. Neutrosophic Reliability of Parallel System

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A classical parallel system of N components that fails if all components fail. The system that fail performs if and only if all the (units) components are malfunction. In parallel system there are alternative components that help the system operate successfully in case of failure of one or more component.

The structure function for parallel system is:

$$\varphi(X) = 1 - [(1 - X_1)(1 - X_2) \ldots .(1 - X_N)]$$

The reliability of this system is:

$$R = 1 - [(1 - R_1) \ldots \ldots .(1 - R_N)] = 1 - \prod_{i=1}^{N}(1 - R_i) \ [9]$$

If the parallel system contains some indeterminacy(unclear) components. that is, it is not clear how it works, in this case there is no definition in classical logic, and therefore we will resort to definition new logic which is neutrosophic logic.

Let $X_1, X_2, \ldots, X_I, \ldots, X_N$, are components of any system, and X_I is indeterminacy component.

The structure-function of neutrosophic parallel system with N components is

$$N_e\varphi(X) = 1 - (1 - X_1)(1 - X_2) \ldots .(1 - X_I) \ldots .(1 - X_N) = (T_i, I_i, F_i),\ i = 1,2, \ldots, N. \quad (3)$$

X_I Indictor to the indeterminacy component.

If the parallel system is success the structure-function equal to (1,1,1), and the structure function takes the value one if at least one of the X_i is one.

Let the components N are independent,

$$N_eR = 1 - [(1 - N_eR_1) \ldots (1 - N_eR_I) \ldots .(1 - N_eR_n)]. \quad (4)$$

6. Neutrosophic Connected Matrix

Let $\mathcal{H}_1, \mathcal{H}_2, \ldots \ldots, \mathcal{H}_n$ denote n nodes, and $(Z_1, Z_2, \ldots \ldots, Z_n)$ represented the edge commons between two nodes $(\mathcal{H}_i, \mathcal{H}_j)$, $N_eA = (N_ea_1, N_ea_2, \ldots, N_ea_n)$ is neutrosophic adjacency matrix , and $Z_k = \{1, I, 0\}$ (I the indeterminate), k=1,2,3…,n.

the neutrosophic connected matrix (N_eCM) is neutrosophic adjacency matrix adding the identify matrix $[I_m]$,

That is, the edge between $\mathcal{H}_1$, and $\mathcal{H}_2$ is Z_1, and the edge between$\mathcal{H}_2, \mathcal{H}_3$ is Z_2, …, and so.

Where Z_k=1: there exists an edge between two nodes (on the state),

and Z_k =I: the edge between two nodes (not determinant, not clear) is indeterminate at that time,

and Z_k= 0: there does not exist edge between two nodes (off state).

Let $\mathcal{H}_i$ and $\mathcal{H}_j$ denote the two nodes in the neutrosophic matrix. If the edge from $\mathcal{H}_i$ to $\mathcal{H}_j$ is direct, then the neutrosophic matrix called a connection.

The weight of every edge in the neutrosophic matrix is a number in the set {0, 1, I}.

Thus $N_eCM = N_eA + [I_m]$. (5)

$$N_eCM = \begin{bmatrix} 0 & a_{12} \cdots & a_{1n} \\ \vdots & \ddots & \vdots \\ a_{n1} & \cdots & 0 \end{bmatrix} + \begin{bmatrix} 1 & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & 1 \end{bmatrix} = \begin{bmatrix} 1 & a_{12} \cdots & a_{1n} \\ \vdots & \ddots & \vdots \\ a_{n1} & \cdots & 1 \end{bmatrix}.$$

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7. Neutrosophic Minimal Paths Method

The minimal path method is an important to finds all paths for any system or network from the start node to the end node. This method is play an important role to create a connection matrix to the graph, after adding the identity matrix of the adjacency matrix of the graph as follows:

$$CM = \begin{bmatrix} 0 & a_{12}\cdots & a_{1n} \\ \vdots & \ddots & \vdots \\ a_{n1} & \cdots & 0 \end{bmatrix} + \begin{bmatrix} 1 & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & 1 \end{bmatrix} = \begin{bmatrix} 1 & a_{12}\cdots & a_{1n} \\ \vdots & \ddots & \vdots \\ a_{n1} & \cdots & 1 \end{bmatrix} \quad (6)$$

Where {1,2,3,4,…, n } is the set of the number of points starts, and a_{ij}=(i, j) is the edge between start i and start j, so explained as follows:

$$a_{ij} = \begin{cases} Z_{ij} & \text{if there exist a connect between start i and start j} \\ 0 & \text{if there not exist a connect between start i and start j} \end{cases}$$

To use the above method, we select any node to delete from the connection matrix that is neither the start nor the end.

After deleting the node, the points of the connection matrix with the remaining nods , can be calculated by the following equation:[20]

$$a_{ij}{}^{1} = a_{ij} + a_{is}a_{sj} \quad (7)$$

When start k is deleting, $i \neq j,\ i \neq s, j \neq s,\ 1 \leq i \leq n,\ 1 \leq j \leq n$

For i=1,2,…,n. except that $a_{ij}{}^{1} = 1$ if and only if $i = j$. And continue deleting the intermediate start, until arriving at the 2×2 matrix, such that the least a_{ij} represent the summation of all minimal paths.

The adjacency matrix of any neutrosophic network (graph) is consider as follow:

Let (N_eG) be a neutrosophic graph, the adjacency matrix of (N_eG) has the points of the set

{0, I,1}, so explained as follow:

$$N_eCM = \begin{bmatrix} 0 & N_ea_{12}\cdots & N_ea_{1n} \\ \vdots & \ddots & \vdots \\ N_ea_{n1} & \cdots & 0 \end{bmatrix} + \begin{bmatrix} 1 & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & 1 \end{bmatrix} = \begin{bmatrix} 1 & N_ea_{12}\cdots & N_ea_{1n} \\ \vdots & \ddots & \vdots \\ N_ea_{n1} & \cdots & 1 \end{bmatrix} \quad (8)$$

$$N_ea_{ij} = \begin{cases} 1 & \text{if there not exist a connection between start i and start j} \\ I & \text{if the connection between start i and start j is indeterminade} \\ 0 & \text{if there not exist a connection between start i and start j} \end{cases} \quad (9)$$

$N_ea_{ij}{}^{1} = N_ea_{ij} + N_ea_{is}N_ea_{sj}$, If start s is deleting, where $i \neq j, i \neq s, j \neq s, 1 \leq i \leq n, 1 \leq j \leq n$, For i=1,…,n. except that $N_ea_{ij}{}^{1} = 1$ if and only if $i = j$. (10)

8. Neutrosophic path tracing method (Neutrosophic TIE-SET method)

The classical path tracing method is consider every path from start node to an end node. Since system or network success contains at least one path available from the beginning to the end , the system is considered not failure.

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To calculate the reliability by using the tracing method , we should follow the following steps:

- Find all the minimal path in the system ,
- System success depended on success of all components in a minimal path(tie-set), that is implies series connections among these component.
- Each minimal tie set causes system succeed, and this implies parallel connections among minimal tie set,
- Draw network and use series parallel method to calculate reliability of network.[17,18]

Define the R $\in \{0,1\}$ the state of the arc component R_i

$R_i = 1$ *where* R_i *is functioning* and $R_i = 0$ *if* R_i *is not faiular* , *for* $i \in \{1,2,3,..,N\}$

The structure function of the entire the system is

$\varphi(X): \{o,1\}^N \rightarrow \{o,1\}$

$R = \varphi(R_1, \dots, R_N)$

$\varphi = \varphi(Z) = \varphi(Z_1, Z_2, \dots, Z_n) = 1 - [(1-\varphi(Z_1))(1-\varphi(Z_2)) \dots (1-\varphi(Z_n))]$

This method depended on basic concept that minimal path, but the indeterminacy minimal path cannot represented by classical path tracing method, so the neutrosophic path tracing method that contains some indeterminacy path is considered. Therefore, the neutrosophic path tracing method (neutrosophic tie set method) defined as:

Define the $N_eR \in \{I,0,1\}$ the state of the arc component R_i
$R_i = 1$ where R_i is functioning ,
$R_i = 0$ where R_i is faiular ,
$R_i = I$ where R_i is indetermancy for $i \in \{1,2,\dots,I,..,N\}$
The structure function of the entire the system is
$\varphi(X): \{I,o,1\}^N \rightarrow \{I,o,1\}$

$$\varphi = \varphi(Z) = \varphi(Z_1, Z_2, \dots Z_I .., Z_n) = 1 - [(1-\varphi(Z_1)), \dots, (1-\varphi(Z_I)) \dots (1-\varphi(Z_n))]. \quad (11)$$

The neutrosophic reliability system
$N_eR = \varphi(N_eR_1, \dots N_eR_I, \dots, N_eR_N)$.

9. Applications

9.1 Let N_eG be a system of any machine, have a four edges Y_1, Y_2, Y_3, Y_4, with the four vertexes labeled as $\mathcal{H}_1, \mathcal{H}_2, \mathcal{H}_3, \mathcal{H}_4$

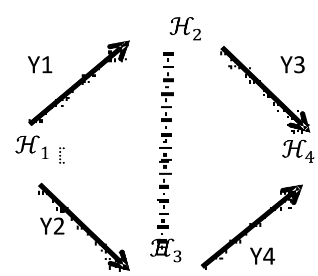

Figure 1

The classical reliability of this system found by minimal path set method. that is, the minimal path set is$\{(Y_1, Y_3), (Y_2, Y_4)\}$ [17,18].

While, if adding to the figure (1) neutrosophic edge that connect between $\mathcal{H}_3, \mathcal{H}_2$ then figure (1) become as in figure (2).

where there one edge is indeterminacy between the nodes $\mathcal{H}_3, \mathcal{H}_2$.

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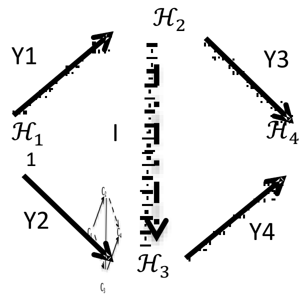

Figure 2

And the neutrosophic connection matrix after adding the unit matrix will be as follows:

$$N_e\text{CM} = \begin{bmatrix} 1 & y_1 & y_2 & 0 \\ 0 & 1 & I & y_3 \\ 0 & 0 & 1 & y_4 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

To find all minimal paths for this system, we take off the node $\mathcal{H}_2$, and the reshaped entries of the primary matrix become the following according to the above equation(10):

$N_e a^1 13 = y_1 I + y_2$

$N_e a^1 14 = y_1 y_3$

$N_e a^1 34 = y_4$

The reshaped NCM becomes the following 3x3 matrix:

$$N_e\text{CM} = \begin{bmatrix} 1 & y_2 + I y_1 & y_1 y_3 \\ 0 & 1 & y_4 \\ 0 & 0 & 1 \end{bmatrix}$$

Then, take off the second row and the second column of the matrix:

The reshaped points

$N_e a^2 13 = y_1\, y_3 + y_4\, y_2 + y_4 y_1 I$

Here $N_e a^1 13$ represent the summation of all neutrosophic minimal paths of the neutrosophic graph (of the system).

Hence, $\{ y_1\, y_3\}$, $\{ y_4\, y_2\}$,$\{y_4 y_1 I\}$ represent all neutrosophic minimal paths of system.

In this example, the minimal path to neutrosophic graph in figure (2) is more and wider than graph in graph(1) since the classical minimal path of graph one it contains only two paths, while the third path was ignored. That is, the neutrosophic graph is included the additional indeterminacy paths to the paths of classical graph.

To find the neutrosophic reliability to the system in figure(2) by using neutrosophic tracing method as follows:

$\varphi(Y): \{I, o, 1\}^3 \rightarrow \{I, o, 1\}$

$\varphi(y_1, y_2, y_3, y_4, I) = 1 - [(1 - \varphi_1(y_1, y_3))(1 - \varphi_2(y_2, y_4))(1 - \varphi_3(y_1, y_4, I))]$

$\varphi_1(y_1, y_3) = (y_1\, y_3)$

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$\varphi_2(y_2, y_4) = (y_2\, y_4)$

$\varphi_3(y_1, y_4, I) = (y_1\, y_4 I)$

$\varphi(y) = 1 - [(1 - y_1\, y_3)(1 - y_2\, y_4)(1 - y_1\, y_4 I)].$

$= y_1\, y_4 I + y_2\, y_4 - y_1\, y_2\, y_4{}^2 I + y_1\, y_3 - y_1{}^2 y_4\, y_3 I - y_1\, y_3 y_2\, y_4 + y_1{}^2 y_2 y_3 y_4{}^2 I$

$N_e R = y_1\, y_4 I + y_2\, y_4 - y_1\, y_2\, y_4\, I + y_1\, y_3 - y_1\, y_4\, y_3 I - y_1\, y_3 y_2\, y_4 + y_1\, y_2 y_3 y_4\, I$

$N_e R = \varphi(N_e R_1, N_e R_2, \ldots., N_e R_N)$

$N_e R(t) = R_1\, R_4 I + R_2\, R_4 - R_1\, R_2\, R_4\, I + R_1\, R_3 - R_1\, R_4\, R_3 I - R_1\, R_3 R_2\, R_4 + R_1\, R_2 R_3 R_4\, I$

While, the classical reliability by tracing method is:

$R(t) = R_1\, R_4 + R_2\, R_4 - R_1\, R_2\, R_4\, I + R_1\, R_3$.

9.2 let $N_e G$ be a system of any machine shown as follows:

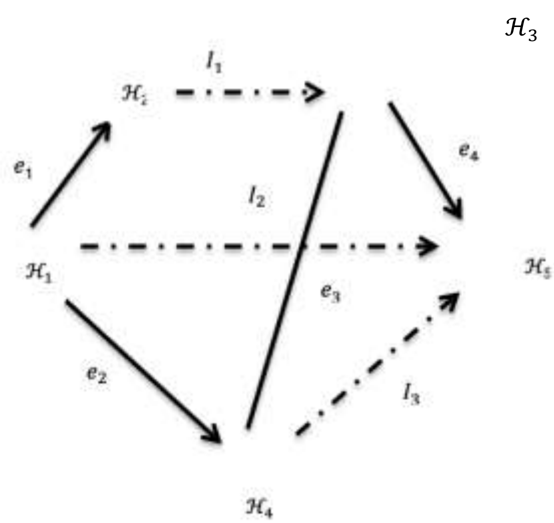

Figure 3

The neutrosophic adjacency matrices is:

$$\begin{bmatrix} 0 & e_1 & 0 & e_2 & I_2 \\ 0 & 0 & I_1 & 0 & 0 \\ 0 & 0 & 0 & e_3 & e_4 \\ 0 & 0 & e_3 & 0 & I_3 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

After adding the identity matrix of neutrosophic adjacency matrices , the neutrosophic connection matrix become as follows :

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$$N_e\text{CM} = \begin{bmatrix} 0 & e_1 & 0 & e_2 & I_2 \\ 0 & 0 & I_1 & 0 & 0 \\ 0 & 0 & 0 & e_3 & e_4 \\ 0 & 0 & e_3 & 0 & I_3 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix} + \begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 \end{bmatrix} = \begin{bmatrix} 1 & e_1 & 0 & e_2 & I_2 \\ 0 & 1 & I_1 & 0 & 0 \\ 0 & 0 & 1 & e_3 & e_4 \\ 0 & 0 & e_3 & 1 & I_3 \\ 0 & 0 & 0 & 0 & 1 \end{bmatrix}$$

To find all minimal paths for this graph, we tak-eoff the node e_2 , and the reshaped entries of the primary matrix become the following according to equation (10):

$N_e a^1 13 = e_1 I_1$, $N_e a^1 14 = e_2$, $N_e a^1 15 = I_2$, $N_e a^1 34 = e_3$, $N_e a^1 35 = e_4$, $N_e a^1 43 = e_3$, $N_e a^1 45 = I_3$

the reshaped N_eCM becomes the following 4x4 matrix:

$$N_e\text{CM} = \begin{bmatrix} 1 & e_1 I_1 & e_2 & I_2 \\ 0 & 1 & e_3 & e_4 \\ 0 & e_3 & 1 & I_3 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

When take-off the node e_3 , and the reshaped entries of the primary matrix become the following according to equation (10):

$N_e a^2 12 = e_1 I_1 + e_2 e_3$, $N_e a^2 14 = I_2 + e_2 I_3$, $N_e a^2 22 = 1 + e_3 e_3$, $N_e a^2 24 = e_3 I_3 + e_4$

the reshaped N_eCM becomes the following 3x3 matrix:

$$N_e\text{CM} = \begin{bmatrix} 1 & e_1 I_1 + e_2 e_3 & I_2 + e_2 I_3 \\ 0 & 1 + e_3 e_3 & e_3 I_3 + e_4 \\ 0 & 0 & 1 \end{bmatrix}$$

When take-off the node e_2 , and the reshaped entries of the primary matrix become the following according to equation (10)

the reshaped N_eCM becomes the following 2x2 matrix:

$$N_e\text{CM} = \begin{bmatrix} 1 & I_2 + e_2 I_3 + (e_1 I_1 + e_2 e_3)(e_3 I_3 + e_4) \\ 0 & 1 \end{bmatrix}$$

$N_e a^3 13 = I_2 + e_2 I_3 + (e_1 I_1 + e_2 e_3)(e_3 I_3 + e_4)$

$= I_2 + e_2 I_3 + e_1 I_1 e_4 + e_1 I_1 I_3 e_3 + e_4 e_2 e_3 + e_2 e_3 e_3 I_3$

$= I_2 + e_2 I_3 + e_1 I_1 e_4 + e_1 I_1 I_3 e_3 + e_4 e_2 e_3$

Here $N_e a^3 13$ represent the summation of all neutrosophic minimal paths of the neutrosophic graph system.

Hence, $\{ I_2 \}$, $\{e_2 I_3\}$, $\{e_1 I_1 e_4\}$, $\{e_1 I_1 e_3 I_3\}$, $\{e_2 e_3 e_4\}$ are all neutrosophic minimal paths of neutrosophic graph.

9.3 let N_eG be a system of any machine shown as follows:

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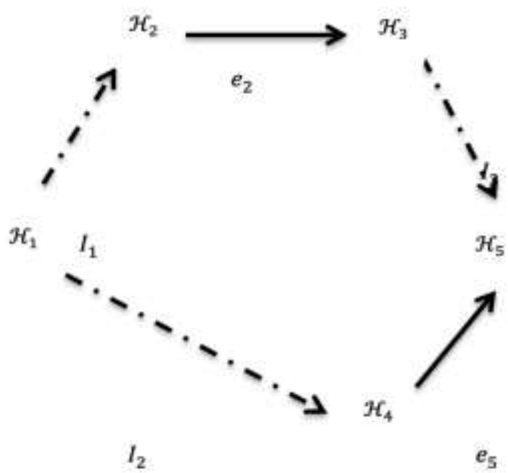

Figure 4

The neutrosophic adjacency matrices is:

$$\begin{bmatrix} 0 & I_1 & 0 & I_2 & 0 \\ 0 & 0 & e_2 & 0 & 0 \\ 0 & 0 & 0 & 0 & I_3 \\ 0 & 0 & 0 & 0 & e_5 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

After adding the identity matrix of neutrosophic adjacency matrices , the neutrosophic connection matrix become as follows :

$$N_e\text{CM} = \begin{bmatrix} 0 & I_1 & 0 & I_2 & 0 \\ 0 & 0 & e_2 & 0 & 0 \\ 0 & 0 & 0 & 0 & I_3 \\ 0 & 0 & 0 & 0 & e_5 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix} + \begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 \end{bmatrix} = \begin{bmatrix} 1 & I_1 & 0 & I_2 & 0 \\ 0 & 1 & e_2 & 0 & 0 \\ 0 & 0 & 1 & 0 & I_3 \\ 0 & 0 & 0 & 1 & e_5 \\ 0 & 0 & 0 & 0 & 1 \end{bmatrix}$$

To find all minimal paths for this system, we remove the node2, and the reshaped entries of the primary matrix become the following according to equation (10)

$N_e a^1 13 = e_2 I_1$, $N_e a^1 14 = 0I_1 + I_2$, $N_e a^1 35 = I_3$

the reshaped N_eCM becomes the following 4x4 matrix:

$$N_e\text{CM} = \begin{bmatrix} 1 & e_2 I_1 & I_2 & 0 \\ 0 & 1 & 0 & I_3 \\ 0 & 0 & 1 & e_5 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

When remove the node 2 , and the reshaped entries of the primary matrix become the following according to equation (10)

$N_e a^2 13 = I_2 + 0 I_1 e_2$, $N_e a^2 14 = I_1 e_2 I_3$, $N_e a^2 34 = e_5 + 0 I_3$

the reshaped N_eCM becomes the following 3x3 matrix:

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$$N_e\text{CM}= \begin{bmatrix} 1 & I_2 & I_1e_2I_3 \\ 0 & 1 & e_5 \\ 0 & 0 & 1 \end{bmatrix}$$

When take-off the node 2 , and the reshaped entries of the primary matrix become the following according to equation (10)

the reshaped N_eCM becomes the following 2x2 matrix:

$$N_e\text{CM}= \begin{bmatrix} 1 & e_5I_2+e_2I_3I_1 \\ 0 & 1 \end{bmatrix}$$

$N_ea^3 13$ $=e_5I_2+e_2I_3I_1$

Here $N_ea^3 13$ represent the summation of all neutrosophic minimal paths of the neutrosophic graph system.

Hence, $\{e_5I_2\}$,$\{I_1e_2I_3\}$ are all neutrosophic minimal paths of system(neutrosophic graph).

NOTE: In the last two examples, these systems cannot solved in classical reliability because there not exist paths between the nods (2)(3), (4)(5), and between (1)(2), (1)(4),(3)(5) in figure (3), and figure (4), respectively. When neutrosophic edges are added between (1)(2), (1)(4),(3)(5) in figure (3), and figure (4), respectively. then became resolved in neutrosophic reliability. Here we conclude the neutrosophic was able to solve systems(graphs) that have not solution in classical reliability.

10. Conclusion

In the technological world, everyone depends on the continuity functioning of the machine, tools, products, equipment of missiles, and aircraft engines. And they expected to work properly for period of time. Where the unexpected failure can lead to loss of life or money. So the assessment and control of reliability are necessary, the higher the reliability and accuracy, the more secure the life of the machines . many products contain some tools or equipment that do not ell good work or unclear and these are often exclude calculating the reliability in the classical approach. therefore , in this paper we study reliability according to neutrosophic logic that includes all tools and pieces of equipment that are clear (works) and unclear (do not work). A new representation of neutrosophic reliability system has been proposed . The analytic expression for neutrosophic adjacency matrix, neutrosophic connected matrix are extensively discussed. In addition, neutrosophic parallel reliability has been defined. The neutrosophic methods to find neutrosophic reliability system , such as neutrosophic minimal path method and neutrosophic tracing method have been explained with applications.

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