# A study on Neutrosophic cognitive maps (NCMs) by analyzing the Risk Factors of Breast Cancer

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**Abstract**— In this paper we analyzed, the impact of risk factors of breast cancer and its solution using Neutrosophic Cognitive Maps (NCMs),which is the generalization of Fuzzy Cognitive Maps(FCMs). defined by W.B. Vasantha Kandasamy and Florentine Smarandache. This paper has a five section. First section gives the information about development of Fuzzy Cognitive Maps and Neutrosophic Cognitive Map. Second section gives the preliminaries of FCMs, NCMs and methods of determining hidden pattern of NCMs. In section three, we give the description of the problem. Section four gives adaptation of NCMs to the problem and Final section gives the conclusion based on our study.

**Index Terms**—Fuzzy Cognitive Maps(FCMs), Neutrosophic Cognitive Maps (NCMs), Breast Cancer, Risk Factors

## 1 INTRODUCTION

In 1965, L.A. Zadeh has introduced a mathematical model called Fuzzy Cognitive Maps. After a decade in the year 1976, Political scientist R. Axelord[1] used this fuzzy model to study decision making in social and political systems. Then B. Kosko[2,3,4] enhanced the power of cognitive maps considering fuzzy values for the concepts of the cognitive map and fuzzy degrees of interrelationships between concepts. FCMs can successfully represent knowledge and human experience, introduced concepts to represent the essential elements and the cause and effect relationships among the concepts to model the behavior of any system. It is a very convenient simple and powerful tool, which is used in numerous fields such as social, economical and medical etc. In this paper we use the Neutrosophic Cognitive Maps (NCMs) created by Florentine Smarandache [5,6] which is an extension / combination of the Fuzzy Cognitive Maps (FCMs)in which indeterminacy is included. It has also become very essential that the notion of Neutrosophic logic plays a vital role in several of the real world problems like law, medicine, industry, finance, IT, stocks and share etc.

## 2 PRELIMINARIES

Fuzzy Cognitive maps (FCMs) are more applicable when the data in the first place is an unsupervised one. The FCMs work on the opinion of experts. Fcms model the world as a collection of classes and causal relations between classes.

### 2.1 Definition

A NCMs is a directed graph with concepts like policies, events etc, as nodes and causalities as edges. It represents causal relationship between concepts.

### 2.2 Definition

When the nodes of the NCM are fuzzy sets then they are called as fuzzy nodes.

### 2.3 Definition

NCMs with edge weights or causalities from the set {-1, 0, 1, *I*} are called simple NCMs

### 2.4 Definition

Let $C_i$ and $C_j$ denote the two nodes of the NCM. The directed edge from $C_i$ to $C_j$ denote the causality of $C_i$on $C_j$ called connections. Every edge in the NCM is weighted with a number in the set {-1, 0, 1, *I*}. Let $e_{ij}$be the weight of the directed edge$C_iC_j$,$e_{ij} \in$ {-1, 0, 1, *I*}. $e_{ij}$ = 0 if $C_i$does not have any effect on $C_j$, $e_{ij}$ = 1 if increase (or decrease) in $C_i$ causes increase (or decreases) in $C_j$. $e_{ij}$ =1 if increase (or decrease) in $C_i$causes decrease (or increase) in $C_j$. $e_{ij}$ = *I* if the relation or effect of $C_i$ on $C_j$ is an indeterminate.

### 2.5 Definition

Let $C_1,C_2,...,C_n$be nodes of a NCM. Let the neutrosophic matrix $N(E)$ be defined as $N(E) = (e_{ij})$ where $e_{ij}$ is the weight of the directed edge $C_iC_j$, where $e_{ij} \in$ {.1, 0, 1, *I*}.$N(E)$ is called the neutrosophic adjacency matrix of the NCM.

### 2.6 Definition

Let $C_1,C_2,...,C_n$be the nodes of the NCM. Let $A=\{a_1, a_2...a_n\}$, where $a_i \in${0, 1, *I*}. A is called the instantaneous state neutrosophic vector and it denotes the on-off -indeterminate state position of the node at

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an instant

$a_i$ = 0 if $a_i$ is off (no effect)
$a_i$ = 1 if $a_i$ is on (has effect)
$a_i$ = I if $a_i$ is indeterminate (effect cannot be determined) for $i = 1, 2...n$

### 2.7 Definition

Let $C_1, C_2, ..., C_n$ be the nodes of the FCM. Let $\overrightarrow{C_1C_2}, \overrightarrow{C_2C_3} ... \overrightarrow{C_iC_j}$ be the edges of the NCM. Then the edges form a directed cycle. An NCM is said to be cyclic if it possesses a directed cyclic. An NCM is said to be acyclic if it does not possess any directed cycle.

### 2.8 Definition

An NCM with cycles is said to have a feedback. When there is a feedback in the NCM i.e. when the causal relations flow through a cycle in a revolutionary manner the NCM is called a dynamical system

### 2.9 Definition

Let $\overrightarrow{C_1C_2}, \overrightarrow{C_2C_3} ... \overrightarrow{C_{n-1}C_n}$ be cycle, when $C_i$ is switched on and if the causality flow through the edges of a cycle and if it again causes $C_i$, we say that the dynamical system goes round and round. This is true for any node $C_i$, for $i = 1, 2...n$ the equilibrium state for this dynamical system is called the hidden pattern.

### 2.10 Definition

If the equilibrium state of a dynamical system is a unique state vector, then it is called a fixed point. Consider the NCM with $C_1, C_2, ..., C_9$ as nodes. For example let us start the dynamical system by switching on $C_1$ Let us assume that the NCM settles down with $C_1$ and $C_n$ on, i.e. the state vector remain as (1,0,...,1) this neutrosophic state vector (1,0,…,0,1) is called the fixed point.

### 2.11 Definition

If the NCM settles with a neutrosophic state vector repeating in the form $A_1 \to A_2 \to ... A_i \to A_1$ then this equilibrium is called a limit cycle of the NCM.

### 2.12 Definition

Finite number of NCMs can be combined together to produce the joint effect of all NCMs. If $N(E_1), N(E_2), ... N(E_p)$ be the neutrosophic adjacency matrices of a NCM with nodes $C_1, C_2, ..., C_n$ then the combined NCM is got by adding all the neutrosophic adjacency matrices $N(E_1), N(E_2), ... N(E_p)$. We denote the combined NCMs adjacency neutrosophic matrix by $N(E) = N(E_1) + N(E_2) + ... + N(E_p)$.

### 2.13 Method of Determining Hidden Pattern

Let $\{C_1, C_2, ..., C_n\}$ be the nodes of an NCM, with feedback. Let $E$ be the associated adjacency matrix. Let us find the hidden pattern when $C_1$ is switched on when an input is given as the vector $A_1$ = (1, 0, 0,., 0), the data should pass through the neutrosophic matrix $N(E)$, this is done by multiplying $A_1$ by the matrix $N(E)$. Let $A_1N(E) = \{a_1, a_2, ..., a_n\}$ with the threshold operation that is by replacing $a_i$ by 1 if $a_i > k$ and $a_i$ by 0 if $a_i < k < (k - a$ suitable positive integer) and $a_i$ by I if $a_i$ is not a integer. We update the resulting concept, the concept $C_1$ is included in the updated vector by making the first coordinate as 1 in the resulting vector. Suppose $A_2N(E) \to A_2$ then consider $A_2N(E)$ and repeat the same procedure. This procedure is repeated till we get a limit cycle or a fixed point.

## 3 Description Of The Problem

Breast cancer is forms in the cells of the breasts. There are numerous types of breast cancer, but cancer that begins in the milk ducts (ductal carcinoma) is the most common type. After skin cancer, breast cancer is the most common cancer diagnosed in women in the United States. Breast cancer can occur in both men and women, but it's far more common in women. By Mayo Clinic Newsletter, "*It's not clear what causes breast cancer. Doctors know that breast cancer occurs when some breast cells begin growing abnormally. These cells divide more rapidly than healthy cells do. The accumulating cells form a tumor that may spread (metastasize) through the breast, to lymph nodes or to other parts of the body*".

### 3.1. Risk Factors of Breast Cancer

A risk factor is anything that makes it more likely to get a particular disease. But having one or more risk factors doesn't necessarily mean it will develop cancer — many women who develop breast cancer have no known risk factors other than simply being women. An estimated 2.2 lakhs women will be diagnosed with breast cancer in 2012. Approximately 5% of new breast cancers are attributable to hereditary syndromes, and well-established risk factors accounts for approximately 30% of cases[7].All women are at risk for breast cancer, and as age increases, risk increases. Researchers estimate that 1 in 8 women will be diagnosed with invasive breast cancer at some time in their lives. This means that the average woman has about a 12-13% risk of developing breast cancer. 12-13% risk means there's an 87-88% chance that WON'T develop breast cancer. It's challenging to make sense of breast cancer risks. Many risks are interrelated, which makes its hard to separate them out and measure each risk's singular effect. So it's hard to figure out the impact of each factor: the extra weight, the lack of exercise, and not eating fresh produce. That's why risk can be hard to understand [8].

Factors that are associated with an increased risk of breast cancer include:

- Being female
- Increasing age.
- A personal history of breast cancer.
- A family history of breast cancer.
- Inherited genes that increase cancer risk.
- Radiation exposure.
- Obesity.
- Onset of puberty at a younger age
- Beginning menopause at an older age.
- Having first child at an older age.
- Postmenopausal hormone therapy.
- Drinking alcohol

## 4 ADAPTATION OF NCM TO THE PROBLEM

A risk factor is anything that makes it more likely you'll get a particular disease. But having one or even several risk factors doesn't necessarily mean you'll develop cancer — many women who develop breast cancer have no known risk factors other than simply being women. Using the survey and the experts (Doctors) opinion, We have taken the above twelve factors as $P_1$, $P_2$, $P_3$, $P_4$, $P_5$, $P_6$, $P_7$, $P_8$, $P_9$, $P_{10}$, $P_{11}$, $P_{12}$ which are the main nodes for our studies: Now based on the expert's opinion also about the notion of indeterminacy we obtain the following neutrosophic directed graph:

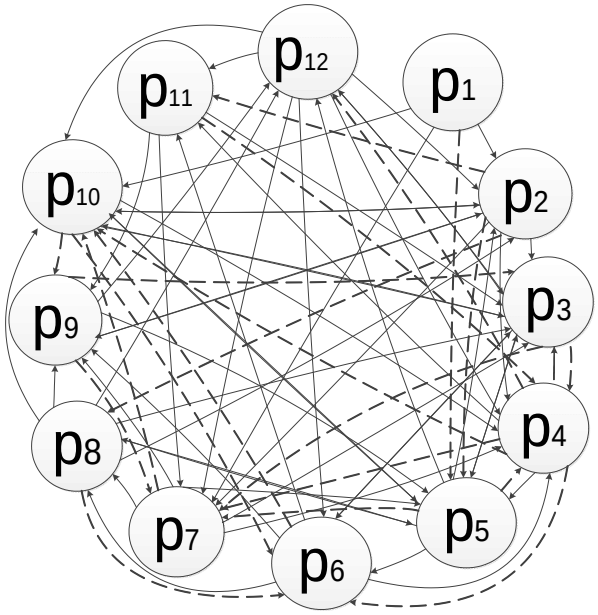


Fig 1 Neutrosophic directed graph

The corresponding neutrosophic adjacency matrix N(E) related to the neutrosophic directed graph is given below

$$N(E) = \begin{array}{c|cccccccccccc} & P_1 & P_2 & P_3 & P_4 & P_5 & P_6 & P_7 & P_8 & P_9 & P_{10} & P_{11} & P_{12} \\ \hline P_1 & 0 & 1 & 0 & 0 & I & 0 & 1 & 0 & 0 & 1 & 0 & 0 \\ P_2 & 0 & 0 & 1 & 1 & I & 0 & 1 & I & 1 & 1 & I & 0 \\ P_3 & 0 & 0 & 0 & I & 1 & 1 & I & 0 & 0 & 1 & 0 & 1 \\ P_4 & 0 & 0 & 1 & 0 & 1 & I & I & 0 & 0 & I & 1 & I \\ P_5 & 0 & 1 & 1 & I & 0 & 1 & I & 1 & 0 & 1 & 1 & 1 \\ P_6 & 0 & 0 & 1 & 1 & 0 & 0 & 0 & 1 & 1 & I & 1 & 0 \\ P_7 & 0 & 0 & 1 & 1 & 1 & 0 & 0 & 1 & 1 & I & 0 & 0 \\ P_8 & 0 & 1 & 1 & 0 & 1 & I & 0 & 0 & 1 & 1 & 0 & 1 \\ P_9 & 0 & 1 & I & 0 & 1 & 0 & I & 0 & 0 & 0 & 0 & 1 \\ P_{10} & 0 & 1 & 1 & 1 & 1 & I & 0 & 0 & I & 0 & 0 & 0 \\ P_{11} & 0 & 0 & 1 & I & 0 & 0 & 1 & 0 & 1 & 0 & 0 & 0 \\ P_{12} & 0 & 1 & 1 & 1 & 0 & 1 & 1 & 0 & 0 & 1 & 1 & 0 \end{array}$$

Suppose we consider the ON state of the attribute increasing age and all other states are OFF, the effect of $X = (0\,1\,0\,0\,0\,0\,0\,0\,0\,0\,0\,0)$ on the NCM is given by

$X\,N(E) = (0\;0\;1\;1\;I\;0\;1\;I\;1\;1\;I\;0) \hookrightarrow (0\;1\;1\;1\;I\;0\;1\;I\;1\;1\;I\;0) = X_1$

$X_1N(E) = (0\;\; 2+2I\;\; 4+4I\;\; 3+I+I^2\;\; 5+2I\;\; 1+3I+I^2\;\; 1+4I+I^2\;\; 1+2I\;\; 2+3I\;\; 2+4I\;\; 1+2I\;\; 2+3I)$
$\hookrightarrow (0\;1\;1\;1\;1\;1\;1\;1\;1\;1\;1\;1) = X_2$

$X_2N(E) = (0\;\; 5\;\; 9+I\;\; 5+3I\;\; 6+I\;\; 3+3I\;\; 3+4I\;\; 3+I\;\; 5+I\;\; 5+3I\;\; 4+I4+I)$
$\hookrightarrow (0\;1\;1\;1\;1\;1\;1\;1\;1\;1\;1\;1) = X_3 = X_2$

($X_2$ is a fixed point of the dynamical system). Thus when increasing age is ON state, other than the first factor all are main causes for Breast Cancer.

Suppose we consider, the ON state of the attributes a personal history of breast cancer, radiation exposure and Onset of puberty at a younger age and all other nodes are in the OFF state, the effect of $Y = (0\;0\;1\;0\;0\;1\;0\;1\;0\;0\;0\;0)$ onthe NCM is given by

$YN(E) = (0\;1\;2\;1+I\;2\;1+II\;1\;2\;2+I\;1\;2)$
$\hookrightarrow (0\;1\;1\;1\;1\;1\;I\;1\;1\;1\;1\;1) = Y_1$

$Y_1\,N(E) = (0\;\; 5\;\; 8+2I\;\; 4+4I\;\; 5+2I\;\; 3+3I\;\; 3+4I\;\; 2+2I\;\; 4+2I\;\; 5+2I+I^2\;\; 4+I4+I)$
$\hookrightarrow (0\;1\;1\;1\;1\;1\;1\;1\;1\;1\;1\;1) = Y_2$

$Y_2\,N(E) = (0\;\; 5\;\; 9+I\;\; 5+3I\;\; 6+I\;\; 3+3I\;\; 3+4I\;\; 3+I\;\; 5+I\;\; 5+3I\;\; 4+I4+I)$
$\hookrightarrow (0\;1\;1\;1\;1\;1\;1\;1\;1\;1\;1\;1) = Y_3 = Y_2$

($Y_2$ is the fixed point of the dynamical system). Thus

when a personal history of breast cancer, radiation exposure and Onset of puberty at a younger age are ON state then being female is on OFF state.

Suppose we consider, the ON state of the attributes a personal history of breast cancer, radiation exposure, obesity, Onset of puberty at a younger age, at a stage of menopause and having first child at an older age are in ON state and all other nodes are in OFF state, the effect of $Z$ = ( 0 0 1 0 0 1 1 1 1 1 0 0 ) on the NCM is given by

$Z\ N(E)$ = ( 0 1 2 1+$I$ 2 1+$II$ 1 2 2+$I$ 1 2 )
↪ ( 0 1 1 1 1 1 $I$ 1 1 1 1 1 )= $Z_1$

$Z_1\ N(E)$ = ( 0 5 8+2$I$ 4+4$I$ 5+2$I$ 3+3$I$ 3+4$I$ 2+2$I$ 4+2$I$ 5+2$I$+$I^2$ 4+$I$4+$I$ )
↪ ( 0 1 1 1 1 1 1 1 1 1 1 1 ) = $Y_2$

$Z_2\ N(E)$ = ( 0 5 9+$I$ 5+3$I$ 6+$I$ 3+3$I$ 3+4$I$ 3+$I$ 5+$I$ 5+3$I$ 4+$I$4+$I$ )
↪ ( 0 1 1 1 1 1 1 1 1 1 1 1 ) = $Z_3$ = $Z_2$
( $Z_2$ is the fixed point of the dynamical system). When a personal history of breast cancer, radiation exposure, obesity, Onset of puberty at a younger age, at a stage of menopause and having first child at an older age are in ON state then except the first one remaining factors are main causes for Breast Cancer.

## 5 Conclusion

While analyzing in NCMs, when increasing age is ON state, other than the first factor all are main causes for Breast Cancer. When a personal history of breast cancer, radiation exposure and Onset of puberty at a younger age are ON state then being female is on OFF state. When a personal history of breast cancer, radiation exposure, obesity, Onset of puberty at a younger age, at a stage of menopause and having first child at an older age are all ON state, then except the first one remaining factors are main causes for Breast Cancer. Women between 20 and 30 years should perform a clinical breast exam regularly. To reduce the death rate of Breast Cancer patient we have to give the awareness of Breast cancer to woman. NGO's and Government should take more concrete efforts to promote awareness of the cancer diseases. The future generations must be aware of the cancer disease and methods of prevention.

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