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A Fuzzy bimodel approach on the exposures to the health hazards of agriculture labourers

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Abstract

In this paper, we introduce a new Fuzzy bimodel called Induced Fuzzy Cognitive Relational Maps (IFCRM). Using this new bimodel, we analyze the problem of health hazards faced by the agricultural labourers due to chemical pollutions. Based on our study, we made conclusions and suggest some remedial measures.

Keywords: Health hazards, FCM, FRM, FCRM, IFCRM, fixed point, limit cycle, hidden pattern.

Introduction

Neural networks based fuzzy modeling is a well established area in computational Intelligence. Fuzzy models are mathematical tools introduced by L.A. Zadeh (1965). Using the concepts of neural networks and fuzzy logic Bart Kosko (1998, 2001) proposed many more models. These models provide a mathematical strength to capture the uncertainties associated with human cognitive processes, such as thinking and reasoning. These models are well suited to get a clear representation of the *knowledge* to support decision-making process and assist in the area of computational intelligence, which involves the application of soft computing methodologies even though the given inputs are vague, uncertain, ambiguous, imprecise, incomplete, inconsistent, redundant and even contradictory in nature (Klir, 1998).

Mostly, Fuzzy models have been used to solve many real world problems in science and engineering which includes fuzzy expert system and fuzzy control. In recent days, many engineering and mathematics researchers are trying to apply fuzzy models to non engineering fields such as social sciences and humanities. Many researchers have used these models to study and analyze the problems such as Rag Pickers problem, AIDS problem and transportation problem , school dropout problem. Balasangu *et al*. (2007, 2009, 2011) have studied the agriculture labours problem.

There are many fuzzy models. Some of the important models which have been used to study these problems are Fuzzy Cognitive Maps (FCM), Combined FCM (CFCM), Bi-directional Associative Memories (BAM), Fuzzy Relational Maps (FRM) , Linked Fuzzy Relational Maps (LFRM), Fuzzy Relational Equations(FRE). Pathinathan *et al*. (2005) have introduced Induced Fuzzy Cognitive Model . Praveenprakash (2010) has introduced a bimodel called Fuzzy Cognitive Relation Maps (FCRM) bimodel to study the psychological problems faced by the People with Disabilities (PWDs) mainly due to disability, discrimination, social stigma and poverty. FCRM is a directed special bigraph with concepts like policies, events, etc., as nodes and causalities as edges. It represents causal relationship between concepts. Social problems have also been studied using these new models.

In this paper we introduce a new bimodel called Induced FCRM bimodel and analyse the problems of the health hazards of the agricultural labourers due to chemical pollutions.

Preliminaries

In this section we describe the basic notions from Praveenprakash (2010) which are relevant to this paper.

Definition 2.1: Let $S = S_1 \cup S_2$, where S_1 and S_2 are non-empty sets; with $S_1 \not\subseteq S_2$ and $S_2 \not\subseteq S_1$ then we call S as a biset.

Example 2.2: Let S = {(01111), (10111), (10110)} ∪ {(111), (101), (000), (100)} = $S_1 \cup S_2$, clearly S is a biset.

Definition 2.3: Let $A_1=(a_1,a_2,...,a_n)$ and $A_2 = (a_1', a_2', a_3',...,a_m')$ be two vectors of length n and m respectively. Then $A = A_1 \cup A_2$ is a bivector.

Example 2.4: Let $A = A_1 \cup A_2$ = (112041) ∪ (345213), A is a bivector. If $A = A_1 \cup A_2$ = (00000) ∪ (00000000), then A is a zero bivector. If $A = A_1 \cup A_2$ = (1111) ∪ (1111111) then A is a unit bivector.

Definition 2.5: A matrix M is said to be a bimatrix if $M = M_1 \cup M_2$ where M_1 and M_2 are two different matrices.

Example 2.6: A matrix M of the form

$M = M_1 \cup M_2$ = (10001) ∪ (111101) is called a bimatrix or a row bimatrix.

Ex.2.7. Let $M = M_1 \cup M_2 = \begin{bmatrix} 1 & 0 & 7 & 0 \\ 9 & 1 & 0 & 4 \\ 3 & 5 & 1 & 6 \\ 1 & 2 & 0 & 8 \end{bmatrix} \cup \begin{bmatrix} 3 & 2 & 1 & 9 \\ 4 & 9 & 4 & 0 \\ 6 & 5 & 0 & 6 \\ 1 & 6 & 9 & 8 \end{bmatrix}$ is a square bimatrix.

Definition 2.8: Let $G = G_1 \cup G_2$ where G_1 and G_2 are two distinct graphs then we call G as a bigraph.

Definition 2.9: Let $A = A_1 \cup A_2$ be a bimatrix where A_1 is a m × n matrix and A_2 is a p×s matrix. If $X = X_1 \cup X_2$ is a bivector such that X_1 has m components and X_2 has p

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components then the product of X with A is defined as $XA = (X_1 \cup X_2)(A_1 \cup A_2) = X_1A_1 \cup X_2A_2$ where X_1A_1 is a 1×n matrix and X_2A_2 is a 1×s matrix or more mathematically; $X_1A_1 \cup X_2A_2 = Y_1 \cup Y_2$ is a bivector or a row bivector.

Definition 2.10: Let $A = A_1 \cup A_2$ be a bimatrix. Then the bitranspose of the bimatrix A is defined as $A^t = (A_1 \cup A_2)^t = A_1^t \cup A_2^t$.

Definition 2.11: A Fuzzy Cognitive Relation Maps (FCRM) is a directed special bigraph with concepts like policies, events, etc as nodes and causalities as edges. It represents causal relationship between concepts. In a FCRM we call the pair of associated nodes as binodes. If the order of the bimatrix associated with FCRM is a n ×n square matrix and a p×m matrix then the binodes are bivectors of length (n,p) or length (n,m).

Let $A = A_1 \cup A_2 = (a_1^1, a_2^1, a_3^1, ..., a_m^1) \cup (a_1^2, a_2^2, a_3^2 .., a_m^2)$ where $a_i \in \{0,1\}$; A is called the instantaneous state bivector and it denotes the ON-OFF position of the binode at an instant. $a_j^i = 0$ if a_j^i is OFF , $a_j^i = 1$ if a_j^i is ON, for $1 \le i \le 2$ and $1 \le j \le m,n$.

Definition 2.12: Consider the binodes biconcepts $\{C_1^1 C_2^1 \ldots C_n^1\}$ of the FCM and $\{D_1, \ldots D_p\}$ and $\{R_1 \ldots R_m\}\}$ of the FRM of the FCRM bimodel. Suppose the directed graph is drawn using the edge biweight $e_{ij}^t = \{0, 1, -1\}$; $1 \le t \le 2$ The bimatrix $E = E_1 \cup E_2$ is defined by $e_{ij}^1 \cup e_{ks}^2$ where e_{ij}^1 is the weight of the directed edge C_iC_j and e_{ks}^2 is the directed edge of D_kR_s. $E = E_1 \cup E_2$ is called adjacency bimatrix of the new FCRM bimodel, also known as the connecting relational bimatrix of the new FCRM bimodel.

Definition 2.13: The new FCRMs with edge biweight $\{1,0, -1\}$ are called simple FCRMs. Let $\{C_1, \ldots C_n\} \cup \{(D_1, \ldots D_p), (R_1 \ldots R_m)\}$ be the binodes of an FCRM. $A = A_1 \cup A_2 = (a_1, \ldots a_n) \cup (b_1, \ldots b_p)$ (or$(c_1, \ldots c_m)$) where $a_i, b_j, c_t \in \{0,1\}$; $1 \le i \le n$, $1 \le j \le p$ and $1 \le t \le m$. A is called instantaneous state bivector and it denotes the ON-OFF position of the node at an instant.

$a_j = 0$ if a_j is OFF and $a_j = 1$ if a_j is ON for $1 \le j \le n$

$b_i = 0$ if b_i is OFF and $b_i = 1$ if b_i is ON for $1 \le i \le p$

$c_t = 0$ if c_t is OFF and $c_t = 1$ if c_t is ON for $1 \le i \le m$

$i = 1,2,3 \ldots m$

Definition 2.14: Let $\{C_1, \ldots C_n\} \cup \{(D_1, \ldots D_p), (R_1 \ldots R_m)\}$ be the binodes of the FCRM. Let $C_i C_j \cup D_sR_k$ be the biedges of the FCRMs; $i \ne j$, $1 \le i,j \le n$, $1 \le s \le p$, $1 \le k \le m$. Then the biedges form a directed bicycle. An FCRM is said to be bicyclic if it possesses a directed bicycle. An FCRM is said to be abicyclic if it does not possess any directed bicycle.

Definition 2.15: An FCRM with bicycles is said to have a feedback. When there is a feed back in an FCRM, i.e., when the casual relations flow through a cycle in a revolutionary way, the FCRM is called a dynamical bisystem.

Definition 2.16: Let $\{C_1C_2 , C_2C_3 \ldots C_{n-1}C_n\} \cup \{(D_iR_j)$(or $R_jD_i)| 1 \le i \le p, 1 \le j \le m\}$ be a bicycle. If $C_i \cup R_j$ (or D_i) is switched ON and if the casuality flows through the edges of the bicycle and if it again causes $C_i \cup R_j$ (or D_i) we say that the dynamical bisystem goes round and round. This is true for the binodes $C_i \cup R_j$ (or D_i) for $1 \le i \le n$, $1 \le j \le m$ (or $1 \le j \le p$). The equilibrium bistate for the dynamical bisystem is called the hidden bipattern. If the equilibrium bistate of the dynamical bisystem is a unique bistate bivector then it is called fixed bipoint.

Ex. 2.17: Consider the FCRMs with $(C_1, \ldots C_n)$ $(D_1, \ldots D_p)$(or $R_1 \ldots R_m$) as binodes. For instant if we start the dynamical bisystem by switching $C_1 \cup R_1$ (or D_1)ON. Let us assume the FCRM settles down with C_1 and $C_n \cup$ (R_1 and R_m)or(D_1 and D_p). That is the state bivector remains as (100000…01) ∪ (100…1) in R (or(100…1) in D. This state bivector is called the fixed bipoint. It is to be noted that in the case of FCRM we get a pair of fixed bipoint say $A = A_1 \cup D$ and $A = A_1 \cup R$; D denote the state vector in the domain space of the FRM component of the FCRM and R denotes the state vector of the range space of the FRM component of the FCRM bimodel.

Definition 2.18: If the FCRM settles down with a bistate bivector repeating in the form $A_1 \to A_2 \to \ldots \to A_1 \cup B_1 \to B_2 \to \ldots B_j \to B_1$(or $D_1 \to D_2 \to \ldots \to D_k \to D_1$) then this equilibrium is called a limit bicycle.

Notation: Suppose $A = A_1 \cup A_2$ is bivector which is passed into a dynamical bisystem $E = E_1 \cup E_2$. Then $AE = A_1E_1 \cup A_2E_2 = (x_1', x_2', \ldots, x_n') \cup (y_1', y_2', \ldots, y_p') \cup$ (or $(z_1', z_2, \ldots, z_m')$) after thresholding and updating the bivector; suppose we get $(x_1, x_2 \ldots x_n) \cup (y_1, \ldots y_p)$ (or $(z_1, \ldots z_m)$) we denote that by $(x_1', x_2', \ldots, x_n') \cup (y_1', y_2', \ldots, y_p')$ (or) $\cup$ $(z_1', z_2', \ldots, z_m') \hookrightarrow (x_1, x_2 \ldots x_n) \cup (y_1, \cup, y_p)$ (or $(z_1, \cup, z_m)$). Thus the symbol $\hookrightarrow$ means the resultant bivector has been thresholded and updated.

Definition 2.19: The biedges $e_{ij} = (e_{ij}^1) \cup (e_{ks}^2)$ take the values in fuzzy casual biinterval [-1,1] ∪ [-1,1].

i) $e_{ij} = 0$ indicates no causality between the binodes.

ii) $e_{ij} > 0$ implies that both $e_{ij}^1 > 0$ and $e_{ks}^2 > 0$; implies increase in the binodes $C_i \cup D_k$(or R_s) ; implies increase in the binodes $C_j \cup R_s$(or D_s) .

iii) $e_{ij} < 0$ implies that both $e_{ij}^1 < 0$ and $e_{ks}^2 < 0$; similarly decrease in the binodes $C_i \cup D_k$(or R_s); implies decrease in the binodes $C_j \cup R_s$(or D_k)

However unlike the FCM and FRM model we can have the following possibilities other than that of $e_{ij} = 0$, $e_{ij} > 0$ and $e_{ij} < 0$.

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i) $e_{ij} = (e_{ij}^1) \cup (e_{ks}^2)$ can be such that $(e_{ij}^1) = 0$ and $(e_{ks}^2) > 0$. No relation in one binode and an increase in other node.

ii) $e_{ij} = (e_{ij}^1) \cup (e_{ks}^2)$ we can have $(e_{ij}^1) = 0$ and $(e_{ks}^2) < 0$. No causality in the FCM node and decreasing relation in the FRM mode.

iii) $e_{ij} = (e_{ij}^1) \cup (e_{ks}^2)$ we can have $(e_{ij}^1) =< 0$ and $(e_{ks}^2) > 0$

iv) In $e_{ij} = (e_{ij}^1) \cup (e_{ks}^2)$ we can have $(e_{ij}^1) < 0$ and $(e_{ks}^2) = 0$

v) In $e_{ij} = (e_{ij}^1) \cup (e_{ks}^2)$ we can have $(e_{ij}^1) > 0$ and $(e_{ks}^2) = 0$

vi) In $e_{ij} = (e_{ij}^1) \cup (e_{ks}^2)$ we can have $(e_{ij}^1) > 0$ and $(e_{ks}^2) < 0$.

Thus in the case of FCRM we can have 9 possibilities where as in FCMs or FRMs we have only 3 possibilities. Thus the extra 6 possibilities can help in making the solution of the problem more sensitive or accurate.

Description of the problem

Here we consider pollutions which are hazardous to the health of the agriculturists. Rice is one of the stable foods in Tamil Nadu. More than half of the people in the world eat this grain as the main part of their meals. Rice is a cereal grain and belongs to the grass family . But unlike other grains rice grows in shallow water. In Tamil Nadu , almost all the people depend upon rice for food . Rice farming dominates the agricultural sector of Tamil Nadu and rice cultivation is associated with exposure to numerous agents that may cause musculo-skeletal disorders and diseases.

It is a known fact that people have been affected by much pollution. We restrict ourselves only to the pollution faced by the agriculture labourers due to pesticides, insecticides, which is realized in the form of land pollution, pollution of grains, pollution of water, pollution of culture, pollution of society and above all pollution of the other natural resources like root vegetables, certain species of crabs, snails and certain ecofriendly insects like dragonfly and earthworm that are natural agents in protecting the environment hear become extinct. Now, these agriculture labourers mainly belong to poor economic status and they suffer all sorts of health hazardous very silently for reasons like no time and money to spend on their health conditions, no proper medical or health center available in the villages.

The problem of chemical pollution and the health hazards of agricultural labourers involves a lot of attributes like types of diseases or symptoms and the degrees to which they are affected. In order to make an analysis of these we have taken sample study from eleven villages in Cuddalore district. The data was gathered from these people using a linguistic questionnaire and this linguistic questionnaire was transformed into a fuzzy data. As the data is an unsupervised one and involves lot of uncertainties. Expert opinion is obtained through some relationship between the set of diseases and the different types of works at different stages. The linguistic questionnaire was transformed into a FCM with these 11 main attributes as nodes. We list out briefly the main attributes and label them as C1,C2, ...,C11. Again, the set of diseases are taken as the attributes for the domain space of a FRM model and the different types of works at different stages are taken as the attributes for the range space of a FRM model. The concepts in the domain space are taken as D1, ...,D11 and the attributes in the range space are taken as R1, ...,R10 and thus the connection matrix is given as follows. Initially we use FCRM and then IFCRM for analysis.

Adaptation of the problem to FCRM BiModel

Let us take the connection bimatrix of FCRM bimodel which has both FCM and FRM components and let I1 be the initial input bivector. In I1, let a particular vector component, say $c_1$and d_1, be kept on ON state and all other components are on OFF state and pass the state vector I1 through the connection bimatrix M. To convert the resultant vector into a signal function, the values in the FCM component which are greater than or equal to one are made as ON state and all others as OFF state by giving values 1 and 0 respectively and the two highest values in the FRM component are made as ON state and all others as OFF state by giving values 1 and 0 respectively. Denote this process by the symbol $\hookrightarrow$.

The first FCM component of the resulting vector is kept as it is and the second FRM component of the resulting vector is multiplied with M^T and thresholding yields a new vector I2. Using this new input bivector, we repeat the same procedure till a fixed point or a limit cycle is obtained. Next we choose the vector with its second vector components in both FCM and FRM components are on ON state and repeat the same to get another cycle. This process has been repeated for all the vectors separately. We observe the hidden pattern of some vectors found in all or many cases. Inference from this hidden pattern highlights the causes.

We list out briefly the main attributes of FCM and label them as C1,C2, ...,C11 where

C1: Breathlessness ; **C2**: Indigestion and loss of appetite ; **C3**: Pollution after drinking water ; **C4** : Diarrhea ; **C5** : Blurred vision / Headache / Vomiting ; **C6** : Manuring the fields with chemical fertilizers ; **C7:** Spraying of pesticides ; **C8:** Mouth and stomach ulcer / Swollen limbs ; **C9:** Ulcer skin ailments in legs and hands ; **C10** : Lack of precaution and treatments ; **C11**: Giddiness / Fainting ;

We list out briefly the main attributes of FRM and label them as D1,D2, ...,D11.

R1,R2, ...,R10, where the attributes for the domain space D are **D1:** Respiratory diseases ; **D2**: Malaria ; **D3**: Dermatitis / Hookworms ; **D4:** Cancer; **D5:** Lung diseases / Leptospirosis ; **D6:** Fertility problems ; **D7:** Hay fever ; **D8:** Common cold ; **D9:** Diseases of the nervous system / Tetanus ; **D10:** Injuries by prickly plants ; **D11:** Asthma.

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The attributes for the range space R are : **R1**: Pudding ; **R2**: Adding minerals before Planting ; **R3:** Planting rice seeds ; **R4:** Transplanting the seed lines ; **R5:** Removing the weeds ; **R6:** Controlling diseases and pesticides ; **R7:** Harvesting ; **R8:** Inhaling the smoke from burning rice stubble ; **R9:** Protecting plants from other animals ; **R10:** Shallowing water ;

We get the synaptic connecting bimatrix M as follows:

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}		R_1	R_2	R_3	R_4	R_5	R_6	R_7	R_8	R_9	R_{10}
C_1	0	1	−1	0	0	0	0	0	1	0	0	D_1	1	1	0	0	1	1	1	1	0	0
C_2	1	0	−1	0	1	0	0	0	1	0	0	D_2	0	0	0	1	1	1	0	0	1	0
C_3	1	1	0	1	1	1	1	1	1	0	0	D_3	1	1	0	0	1	1	0	1	0	0
C_4	0	0	0	0	1	−1	1	1	1	0	0	D_4	1	1	0	0	1	1	0	1	0	0
C_5	0	1	0	1	0	−1	1	1	1	1	1	$\cup$ D_5	1	1	0	0	1	1	0	1	0	0
C_6	1	1	0	1	1	0	1	1	1	1	1	D_6	0	1	0	1	0	1	0	0	0	0
C_7	1	1	0	1	1	1	0	1	1	1	0	D_7	0	0	1	0	0	0	1	1	1	0
C_8	1	1	0	1	1	−1	1	0	1	1	1	D_8	1	1	1	1	1	0	0	1	0	1
C_9	0	0	0	0	1	0	1	0	0	1	1	D_9	1	1	1	1	1	1	1	0	1	1
C_{10}	1	1	−1	1	1	1	1	1	1	0	1	D_{10}	0	0	0	1	1	0	1	0	1	1
C_{11}	0	0	0	0	0	0	0	0	1	1	0	D_{11}	1	0	1	1	1	0	1	0	1	0

$$M = M_1 \cup M_2$$

Analysis using FCRM BiModel

First we work for the result for FCRM with initial vector c_1 in FCM component of FCRM bimodel as ON state saying that Breathlessness and its related diseases is initializing attribute and all other attributes are left in the OFF state and the initial vector d_1, in FRM. component of FCRM bimodal as ON state saying that Respiratory diseases is initializing attribute and all other attributes are left in the OFF state. The symbol $\hookrightarrow$ stands for threshholding and it means that negative values are replaced by zeros , values greater than or equal to one or replaced by 1 and that component in FCM component which had been initially kept on ON state, will always be retained as ON state.

Let I1 = (1 0 0 0 0 0 0 0 0 0 0) ∪ (1 0 0 0 0 0 0 0 0 0 0).

The effect of I1 on the dynamical system M is

I1M = (0 1 −1 0 0 0 0 0 1 0 0) ∪ (1 1 0 0 1 1 1 1 0 0)
$\hookrightarrow$ (1 1 0 0 0 0 0 0 1 0 0) ∪ (1 1 0 0 1 1 1 1 0 0)
==> (1 1 0 0 0 0 0 0 1 0 0) ∪ (1 1 0 0 1 1 1 1 0 0)
M^T= (1 1 0 0 0 0 0 0 1 0 0) ∪ (6 2 5 5 5 2 2 4 5 2 3)
$\hookrightarrow$ (1 1 0 0 0 0 0 0 1 0 0) ∪ (1 0 1 1 1 0 0 0 1 0 0)
= I2

Now I1 ≠ I2. Hence we proceed further to get the limit point as follows:

I2M = (1 1 −2 0 2 0 1 0 2 1 1) ∪ (5 5 1 1 5 5 2 4 1 1)
$\hookrightarrow$ (1 1 0 0 1 0 1 0 1 1 1) ∪ (1 1 0 0 1 1 1 1 0 0)
==> (1 1 0 0 1 0 1 0 1 1 1) ∪ (1 1 0 0 1 1 1 1 0 0) M^T
= (1 1 0 0 1 0 1 0 1 1 1) ∪ (5 2 5 5 5 2 1 4 4 1 2)
$\hookrightarrow$ (1 1 0 0 1 0 1 0 1 1 1) ∪ (1 0 1 1 1 0 0 1 1 0 0)
= I3

Now I2 ≠ I3. Hence we proceed further to get the limit point as follows:

I3M = (3 4 −3 3 4 1 3 3 6 4 3) ∪ (6 6 2 2 6 5 2 5 1 2)
$\hookrightarrow$ (1 1 0 1 1 1 1 1 1 1 1) ∪ (1 1 0 0 1 1 0 1 0 0)
==> (1 1 0 1 1 1 1 1 1 1 1) ∪ (1 1 0 0 1 1 0 1 0 0)M^T
= (1 1 0 1 1 1 1 1 1 1 1) ∪ (5 2 5 5 5 2 1 4 4 1 2)
$\hookrightarrow$ (1 1 0 1 1 1 1 1 1 1 1) ∪ (1 0 1 1 1 0 0 1 1 0 0)= I4

Continuing this process and updating we get,

I4M = (5 6 −3 5 7 −1 6 5 9 6 5) ∪ (1 0 1 1 1 0 0 1 1 0 0)
$\hookrightarrow$ (1 1 0 1 1 0 1 1 1 1 1) ∪ (1 0 1 1 1 0 0 1 1 0 0) = I5
I5M = (4 5 −3 4 6 −1 5 4 8 5 4) ∪ (1 0 1 1 1 0 0 1 1 0 0)
$\hookrightarrow$ (1 1 0 1 1 0 1 1 1 1 1) ∪ (1 0 1 1 1 0 0 1 1 0 0) =
I6 = I5

The set of limit points corresponding to different input vectors are given Table1.

Induced FCRM BiModel

In this section we introduce a new bimodel called Induced FCRM bimodel. It is found that in the analysis of FCRM bimodel, the expert or the analyst chooses certain vectors on ON state with 1 and certain other vectors to OFF state with 0. If many vectors are chosen as ON state at the input level, naturally at the output level, the resultant vector will have too many 1s, that is, many attributes will be as ON state. There is no specific criteria or framework laid down to guide the expert or analyst while choosing the input vector. To avoid this state of affairs, in this paper we introduce a new guideline and methodology for the analysis. Hence first, each vector is given its due importance by keeping it on ON state and applying on the dynamical system; second, the impact of all the attributes are gathered into one induced graph for the final analysis. Third, in the process it is possible to detect the interrelationship between the attributes and how one induces or influences the other while reaching the state of equilibria. The fixed point obtained will include

Table1.The set of limit points corresponding to different input vectors

No	Input vector	Limit points
1	(100000000000)	(11011011111) ∪ (1 0 1 1 1 0 0 0 1 0 0 0) (1 1 0 0 1 1 0 1 0 0)
2	(010000000000)	(10110111111) ∪ (0 1 0 0 0 0 0 0 1 1 1 0) (0 0 0 1 1 0 1 0 1 0)
3	(001000000000)	(11111011111) ∪ (1 0 1 1 1 0 0 0 1 0 0 0) (1 1 0 0 1 1 0 1 0 0)
4	(000100000000)	(11011011111) ∪ (1 0 1 1 1 0 0 0 1 0 0 0) (1 1 0 0 1 1 0 1 0 0)
5	(00001000000)	(11011011111) ∪ (1 0 1 1 1 0 0 0 1 0 0 0) (1 1 0 0 1 1 0 1 0 0)
6	(00000100000)	(11011111111) ∪ (1 1 1 1 1 1 0 1 1 0 0 1) (0 1 0 0 1 1 0 0 0 0)
7	(00000010000)	(11011011111) ∪ (0 0 0 0 0 0 0 1 1 0 1 0) (1 1 1 1 1 0 1 0 1 1)
8	(00000001000)	(11011011111) ∪ (0 0 0 0 0 0 0 1 1 0 0 0) (1 1 1 1 1 1 1 1 1 1)
9	(00000000100)	(11011011111) ∪ (0 0 0 0 0 0 0 1 1 0 1 0) (1 1 1 1 1 0 1 0 1 1)
10	(00000000010)	(11011011111) ∪ (0 0 0 0 0 0 0 1 1 0 1 0) (1 1 1 1 1 0 1 0 1 1)
11	(00000000001)	(11011011111) ∪ (0 0 0 0 0 0 0 1 1 0 1 0) (1 1 1 1 1 0 1 0 1 1)

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the impact of all the mentioned attributes and the interpretation of the results will be holistic rather than partial.

Let us take the connection bimatrix of FCRM bimodel which has both FCM and FRM components and let I1 be the initial input bivector. In I1, let a particular vector component, say $c_1$and d_1, be kept on ON state and all other components are on OFF state and pass the state vector I1 through the connection bimatrix M. To convert the resultant vector into a signal function, the values in the FCM component which are greater than or equal to one are made as ON state and all others as OFF state by giving values 1 and 0 respectively and the two highest values in the FRM component are made as ON state and all others as OFF state by giving values 1 and 0 respectively. Denote this process by the symbol $\hookrightarrow$. This new bivector is related with the connection bimatrix and that vector which triggers the highest number of attributes to ON state is chosen as I_1'. That is, for each positive entry we get a set of resultant vectors; among these vectors a vector which contains maximum number of 1s is chosen as I_2. If there are two or more vectors with equal number of 1s on ON state, choose the first occurring one in the set of vectors. Repeat the same procedure till a fixed point or a limit cycle is obtained. This process is done to give due importance to each vector separately as one vector induces another or many more vectors into ON state. Get the hidden pattern by the limit cycle or by getting a fixed point. Observe a pattern that leads one cause to another and may end up in one vector or a cycle. Next choose the vector with its second component in ON state and repeat the same to get another cycle. This process has been repeated for all the vectors separately. We observe the hidden pattern of some vectors found in all or many cases. Inference from this hidden pattern summarizes or highlights the causes.

Now we work for the result for IFCRM bimodel with initial vector c_1 in FCM component of FCRM bimodel as ON state saying that Breathlessness and its related diseases is initializing attribute and all other attributes are left in the OFF state and the initial vector d_1, in FRM. component of FCRM bimodel as ON state saying that Respiratory diseases is initializing attribute and all other attributes are left in the OFF state. The symbol $\hookrightarrow$ stands for threshholding and it means that negative values are replaced by zeros , values greater than or equal to one are replaced by 1 .

We take the same synaptic connecting bimatrix M as given in previous section.

Let the initial state vector be I_1 = (1 0 0 0 0 0 0 0 0 0 0) $\cup$ (1 0 0 0 0 0 0 0 0 0 0). The effect of I_1 on the dynamical system M is

I_1 M = (1 0 0 0 0 0 0 0 0 0 0)M_1 $\cup$ (1 0 0 0 0 0 0 0 0 0 0)M_2
= (0 1 -1 0 0 0 0 0 1 0 0) $\cup$ (1 1 0 0 1 1 1 1 0 0)
$\hookrightarrow$ (0 1 0 0 0 0 0 0 1 0 0) $\cup$ (11 0 0 1 1 1 1 0 0)
==> (0 1 0 0 0 0 0 0 1 0 0) $\cup$ (1 1 0 0 1 1 1 1 0 0)M_2^T
= (0 1 0 0 0 0 0 0 1 0 0) $\cup$ (6 2 5 5 5 2 2 4 5 2 3)
$\hookrightarrow$ (0 1 0 0 0 0 0 0 1 0 0) $\cup$ (1 0 1 1 1 0 0 0 1 0 0) = I_1'

Let $I_1' = IC_1' \cup IR_1'$

In IC_1' the ON states are c_2 and c_9 and in IR_1' the ON states are d_1, d_3, d_4, d_5 and d_9.

From I_1' it is observed that the new bivectors are :

$I_1^{(1)}$ = (0 0 0 0 0 0 0 0 0 0 0) $\cup$ (1 0 0 0 0 0 0 0 0 0 0)
$I_1^{(2)}$ = (0 1 0 0 0 0 0 0 0 0 0) $\cup$ (1 0 0 0 0 0 0 0 0 0 0)
$I_1^{(3)}$ = (0 0 0 0 0 0 0 0 0 0 0) $\cup$ (0 0 1 0 0 0 0 0 0 0 0)
$I_1^{(4)}$ = (0 0 0 0 0 0 0 0 0 0 0) $\cup$ (0 0 0 1 0 0 0 0 0 0 0)
$I_1^{(5)}$ = (0 0 0 0 0 0 0 0 0 0 0) $\cup$ (0 0 0 0 1 0 0 0 0 0 0)
$I_1^{(6)}$ = (0 0 0 0 0 0 0 0 1 0 0) $\cup$ (0 0 0 0 0 0 0 0 1 0 0)

Now let us find the new input vector I_2.

$I_1^{(1)}$ M = (0 0 0 0 0 0 0 0 0 0 0)M_1 $\cup$ (1 0 0 0 0 0 0 0 0 0 0)M_2 $\hookrightarrow$ (0 0 0 0 0 0 0 0 0 0 0) $\cup$ (1 0 0 0 0 0 0 0 0 0 0)
==> (0 0 0 0 0 0 0 0 0 0 0) $\cup$ (1 1 0 0 1 1 1 1 0 0 0)M_2^T
= (0 0 0 0 0 0 0 0 0 0 0) $\cup$ (6 2 5 5 5 2 2 4 5 2 3)
$\hookrightarrow$ (0 0 0 0 0 0 0 0 0 0 0) $\cup$ (1 0 1 1 1 0 0 0 1 0 0)

ROW SUM is :(0,5).

$I_1^{(2)}$ M = (0 1 0 0 0 0 0 0 0 0 0) M_1 $\cup$ (1 0 0 0 0 0 0 0 0 0 0)M_2
= (1 0 -1 0 1 0 0 0 1 0 0 0) $\cup$ (0 0 0 0 0 0 0 0 0 0 0)
$\hookrightarrow$ (1 0 0 0 1 0 0 0 1 0 0) $\cup$ (0 0 0 0 0 0 0 0 0 0 0)
==> (1 0 0 0 1 0 0 0 1 0 0) $\cup$ (0 0 0 0 0 0 0 0 0 0 0)M_2^T
$\hookrightarrow$ (1 0 0 0 1 0 0 0 1 0 0) $\cup$ (0 0 0 0 0 0 0 0 0 0 0)

ROW SUM is (3,0)

$I_1^{(3)}$M = (0 0 0 0 0 0 0 0 0 0 0) M_1 $\cup$ (1 1 0 0 11 0 1 0 0 0)M_2
$\hookrightarrow$ (0 0 0 0 0 0 0 0 0 0 0 0) $\cup$ (1 1 0 0 11 0 1 0 0 0)
==> (0 0 0 0 0 0 0 0 0 0 0) $\cup$ (1 1 0 0 11 0 1 0 0 0)M_2^T
= (0 0 0 0 0 0 0 0 0 0 0) $\cup$ (5 2 5 5 5 2 1 4 4 1 2)
$\hookrightarrow$ (0 0 0 0 0 0 0 0 0 0 0) $\cup$ (1 0 1 11 0 0 11 0 0)

ROW SUM is (0,6)

$I_1^{(4)}$M = (0 0 0 0 0 0 0 0 0 0 0 0)M_1 $\cup$ (00010000000)M_2
$\hookrightarrow$ (0 0 0 0 0 0 0 0 0 0 0) $\cup$ (1 1 0 0 1 1 0 1 0 0)
==> (0 0 0 0 0 0 0 0 0 0 0) $\cup$ (1 1 0 0 1 1 0 1 0 0)M_2^T
= (0 0 0 0 0 0 0 0 0 0 0) $\cup$ (5 2 5 5 5 2 1 4 4 1 2)
$\hookrightarrow$ (0 0 0 0 0 0 0 0 0 0 0) $\cup$ (1 0 1 1 1 0 0 1 1 0 0)

ROW SUM is (0,6)

$I_1^{(5)}$M = (0 0 0 0 0 0 0 0 0 0 0 0)M_1 $\cup$ (00001000000)M_2
$\hookrightarrow$ (0 0 0 0 0 0 0 0 0 0 0) $\cup$ (1 1 0 0 1 1 0 1 0 0)
==> (0 0 0 0 0 0 0 0 0 0 0) $\cup$ (1 1 0 0 1 1 0 1 0 0)M_2^T
= (0 0 0 0 0 0 0 0 0 0 0) $\cup$ (5 2 5 5 5 2 1 4 4 1 2)
$\hookrightarrow$ (0 0 0 0 0 0 0 0 0 0 0) $\cup$ (1 0 1 1 1 0 0 1 1 0 0)

ROW SUM is (0,6)

$I_1^{(6)}$M = (0 0 0 0 0 0 0 0 0 0 0 0)M_1 $\cup$ (00001000000)M_2
$\hookrightarrow$ (0 0 0 0 1 0 1 0 0 1 1) $\cup$ (1 1 1 1 1 1 1 0 1 1)
==> (0 0 0 0 1 0 1 0 0 1 1) $\cup$ (1 1 1 1 1 1 1 0 1 1)M_2^T
= (0 0 0 0 1 0 1 0 0 1 1) $\cup$ (5 4 4 4 4 3 3 6 9 5 6)
$\hookrightarrow$ (0 0 0 0 1 0 1 0 0 1 1) $\cup$ (0 0 0 0 0 0 0 1 1 0 1)

ROW SUM is (4,3)

Hence the new input vector I_2 is: (0 0 0 0 1 0 1 0 0 1 1) $\cup$ (1 0 1 1 1 0 0 1 1 0 0)

The effect of I_2 on M is :

I_2 M = (0 0 0 0 1 0 1 0 0 1 1)M_1 $\cup$ (1 0 1 1 1 0 0 1 1 0 0)M_2.
= (2 3 -1 3 2 1 2 3 4 3 2) $\cup$ (6 6 2 2 6 5 2 5 2 2)
$\hookrightarrow$ (1 1 0 1 1 1 1 1 1 1 1) $\cup$ (1 1 0 0 1 1 0 1 0 0)
==> (1 1 0 1 1 1 1 1 1 1 1) $\cup$ (1 1 0 0 1 1 0 1 0 0)M_2^T

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= (1 1 0 1 1 1 1 1 1 1 1) ∪ (5 2 5 5 5 2 1 4 4 1 2)
↪ (1 1 0 1 1 1 1 1 1 1 1) ∪(1 0 1 1 1 0 0 1 1 0 0) = I_2'
Let $I_2' = IC_2' \cup IR_2'$
The new bivectors are :
$I_2^{(1)}$ = (1 0 0 0 0 0 0 0 0 0 0) ∪ (1 0 0 0 0 0 0 0 0 0 0)
$I_2^{(2)}$ = (0 1 0 0 0 0 0 0 0 0 0) ∪ (0 0 0 0 0 0 0 0 0 0 0)
$I_2^{(3)}$ = (0 0 0 0 0 0 0 0 0 0 0) ∪ (0 0 1 0 0 0 0 0 0 0 0)
$I_2^{(4)}$ = (0 0 0 1 0 0 0 0 0 0 0) ∪ (0 0 0 1 0 0 0 0 0 0 0)
$I_2^{(5)}$ = (0 0 0 0 1 0 0 0 0 0 0) ∪ (0 0 0 0 1 0 0 0 0 0 0)
$I_2^{(6)}$ = (0 0 0 0 0 1 0 0 1 0 0) ∪ (0 0 0 0 0 0 0 0 1 0 0)
$I_2^{(7)}$ = (0 0 0 0 0 0 1 0 0 0 0) ∪ (0 0 0 0 0 0 0 0 0 0 0)
$I_2^{(8)}$ = (0 0 0 0 0 0 0 1 0 0 0) ∪ (0 0 0 0 0 0 0 1 0 0 0)
$I_2^{(9)}$ = (0 0 0 0 0 0 0 0 1 0 0) ∪ (0 0 1 0 0 0 0 0 1 0 0)
$I_2^{(10)}$ = (0 0 0 0 0 0 0 0 0 1 0) ∪ (0 0 0 0 0 0 0 0 0 0 0)
$I_2^{(11)}$ = (0 0 0 0 0 0 0 0 0 0 1) ∪ (0 0 0 0 0 0 0 0 0 0 0)
The effects of $I_2^{(1)}$, $I_2^{(2)}$, $I_2^{(3)}$, $I_2^{(4)}$, $I_2^{(5)}$, $I_2^{(6)}$, $I_2^{(7)}$, $I_2^{(8)}$, $I_2^{(9)}$, $I_2^{(10)}$, $I_2^{(11)}$ on M we get the row sums as (2, 5), (3, 0) ,(0, 6) , (4, 6) , (7, 6) ,(9, 0), (8, 0) , (8, 2) , (4, 3) ,(9, 0) and (2, 0) respectively. Therefore the new input vector is :
I_3 = (1 1 0 1 1 0 1 1 1 1 1) ∪ (1 0 1 1 1 0 0 1 1 0 0)
The effect of I_3 on the dynamical system M is :
I_3M = (1 1 0 1 1 0 1 1 1 1 1)M_1 ∪ (1 0 1 1 1 0 0 1 1 0 0)M_2
= (4 5 -3 4 6 -1 5 4 8 5 4) ∪ (6 6 2 2 6 5 2 5 1 2)
↪ (1 1 0 1 1 0 1 1 1 1 1) ∪ (1 1 0 0 1 1 0 1 0 0)
==> (1 1 0 1 1 0 1 1 1 1 1) ∪ (1 1 0 0 1 1 0 1 0 0)M^T
= (1 1 0 1 1 0 1 1 1 1 1) ∪ (5 2 5 5 5 2 1 4 4 1 2)
↪ (1 1 0 1 1 0 1 1 1 1 1) ∪ (1 0 1 1 1 0 0 1 1 0 0)
(1 1 0 1 1 0 1 1 1 1 1) ∪ IR_2' = (1 1 0 1 1 0 1 1 1 1 1) M_1 ∪ IR_2'
The new bivectors are :
$I_3^{(1)}$= (1 0 0 0 0 0 0 0 0 0 0) ∪ IR_3' ; $I_3^{(2)}$= (0 1 0 0 0 0 0 0 0 0 0) ∪ IR_3'
$I_3^{(3)}$= (0 0 0 1 0 0 0 0 0 0 0) ∪ IR_3' ; $I_3^{(4)}$= (0 0 0 0 1 0 0 0 0 0 0) ∪ IR_3'
$I_3^{(5)}$= (1 0 0 0 0 0 1 0 0 0 0) ∪ IR_3' ; $I_3^{(6)}$= (1 0 0 0 0 0 0 0 1 0 0 0) ∪ IR_3'
$I_3^{(7)}$= (1 0 0 0 0 0 0 0 1 0 0) ∪ IR_3' ; $I_3^{(8)}$= (1 0 0 0 0 0 0 0 0 1 0) ∪ IR_3'
$I_3^{(9)}$= (0 0 0 0 0 0 0 0 0 0 1) ∪ IR_3'
Repeating the above process we get
I_4 = (1 1 0 1 1 1 0 1 1 1 0) ∪(1 0 1 1 1 0 0 1 1 0 0)
I_5 = (1 1 0 1 1 1 0 1 1 1 0) ∪(1 0 1 1 1 0 0 1 1 0 0) = I_4
Therefore the limit point is
(1 1 0 1 1 1 0 1 1 1 0) ∪ (1 0 1 1 1 0 0 1 1 0 0).

Table 2 presents the set of limit points corresponding to different input bivectors.

Conclusions and suggestions

We analyzed the health problems of agriculture labourers and coolies. As we use different inputs, and by merging all these graphs, we get the combined graph which is shown in Fig.1. We observe that the node C_7 is reachable from all the nodes of the graph and more number of paths are through the node C_6. Similarly, the nodes D_3 and D_{11} more inputs. This reveals that C_7 is the main cause and C_6 is second prime cause for the above mentioned health hazards. Hence we conclude that the pollution and the health hazards are mainly due to spray of pesticides and manuring the fields with chemical fertilizers. Similarly, the main diseases which affect the Rice cultivators are Dermatitis/Hookworms (D_3) and Asthma (D_{11}) while they are doing cultivation like Pudding (R_1), Adding minerals before planting (R_2), removing the weeds (R_5) and controlling diseases and Pesticides (R_6).

Based on the above conclusion the following remedial measures are suggested:

(1) The farmers may use natural pesticides and manures in their agricultural fields for cultivation purpose. This means our fore farmers were used organic matters like dump the plant and animal wastes at open places and allow them to decompose, the decomposition is facilitated

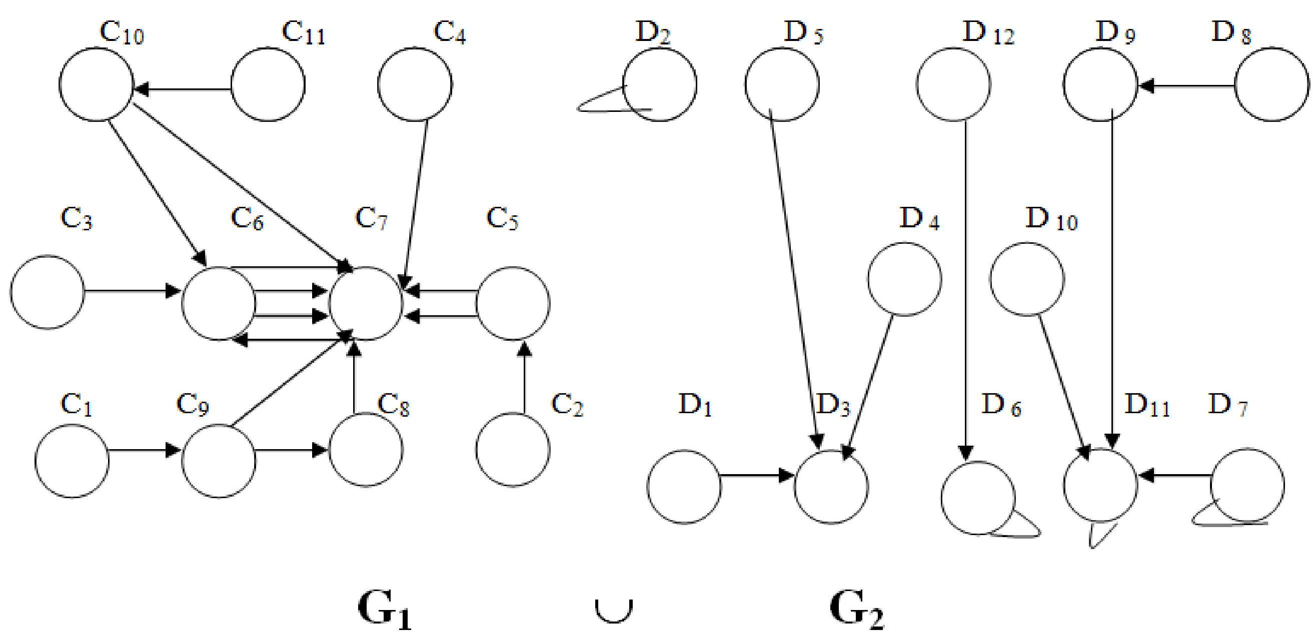

Table 2. The set of limit points corresponding to different input bivectors

S.No	Input bivector	Limit points	Induced path
1	(100 000 000 00) ∪ (100 000 000 00)	(110 111 01110)) ∪ ((1100110100) ((10111001100))	(c_1=>c_9=>c_6=>c_7=>c_7) ∪ (c_1=>c_3=>c_3)
2	(010 000 000 00) ∪ (010 000 000 00)	(110 111 01110)) ∪((0001101010) (01000000111))	(c_2=> c_5=>c_7=>c_7) ∪ (c_2=>c_2=>c_2)
3	(001 000 000 00) ∪ (001 000 000 00)	(110 111 01110)) ∪ ((1100110100) (10111001100))	(c_3=> c_6=>c_7=>c_7)) ∪ (c_3=>c_3=>c_3)
4	(000100 000 00) ∪ (000100 000 00)	(110 111 01110)) ∪ ((1100110100) (10111001100))	(c_4=> c_7=>c_7) ∪ (c_4=>c_3=>c_3)
5	(000 010 000 00) ∪ (000 010 000 00)	(110 111 01110)) ∪ ((1100110100) (10111001100))	(c_5=> c_7=>c_7) ∪ (c_5=>c_3=>c_3)
6	(000 001 000 00) ∪ (000 001 000 00)	(110 111 01110)) ∪ ((0100110000) (11111101100))	(c_6=> c_7=>c_7) ∪ (c_6=>c_6=>c_6)
7	(000 000 100 00) ∪ (000 000 100 00)	(110 111 01110)) ∪ ((1011101011) (00000000101))	(c_7=> c_6=>c_7=>c_7) ∪ (c_7=>c_{11}=>c_{11})
8	(000 000 010 00) ∪ (000 000 010 00)	(110 111 01110)) ∪ ((1011101011)) (00000000101))	(c_8=> c_7=>c_7) ∪ (c_8=>c_9=>c_{11}=>c_{11})
9	(000 000 001 00) ∪ (000 000 001 00)	(110 111 01110)) ∪ ((1011101011)) (00000000101))	(c_9=> c_7=>c_7) ∪ (c_9=>c_{11}=>c_{11})
10	(000 000 000 10) ∪ (000 000 000 10)	(110 111 01110)) ∪ ((1011101011)) (00000000101))	(c_{10}=> c_6=>c_7=>c_7) ∪ (c_{10}=>c_{11}=>c_{11})
11	(000 000 000 01) ∪(000 000 000 01)	(110 111 01110)) ∪ ((1011101011)) (00000000101))	(c_{11}=> c_{10}=>c_7 =>c_7) ∪ c_{11}=>c_{11}=>c_{11})

by organisms like bacteria and fungi, the decomposed is used as manure. It is simple recycling of nutrients through soil, it is traditional fertilizer better than the inorganic fertilizer like ammonium sulphate, super phosphate, potassium sulphate etc.

(2) The employer should advice the labourer about the proper methods of handling pesticides and they should also advice the workers about the usage of fertilizers.

(3) The employees should cover their face for protection while spraying pesticides. Use of protective equipment as long rubber boots, mask, gloves and glasses have big values in protecting against different parasites and chemical agents.

(4) The employer should provide proper place to the labourers for washing their hands, plates etc.,. Improvement of housing, sanitary standards, nutritional environment hygiene and economic stability are essential for the quality of rice field workers.(separate eating area, hand washing facilities). They should also provide protected drinking water to the agriculture labourers.

(5) Necessary medical preventive methods should be strictly applied including the introduction of first aid instruction, the provision of treatment facilities and medical surveillance of workers. We suggest that the Government must open more health centers in villages to provide medical facilities for them.

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