

Using Induced Fuzzy Bi-Model to Analyze Employee Employer Relationship in an Industry

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Abstract—The employee-employer relationship is an intricate one. In an industry, the employers expect to achieve performances in quality and production in order to earn profit, on the other side employees need good pay and all possible allowances and best advantages than any other industry. Our main objective of this paper is to analyze the relationship between employee and employer in workplace and discussed how to maintain a strong employee and employer relationship which can produce the ultimate success of an organization using Induced Fuzzy bi-model called Induced Fuzzy Cognitive Relational Maps (IFCRMs). IFCRMs are a directed special fuzzy digraph modelling approach based on expert's opinion. This is a non statistical approach to study the problems with imprecise information.

Keywords—Fuzzy Cognitive Map; Fuzzy Relational Maps; Fuzzy Cognitive Relational Maps; Induced Fuzzy Cognitive Relational Maps; Fuzzy bi-model; employee employer relationship

I. INTRODUCTION

The fuzzy model is a finite set of fuzzy relations that form an algorithm for determining the outputs of a process from some finite number of past inputs and outputs. Fuzzy model can be used in applied mathematics, to study social and psychological problem and also used by doctors, engineers, scientists, industrialists and statisticians. Fuzzy models are mathematical tools introduced by L.A. Zadeh (1965). Later Politician scientist Axelord (1976) used this fuzzy model Cognitive Maps (CMs) to study decision making in social and political systems. CMs are signed digraphs designed to represent causal assertion and belief system of a person (or group of experts) with respect to a specific domain, and use that statement in order to analyze the effect of a certain choice on a particular objective.

Using the concepts of neural networks and fuzzy logical approach Bart Kosko (1986) proposed some models which extend the idea of Cognitive Maps by allowing the concepts to be represented linguistically with an associated fuzzy set. 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 and even contradictory in nature. There are various types of fuzzy models like Fuzzy Cognitive Maps (FCMs), Fuzzy Relational Maps (FRMs), Fuzzy Relational Equations (FREs), Induced Fuzzy Cognitive Maps (IFCMs). Those models plays a vital role in several real

world data problems like various infectious diseases problems (cancer, tuberculosis, migration etc.), student life in rural area, problems of private employees in their day to day life, effects of social networks on children's daily life etc. In this paper we use fuzzy bi-model called Induced Fuzzy Cognitive Relational Maps (IFCRMs) which is a directed bi-graph with concepts like policies, events, etc. as nodes and causalities as edges. It represents causal relationship between concepts. This fuzzy bi-model studied various social problems. Among these problems we are going to discuss about a particular one. Recent years deals with one of the key human resources (HR) issues in current working life, namely employee relations. Employee relations is a term used to describe a company's efforts to prevent and resolve problems arising from situations at work. In this paper we have focused on employee relation programs and its essential elements which increase employee satisfaction and good morale among workers. Happy workers are more productive, and more productive means a better bottom line for an industry. This paper have organized in nine section. Section one contains introduction. Section two represents basic definition of FCMs and FRMs models. Section three describes about fuzzy bi-model method. Section four gives the idea of FCRMs. Section five gives the mathematical approach of FCRMs of discussed problems. Section six gives the idea of IFCRMs. Section seven gives the mathematical approach of IFCRMs of discussed problems. Section eight describes the difference between FCRMs and its induced form IFCRMs. Section nine conclusions based on our study.

II. FUZZY MAPPING

Before the discussion of FCMs we describe about the CMs. CMs were introduced by Axelord (1976), in order to develop and study social scientific knowledge in the field of decision making in activities related to international politics. CMs are signed digraphs designed to represent causal assertion and belief system of a person (or group of experts) with respect to a specific domain, and use that statement in order to analyze the effect of a certain choice on particular objectives.

A. Fuzzy Cognitive Maps

Fuzzy Cognitive Maps (FCMs) introduced by Kosko (1986) extend the idea of Cognitive Maps by allowing the concepts to be represented linguistically with an associated fuzzy set. FCMs are fuzzy signed digraph with feedback (Kosko, 1986, 1988). It represents causal relationship between concepts. FCMs list the fuzzy rule or causal flow paths that relate events.

B. Formation of FCMs

If increase in one concept or node leads to increase in another concepts, we assign the value 1 and for decreasing we assign the value -1. If there exists no relation between concepts the value 0 is given. Consider the C_1, C_2, \dots, C_n be the nodes of the FCM. Suppose the directed graphs drawn using edge weight $e_{ij} \in \{0, 1, -1\}$. The Matrix E be defined by $E = (e_{ij})$ where e_{ij} is the weight of the directed edge $C_i C_j$. E is called adjacency matrix of the FCM. All matrices associated with an FCM are always square matrices with diagonal entries as zero. Now

- The instantaneous state vector $A = (a_1, a_2, \dots, a_n)$ where $a_i \in \{0, 1\}$, and it denotes the ON-OFF position of the node at an instant; $a_i = 0$ if a_i is off and $a_i = 1$ if a_i is on for $i = 1, 2, \dots, n$.
- Let $C_1 C_2, C_2 C_3, \dots, C_i C_j$ be the nodes of the edge of the FCM ($i \neq j$) form a directed cycle and FCM is said to be cyclic if it possesses a directed cycle. Otherwise it is acyclic.
- FCM with cycles is said to have a feedback. when there is a feedback in an FCM, i.e., when the causal relations flow through a cycle in a revolutionary way, the FCM is called dynamical system.
- When node C_i switched on and if the causality flows through the edges of a cycle and if it again caused C_i , we say that dynamical system goes round and round where $i = 1, 2, \dots, n$.
- The equilibrium state for this dynamical system is called hidden pattern.
- If the equilibrium state of a dynamical system is a unique state vector, then is called fixed point.
- If the FCM settles down with a state vector repeating in the form $A_1 \rightarrow A_2 \rightarrow \dots \rightarrow A_i \rightarrow A_1$, then this equilibrium is called a limit cycle.
- Finite number of FCMs can be combined together to produce the joint effect of all the FCMs with nodes i.e. Combined FCMs denotes the relational matrix by $E = E_1 + E_2 + \dots + E_p$.
- Suppose $A = (a_1, \dots, a_n)$ is a vector which is passed into a dynamical system E. Then $AE = (a'_1, \dots, a'_n)$ after thresholding and updating the vector suppose we get (b_1, \dots, b_n) . We denote that by $(a'_1, \dots, a'_n) \xrightarrow{\text{threshold and update}} (b_1, \dots, b_n)$. Thus the symbol ' $\xrightarrow{\text{threshold and update}}$ ' means the resultant vector has been threshold and updated.

C. Definition of Fuzzy Relational Maps

Fuzzy Relational Maps (FRMs) are a directed graph or a map from domain space to range space with concepts and causalities as edges.

Let,

Domain space = n

Range space = m [$m \neq n$]

R_1, R_2, \dots, R_m be the nodes of range space.

$R = \{(x_1, x_2, \dots, x_m) \mid x_j = 0 \text{ or } 1\} \forall j = 1, 2, \dots, m.$

if $x_j = 1$ i.e. R_j is on state

else $x_j = 0$ i.e. R_j is off state

Similarly,

D_1, D_2, \dots, D_n be the nodes of domain space.

$D = \{(x_1, x_2, \dots, x_n) \mid x_i = 0 \text{ or } 1\} \forall i = 1, 2, \dots, n.$

if $x_i = 1$ i.e. D_i is on state

else $x_i = 0$ i.e. D_i is off state.

D. Formation of FRMs

Let D_i and R_j denotes the two nodes of FRMs. e_{ij} be the weight of the edge $D_i R_j$ (or $R_j D_i$), then $e_{ij} \in \{0, 1, -1\}$ The relational matrix E be defined as $E = (e_{ij})$.

- Let $A = (a_1, \dots, a_n)$, $a_i \in \{0, 1\}$ where $i = 1, 2, \dots, n$. A is called the instantaneous state vector of the domain space and it denotes the on-off position of the nodes at any instant i.e. $a_i = 0$ if a_i is off and $a_i = 1$ if a_i is on for $i = 1, 2, \dots, n$ for domain space. Similarly, $B = (b_1, \dots, b_m)$, $b_j \in \{0, 1\}$ where $j = 1, 2, \dots, m$. B is the instantaneous state vector of the range space. $b_j = 0$ if b_j is off and $b_j = 1$ if b_j is on for $j = 1, 2, \dots, m$ for range space.
- Let $D_i R_j$ (or $R_j D_i$) be the edges of an FRM where $j = 1, 2, \dots, m$ and $i = 1, 2, \dots, n$ form a directed cycle, FRM is said to be cycle if it possesses a directed cycle. Otherwise, it is acyclic.
- An FRM with cycle is said to be an FRM with feedback. When there is feedback in the FRM, the FRM is called a dynamical system.
- Let $D_i R_j$ (or $R_j D_i$) where $1 \leq j \leq m$ and $1 \leq i \leq n$. When D_i (or R_j) is switched on and if causality flows and if again causes D_i (or R_j) an equilibrium is attained. This equilibrium state is called hidden pattern.
- If the equilibrium state of this system is a unique state vector then it is called fixed point.
Example: Let us assume dynamical system by switching on R_1 (or D_1). FRM settles down with R_1 and R_m (D_1 and D_n) on i.e. state vector remains as $(1, 0, \dots, 0, 1)$ as in $R(1, 0, \dots, 0, 1)$. This state vector is called the fixed point.
- If the FRM reach a state vector in the forms: $D_1 \rightarrow D_2 \rightarrow \dots \rightarrow D_i \rightarrow D_1 (R_1 \rightarrow R_2 \rightarrow \dots \rightarrow R_i \rightarrow R_1)$; This form is called limit cycle.
- Let E_1, E_2, \dots, E_p be the relational matrices of the FRMs. Combined FRMs denotes the relational matrix by $E = E_1 + E_2 + \dots + E_p$.
- Let R_1, R_2, \dots, R_m and D_1, D_2, \dots, D_n be the nodes of FRM. Let us assume D_1 is switched on i.e. when an input is given as vector $A_1 = (1, 0, \dots, 0)$ in D_1 and the relational matrix is E. Now $A_1 E = (r_1, r_2, \dots, r_m)$, after thresholding and updating the resultant vector $A_1 E \in R$. Now let $B = A_1 E$, passing B into E^T and obtain BE^T . After threshold and update the vector

$BE^T \in D$. The procedure repeated till we get a fixed point or limit cycle.

III. FUZZY MODEL

In this section we describe the basic notions of Fuzzy Bi-model.

A. Bi-Set

Let $BM = BM_1 \cup BM_2$, where BM_1 and BM_2 are non-empty sets with $BM_1 \not\subseteq BM_2$ and $BM_2 \not\subseteq BM_1$, then we call BM as biset.

B. Bi-Vector

Let $X_1 = (x_1, x_2, \dots, x_n)$ and $X_2 = (x'_1, x'_2, \dots, x'_m)$ be the two vectors of length n and m respectively. Then $X = X_1 \cup X_2$ is a bi-vector. Let $X = X_1 \cup X_2 = (2104) \cup (4125)$, where X is a bi-vector. Now, $X = X_1 \cup X_2 = (000) \cup (000)$, where A is a zero vector. If $X = X_1 \cup X_2 = (1111) \cup (1111)$, then X is an unit vector.

C. Bi-matrix

A matrix BMT is said to be a fuzzy bi-matrix if $BMT = BMT_1 \cup BMT_2$ where BMT_1 and BMT_2 are two different matrices. Example: let $BMT = BMT_1 \cup BMT_2 = (0101) \cup (1100)$, then BMT is called a bi-matrix or row bi-matrix. Let $BMT = BMT_1 \cup BMT_2 = \begin{bmatrix} 1 & 9 \\ 2 & 0 \end{bmatrix} \cup \begin{bmatrix} 1 & 6 \\ 8 & 5 \end{bmatrix}$ then BMT is called square bi-matrix.

D. Bi-graph

Let $BG = BG_1 \cup BG_2$ where BG_1 and BG_2 are two distinct graphs then we call G as a bi-graph.

E. Product rule of bi-matrix

Let $BMT = BMT_1 \cup BMT_2$ be a bi-matrix where BMT_1 is a $m \times n$ matrix and BMT_2 is a $p \times s$ matrix. If $X = X_1 \cup X_2$ is a bi-vector such that X_1 has m components and X_2 has p components then the product of X with A is defined as $XBMT = (X_1 \cup X_2)(BMT_1 \cup BMT_2) = X_1BMT_1 \cup X_2BMT_2$. is a $1 \times s$ matrix or more mathematically; $X_1BMT_1 \cup X_2BMT_2 = Y_1 \cup Y_2$ a bi-vector or a row bi-vector.

F. Bi-transpose of bi-matrix

Let $BM = BM_1 \cup BM_2$ be a bi-matrix. Then the bi-transpose of the bi-matrix BM is defined as $BM^t = (BM_1 \cup BM_2)^t = BM_1^t \cup BM_2^t$.

IV. FUZZY COGNITIVE RELATIONAL MAPS

Fuzzy Cognitive Relational Maps (FCRMs) is a directed bi-graph where the pair of associated nodes are bi-nodes. If the order of the bi-matrix associated with FCRMs is $n \times n$ square matrix and $p \times m$ matrix then the bi-nodes are bi-vectors of length (n, p) or length (n, m) .

A. Adjacency Bi-matrix

Consider the bi-nodes concepts $\{C^1_1, C^1_2, \dots, C^1_n\}$ of FCMs and $\{D_1, \dots, D_p\}$ and $\{R_1, \dots, R_m\}$ of FRMs to define a new FCRMs model. Suppose the directed graph is drawn using the edge bi-weight $e^t_{ij} = \{0, 1, -1\}$, $1 \leq t \leq 2$. The bi-matrix $BM = BM_1 \cup BM_2$ is defined by $e^1_{ij} \cup e^2_{ks}$, where e^1_{ij} is

the weight of the directed edge C_iC_j and e^2_{ks} is the directed edge of D_kR_s . BM is called adjacency bi-matrix of FCRMs model, also known as the connecting relational bi-matrix of FCRMs model.

B. Instantaneous rate

Let $\{C_1, \dots, C_n\} \cup \{(D_1, \dots, D_p) \cup (R_1, \dots, R_m)\}$ be the bi-nodes of FCRMs. Now $A = A_1 \cup A_2 = (a_1, a_2, \dots, a_n) \cup (b_1, b_2, \dots, b_p) (or) (c_1, c_2, \dots, c_m)$ where $a_i, b_j, c_t \in \{0, 1\}$ $1 \leq i \leq n, 1 \leq j \leq p$ and $1 \leq t \leq m$. A is called instantaneous state bi-vector and it denotes the ON – OFF position of the node at an instant.

- 1) $a_j = 0$ if a_j is OFF and $a_j = 1$ if a_j is ON for $1 \leq j \leq n$.
- 2) $b_i = 0$ if b_i is OFF and $b_i = 1$ if b_i is ON for $1 \leq i \leq p$.
- 3) $c_t = 0$ if c_t is OFF and $c_t = 1$ if c_t is ON for $1 \leq t \leq m$.

C. Bi-cyclic FCRMs

Let $\{C_1, \dots, C_n\} \cup \{(D_1, \dots, D_p) \cup (R_1, \dots, R_m)\}$ be the bi-nodes of FCRMs. Now $C_iC_j \cup D_sR_k$ be the bi-edges of FCRMs where $i \neq j, 1 \leq i, j \leq n, 1 \leq s \leq p$ and $1 \leq k \leq m$, then the bi-edges form a directed bi-cycle. An FCRMs are said to be bi-cyclic if it possesses a directed bi-cycle. FCRMs are said to be abi-cyclic if it does not possess any directed bi-cycle.

D. Dynamicalbi-system

An FCRMs with bi-cycles is said to have a feedback, when there is a feedback in an FCRMs, i.e. when the causal relations flow through a cycle in a revolutionary way, the FCRMs are called a dynamical bi-systems.

E. Hidden bi-pattern

Let $\{C_1C_2, C_2C_3, \dots, C_{n-1}C_n\} \cup \{(D_iR_j) or (R_jD_i) | 1 \leq i \leq p, 1 \leq j \leq m\}$ be a bi-cycle. If $C_i \cup R_j (or) D_j$ is switched ON and if the causality flows through the edges of the bi-cycle and if it again causes $C_i \cup R_j (or) D_j$ we say that the dynamical bi-system in a loop. This is true for the bi-nodes $C_i \cup R_j (or) D_j$ for $1 \leq i \leq n, 1 \leq j \leq m$ (or $1 \leq j \leq p$) The equilibrium bi-state for the dynamical bi-system is called hidden pattern. If the equilibrium bi-state of the dynamical bi-system is a unique bi-state bi-vector then it is called fixed bi-point.

F. Limit-bicycle

If the FCRMs settles down with a bi-state bi-vector repeating in the form $A_1 \rightarrow A_2 \rightarrow \dots \rightarrow A_1 \cup B_1 \rightarrow B_2 \rightarrow \dots \rightarrow B_1 (or) D_1 \rightarrow D_2 \rightarrow \dots \rightarrow D_1$ then this equilibrium is called a limit bi-cycle.

G. Threshold and update

Suppose $A = A_1 \cup A_2$ is bi-vector which is passes into a dynamical bi-system $E = E_1 \cup E_2$. Then $AE = A_1E_1 \cup A_2E_2 = (x'_1, x'_2, \dots, x'_n) \cup (y'_1, y'_2, \dots, y'_p) (or) (z'_1, z'_2, \dots, z'_m)$ after thresholding and updating the bi-vector; suppose we get

$(x_1, x_2, \dots, x_n) \cup (y_1, \dots, y_p) \text{ (or } (z_1, \dots, z_m))$ we denote that by $(x'_1, x'_2, \dots, x'_n) \cup (y'_1, y'_2, \dots, y'_p)$

$(\text{or } ((z'_1, z'_2, \dots, z'_m) \Leftrightarrow (x_1, x_2, \dots, x_n) \cup (y_1, \dots, y_p) \text{ (or } (z_1, \dots, z_m))))$. Thus the symbol \Leftrightarrow means the resultant bi-vector has been threshold and updated.

H. Properties of bi-edges

The bi-edges $e_{ij} = (e^1_{ij}) \cup (e^2_{ks})$ take the values in fuzzy causal bi-interval $[-1,1] \cup [-1,1]$. We have 9 possibilities in FCRMs which making the solution of the problem more sensitive or accurate.

- 1) $e_{ij} = 0$ denotes no causality between the bi-nodes.
- 2) $e_{ij} > 0$ indicates that both $e^1_{ij} > 0$ and $e^2_{ks} > 0$; this implies increase in bi-nodes $C_i \cup D_k$ (or R_s).
- 3) $e_{ij} < 0$ indicates that both $e^1_{ij} < 0$ and $e^2_{ks} < 0$; this implies decrease in bi-nodes $C_i \cup D_k$ (or R_s).
- 4) Considering the case when $(e^1_{ij}) = 0$ and $(e^2_{ks}) > 0$ then no relation in one bi-node and an increase in other node.
- 5) If $(e^1_{ij}) = 0$ and $(e^2_{ks}) < 0$ then no causality in the FCMs node and decreasing relation in FRMs mode.
- 6) $(e^1_{ij}) > 0$ and $(e^2_{ks}) = 0$ then increasing relation in FCMs mode and no relation in FRMs.
- 7) $(e^1_{ij}) < 0$ and $(e^2_{ks}) = 0$ then no relation in FRMs and an increasing relation in FCMs mode.
- 8) $(e^1_{ij}) < 0$ and $(e^2_{ks}) > 0$ then decreasing relation in FCMs mode and increasing relations in FRMs.
- 9) $(e^1_{ij}) > 0$ and $(e^2_{ks}) < 0$ then increasing relation in FCMs mode and decreasing relations in FRMs.

I. Modification of given problem

Connection bi-matrix of FCRMs bi-model which has both FCMs and FRMs bi-model. We have assumed I_1 be the initial input bi-vector. In I_1 , a particular vector components, c_1 and d_1 , which is in FCMs and FRMs be kept ON state and all other components are OFF state. Now we pass the state vector I_1 through the FCRMs bi-model. To convert the resultant vector, the values in FCMs and FRMs component which are greater than or equal to one are made as on state and all others denote as OFF state by assigning the values 1 and 0. The component of FCMs of the resulting vector is kept as it is and the components of FRMs of the resulting vector is multiplied with the inverse of the FCMs bi-matrix and thresholding yield in a new vector I_2 . Using this new input bi-vector, we repeat the same procedure until a fixed point or a limit cycle is obtained. The process has been repeated for all the vectors separately. From this operation we have found the hidden pattern of some vectors in all or many cases from which we have analyzed the causes.

V. ANALYZE THE PROBLEMS OF EMPLOYEE EMPLOYER RELATIONSHIP USING FCRMS MODEL

The most important part of any business is its people. No business can run effectively without them. But people don't work in a vacuum; they need to communicate and work with others to get their jobs done. To be successful, employers need to manage relationships in the workplace to keep the business

functioning smoothly, avoid problems and make sure individual employees are performing at their best. An organisation with good employee-employer relations provide fair and consistent treatment to all means employers must provide. Employee relations programs are typically part of a human resource strategy designed to ensure the most effective use of people to accomplish the organization's mission. Human resource strategies are deliberate plans companies use to help them gain and maintain a competitive edge in the marketplace. One way to stay ahead is to make sure employees are happy so they don't leave their job and go work for the competition. An effective employee-employer relations program starts with clearly written policies which describe the company's rules, philosophy, procedure for addressing employee-related matters and resolving problems in the workplace. Strategies for good employee-employee relations can take many forms and vary by a number of factors including company size, job security, salaries, promotion, responsibility and many more. Now we proceed onto study and analyze the relationship between employee-employer which is the key to the ultimate success of an organization using FCRMs model. According to experts view and adaptation of the necessary requirement of employee and employer in an industry associated to FCMs of FCRMs model have done by taking as the attribute X_1, X_2, \dots, X_{16} . This is very important, that we have several nodes and several opinions to draw various model of this relationship. Attributes relating with FCMs of FCRMS model are as follows:

$X_1 \rightarrow$	Pay with allowances and bonus to the employee
$X_2 \rightarrow$	Only pay to the employee
$X_3 \rightarrow$	Pay with allowances (or bonus) to the employee
$X_4 \rightarrow$	Best performance
$X_5 \rightarrow$	Average performance
$X_6 \rightarrow$	Poor performance
$X_7 \rightarrow$	Employee works more number of hours
$X_8 \rightarrow$	Employee works less number of hours
$X_9 \rightarrow$	Maximum profit to the industry
$X_{10} \rightarrow$	Only profit to the industry
$X_{11} \rightarrow$	Neither profit nor loss to the industry
$X_{12} \rightarrow$	Loss to the industry
$X_{13} \rightarrow$	Heavy loss to the industry
$X_{14} \rightarrow$	Stop work or strike by the employee
$X_{15} \rightarrow$	Good relation between employee and employer
$X_{16} \rightarrow$	Demand of the employee which are not fulfilled

Similarly we have drawn aFRMs of the bi-matrix FCRMs model. We have taken 16 nodes D_1, D_2, \dots, D_{16} , in domain space which denote the employee's requirement.

- $D_1 \rightarrow$ Salaries ways & other benefit
- $D_2 \rightarrow$ Company policies & administration
- $D_3 \rightarrow$ Good inter personal relationship
- $D_4 \rightarrow$ Quality supervisor
- $D_5 \rightarrow$ Job security
- $D_6 \rightarrow$ Working condition
- $D_7 \rightarrow$ Work/life balance
- $D_8 \rightarrow$ Sense of personal achievement
- $D_9 \rightarrow$ Status
- $D_{10} \rightarrow$ Recognition
- $D_{11} \rightarrow$ Challenging/ stimulating work
- $D_{12} \rightarrow$ Responsivility
- $D_{13} \rightarrow$ Opportunity for advancement
- $D_{14} \rightarrow$ Promotion
- $D_{15} \rightarrow$ Growth
- $D_{16} \rightarrow$ Feedback & support

- $R_1 \rightarrow$ Offer clearly defined and specialized employment opportunities
- $R_2 \rightarrow$ Reinforce the need to follow organization policies and practice
- $R_3 \rightarrow$ Linked rewards and benefits to fulfilling, job requirement
- $R_4 \rightarrow$ Structure work condition
- $R_5 \rightarrow$ Reward employee who are loyal to the organization
- $R_6 \rightarrow$ Provide opportunities for employee to develop technical skill
- $R_7 \rightarrow$ Achievement of the industry
- $R_8 \rightarrow$ Good manager relationship

The attributes $R_1, R_2, R_3, R_4, R_5, R_6, R_7, R_8$ that is relate to owner of any industry have briefly described.

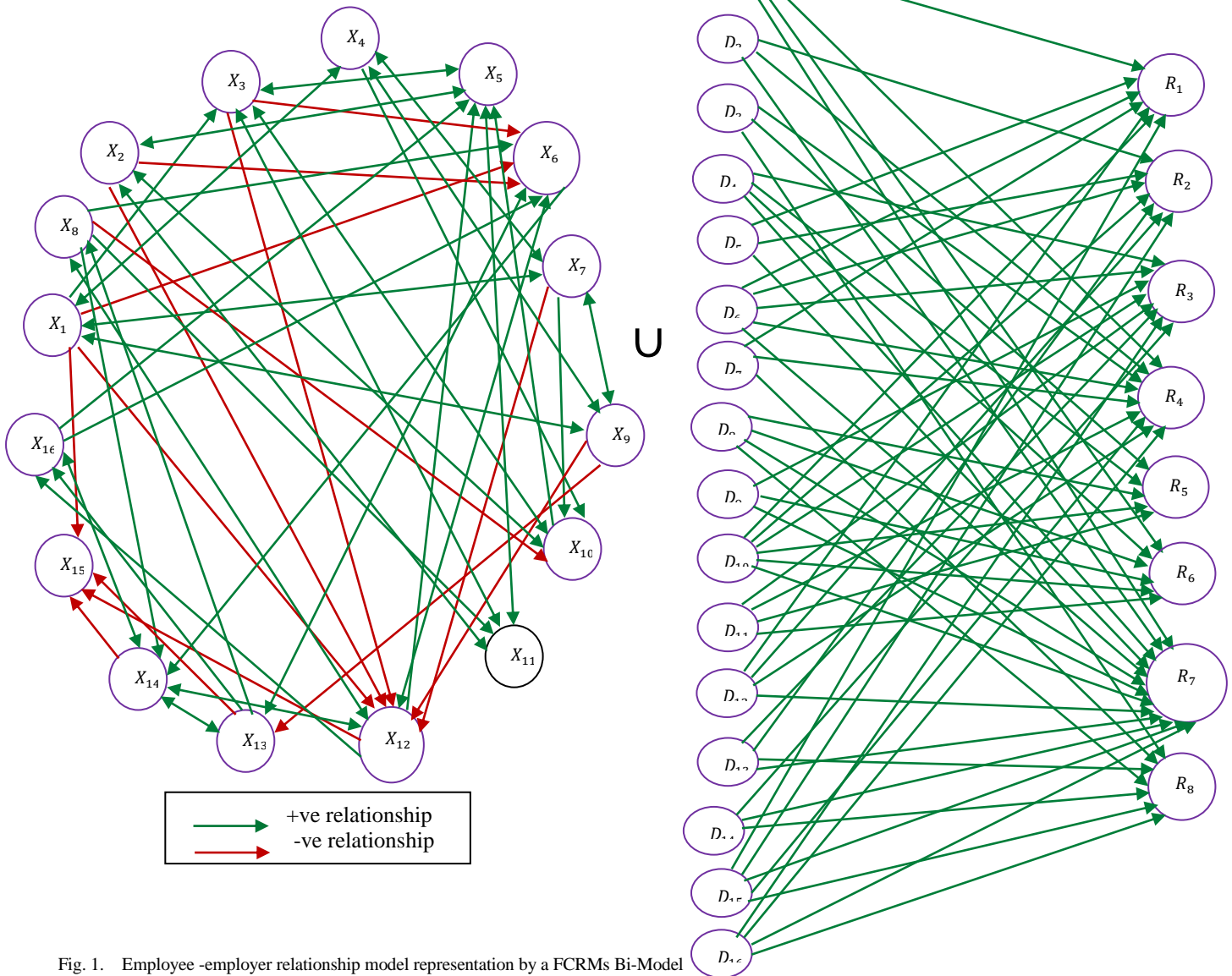


Fig. 1. Employee -employer relationship model representation by a FCRMs Bi-Model

With the help of relational model we have drawn a adjacency matrix called E.

TABLE I. ADJACENCY MATRIX OF FCRMS

	X ₁	X ₂	X ₃	X ₄	X ₅	X ₆	X ₇	X ₈	X ₉	X ₁₀	X ₁₁	X ₁₂	X ₁₃	X ₁₄	X ₁₅	X ₁₆
X ₁	0	0	1	1	0	-1	1	0	1	0	0	-1	0	0	1	0
X ₂	0	0	0	0	1	-1	0	0	0	1	1	-1	0	0	0	0
X ₃	0	0	0	0	1	-1	0	0	0	1	1	-1	0	0	0	0
X ₄	1	0	0	0	0	0	1	0	1	1	0	0	0	0	0	0
X ₅	0	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0
X ₆	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0
X ₇	1	0	0	1	0	0	0	0	1	1	0	-1	0	0	0	0
X ₈	0	0	0	0	0	1	0	0	0	-1	1	1	0	1	0	0
X ₉	1	0	0	1	0	0	1	0	0	0	0	-1	-1	0	0	0
X ₁₀	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0
X ₁₁	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0
X ₁₂	0	0	0	0	1	1	0	1	0	0	0	0	0	1	-1	1
X ₁₃	0	0	0	0	0	1	0	1	0	0	0	0	0	1	-1	1
X ₁₄	0	0	0	0	0	0	0	0	0	0	0	1	1	0	-1	1
X ₁₅	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
X ₁₆	0	0	0	0	1	1	0	0	0	0	0	0	0	1	0	0

E = \bigcup

	R ₁	R ₂	R ₃	R ₄	R ₅	R ₆	R ₇	R ₈
D ₁	1	0	0	1	0	1	1	0
D ₂	0	1	0	1	0	0	1	0
D ₃	0	0	0	1	1	0	0	1
D ₄	0	0	1	0	1	1	1	0
D ₅	1	1	0	0	0	0	1	0
D ₆	1	1	1	1	0	0	1	0
D ₇	1	0	0	1	0	0	0	1
D ₈	0	0	0	0	1	1	1	1
D ₉	0	0	1	0	0	1	1	0
D ₁₀	1	1	1	0	1	1	1	0
D ₁₁	0	0	1	1	1	1	0	0
D ₁₂	1	1	0	1	0	0	1	0
D ₁₃	0	1	1	0	0	0	1	1
D ₁₄	0	0	1	0	0	0	1	1
D ₁₅	1	1	0	1	0	0	1	1
D ₁₆	0	0	1	1	0	0	1	1

Here E denotes the connection matrix of the directed graph of FCRMs model. Considering all cases on this relationship model with taking some nodes are on or off and try to find out some hidden pattern

Case 1:

Now we have considered the node X₁ (Pay with allowances and bonus to the employee) in FCMs and D₁ (Salaries and

other benefits) in FRMs as the on state and all the remaining nodes are in the OFF state.

According the FCRMs method when the same threshold value occurs twice, the value is considered as the fixed point and the iteration and also the calculation gets terminated. Similarly we consider all the different input vectors on and find the hidden patterns for this FCRMs model which are shown in table 2.

TABLE II. THE SET OF FIXED POINTS CORRESPONDS TO DIFFERENT INPUT VECTORS OF FCRMS

Node	Input Vector	Limit Points
1	(1000000000000000)	$(1111101011100010) \cup \{(1100110001010010) (11010010)\}$
2	(0100000000000000)	$(0110100001100000) \cup \{(1100110001010010) (11010010)\}$
3	(0010000000000000)	$(0110100001100000) \cup \{(0100010001001111) (01110011)\}$
4	(0001000000000000)	$(1111101011100010) \cup \{(1001010111100001) (00111110)\}$
5	(0000100000000000)	$(1111101011100010) \cup \{(1100110001010010) (11010010)\}$
6	(0000010000000000)	$(0110110101111101) \cup \{(1100110001010010) (11010010)\}$
7	(0000001000000000)	$(1111101011100010) \cup \{(1100110001010010) (10010010)\}$
8	(0000000100000000)	$(0110110101101101) \cup \{(0001000111100000) (00101110)\}$
9	(0000000010000000)	$(1111101011100010) \cup \{(0001010111001111) (00100011)\}$
10	(0000000001000000)	$(0110100001100010) \cup \{(0001010001000000) (11101110)\}$
11	(0000000000100000)	$(0110100001100000) \cup \{(0001010111100000) (00101110)\}$
12	(0000000000010000)	$(1111101111100010) \cup \{(1100110001010010) (11010010)\}$
13	(0000000000001000)	$(0110110101111101) \cup \{(0001110101011111) (01100001)\}$
14	(0000000000000100)	$(0110110101101101) \cup \{(0001010111001111) (00100011)\}$
15	(0000000000000010)	$(0000000000000010) \cup \{(1100110001010010) (11010010)\}$
16	(0000000000000001)	$(1111101111100010) \cup \{(0001010111001111) (00110011)\}$

Hence from the above table 2 we define the set of limit points as well as fixed point for each different input vectors of FCRMs bi-model and observe the hidden pattern of each cases. Hidden pattern of some vectors found in all or many cases. Inference from this hidden pattern summarizes or highlights the causes.

VI. INDUCED FUZZY COGNITIVE RELATIONAL MAPS

Induced Fuzzy Cognitive Relational Maps (IFCRMs) is a modified version of FCRMs. IFCRMs focussed on algorithmic approaches of FCRMs which works on unsupervised data to derive an optimistic solution.

Step 1: Collect the nodes for the given problem, which is unsupervised data that is in determinant factors.

Step 2: Draw the directed bi-graph for FCRMs model, according to the expert opinion.

Step 3: From FCRMs, obtain the connection matrix E which is combination of both FCMs and FRMs.

Step 4: Consider the initial input bi-vector C_1 by setting the first component of this vector C_1 in ON position which is denoted by 1 and the rest of the components as 0 which are OFF state.

Step 5: Find $M = C_1 \times E$. At each stage the state vector is updated and threshold. The symbol θ represents the threshold value for the product of the result. The threshold value is calculated from M of FCMs components by assigning 1 for the values $x_1 > 0$ and assigning 0 when $x_1 < 0$ and two highest values in FRMs components are assigned as ON state and all others as OFF state by the giving values 1 or 0.

Step 6: The new bi-vector is related with the bi-matrix and that bi-vector which triggers the highest number

of attributes to *ON* state i.e. for each positive entry we get a set of resultant vectors from which a vector which contain maximum number of 1s is chosen as C_2 . If there are two or more bi-vector with equal number of 1s as *ON* state, choose the first occurring one.

Step 7: Considered as fixed point when the same threshold value occurs twice and the iteration gets terminated. This process is done to give due importance to each vector separately as one vector induces another or many more vectors into *ON* state.

Step 8: Set the state vector C_2 in *ON* state which is assigning the second component of the vector to be 1 and the rest of the components as 0. Precede the calculations discussed in steps 4 to 7.

Step 9: Continue the above process for all the remaining state vector C_n and find out the hidden pattern.

VII. ANALYZE THE RELATIONS BETWEEN EMPLOYEE-EMPLOYER USING FCRMS MODEL

We illustrate a general study to access the impact of daily requirement, satisfactory and dissatisfactory problems of both workers and owner of an Industry. We consider the dynamical system of this problem. At the first stage, we have taken the connection matrix E of the directed graph of FCRMs model.

Let

$$X_1 = (1000000000000000) \cup (1000000000000000)$$

$$X_1 E = (00110-110100-10010) \cup (10010110)$$

$$\hookrightarrow (1011001010000010) \cup (10010110)$$

$$X_1^T E = (1011001010000010) \cup (4211232223231132)$$

$$(1011001010000010) \cup (1000010001010010) = X_1'$$

Let $X_1' = XC_1' \cup XR_1'$
Let XC_1' is the *ON* state are $X_3, X_4, X_7, X_9, X_{15}$ and in XR_1' the *ON* states are $D_6, D_{10}, D_{12}, D_{15}$.

Now considering each vector as *ON*.

$$X_1^1 = (0000000000000000) \cup (1000000000000000)$$

$$X_1^2 = (0010000000000000) \cup (0000000000000000)$$

$$X_1^3 = (0001000000000000) \cup (0000000000000000)$$

$$X_1^4 = (0001000000000000) \cup (0000010000000000)$$

$$X_1^5 = (0000001000000000) \cup (0000000000000000)$$

$$X_1^6 = (0000000010000000) \cup (0000000000000000)$$

$$X_1^7 = (0000000010000000) \cup (0000000001000000)$$

$$X_1^8 = (0000000010000000) \cup (00000000000010000)$$

$$X_1^9 = (0000000000000010) \cup (00000000000010010)$$

Now passing through the bi-matrix E to get the new bi-vector X_2 .

$$X_1^1 E = (0000000000000000) \cup (10010110)$$

$$\Rightarrow (0000000000000010) \cup (1000010001010010)$$

Row sum: (0,5)

$$X_1^2 E = (00001-100011-10000) \cup (0000000000000000)$$

$$\hookrightarrow (0000100001100000) \cup (0000000000000000)$$

Row sum: (3,0)

$$X_1^3 E = (1000001011000000) \cup (0000000000000000)$$

Row sum: (4,0)

$$X_1^4 E = (0000000000000000) \cup (0000110001010010)$$

Row sum: (0,4)

$$X_1^5 E = (1001000011000000) \cup (0000000000000000)$$

Row sum: (4,0)

$$X_1^6 E = (1001001000000000) \cup (0000000000000000)$$

Row sum: (3,0)

$$X_1^7 E = (0000000000000000) \cup (0001010001000000)$$

Row sum: (0,3)

$$X_1^8 E = (1001000011000000) \cup (1100110001010010)$$

Row sum: (0,7)

$$X_1^9 E = (0000000000000000) \cup (1100111001011010)$$

Row sum: (4,0)

Now new input vector $X_2' = XC_2' \cup XR_2'$

$$X_2' = (1000001011000000) \cup (1100111001011010)$$

$$X_2^1 = (1000000000000000) \cup (1000000000000000)$$

$$\begin{aligned}
 X_2^2 &= (0100000000000000) \cup (0000010001010010) \\
 &\quad (0100000000000000) \quad \text{Row sum: (0,4)} \\
 X_2^3 &= (0010000000000000) \cup X_2^7 E = (1001000011000000) \\
 &\quad (0000000000000000) \quad \cup (0000000000000000) \\
 X_2^4 &= (0001000000000000) \cup \quad \text{Row sum: (4,0)} \\
 &\quad (0000000000000000) \\
 X_2^5 &= (0000100000000000) \cup X_2^8 E = (1001001000000000) \\
 &\quad (0000100000000000) \quad \cup (0000000000000000) \\
 &\quad \text{Row sum: (3,0)} \\
 X_2^6 &= (0000000000000000) \cup X_2^9 E = (0110100000000000) \\
 &\quad (0000010000000000) \quad \cup (0001010001000000) \\
 &\quad \text{Row sum: (3,3)} \\
 X_2^7 &= (0000001000000000) \cup X_2^{10} E = (0000000000000000) \\
 &\quad (0000000000000000) \quad \cup (1100110001010010) \\
 &\quad \text{Row sum: (0,7)} \\
 X_2^8 &= (0000000010000000) \cup X_2^{11} E = (0000000000000000) \\
 &\quad (0000000000000000) \quad \cup (1100111001011010) \\
 &\quad \text{Row sum: (0,9)} \\
 X_2^9 &= (0000000001000000) \cup \quad \text{Now new input vector } X_3' = XC_3' \cup XR_2' \\
 &\quad (0000000001000000) \\
 X_2^{10} &= (0000000000000000) \cup X_3' = (1011101011100010) \\
 &\quad (00000000000010000) \quad \cup XR_2' \\
 X_2^{11} &= (0000000000000010) \cup X_3^1 = (1000000000000000) \\
 &\quad (0000000000000010) \quad \cup XR_2' \\
 \end{aligned}$$

Now passing through the bi-matrix E to get the new bi-vector X_3 .

$$\begin{aligned}
 X_2^1 E &= (0011001010000010) \\
 &\quad \cup (1000010001010010) \\
 &\quad \text{Row sum: (5,5)} \\
 X_2^2 E &= (0000100001100000) \\
 &\quad \cup (0100010001010010) \\
 &\quad \text{Row sum: (3,5)} \\
 X_2^3 E &= (0000100001100000) \\
 &\quad \cup (0000000000000000) \\
 &\quad \text{Row sum: (3,0)} \\
 X_2^4 E &= (1000001011000000) \\
 &\quad \cup (0000000000000000) \\
 &\quad \text{Row sum: (4,0)} \\
 X_2^5 E &= (0110000000100000) \\
 &\quad \cup (0000110001010010) \\
 &\quad \text{Row sum: (3,5)} \\
 X_2^6 E &= (0000000000000000)
 \end{aligned}$$

$$\begin{aligned}
 X_3^1 &= (1000000000000000) \\
 &\quad \cup XR_2' \\
 X_3^2 &= (0010000000000000) \\
 &\quad \cup XR_2' \\
 X_3^3 &= (0001000000000000) \\
 &\quad \cup XR_2' \\
 X_3^4 &= (0000100000000000) \\
 &\quad \cup XR_2' \\
 X_3^5 &= (0000100000000000) \\
 &\quad \cup XR_2' \\
 X_3^6 &= (0000000010000000) \\
 &\quad \cup XR_2' \\
 X_3^7 &= (0000000001000000) \\
 &\quad \cup XR_2' \\
 X_3^8 &= (0000000000100000) \\
 &\quad \cup XR_2' \\
 X_3^8 &= (0000000000000010) \\
 &\quad \cup XR_2'
 \end{aligned}$$

Now passing through the bi-matrix E to get the new bi-vector X_4 .

$$X_3^1 E = (0011001010000010)$$

$$\cup XR_2'$$

Row sum: (0,9)

$$X_3^2 E = (0000100001100000)$$

$$\cup XR_2'$$

Row sum: (3,9)

$$X_3^3 E = (1000001011000000)$$

$$\cup XR_2'$$

Row sum: (4,9)

$$X_3^4 E = (0110000000100000)$$

$$\cup XR_2'$$

Row sum: (3,9)

$$X_3^5 E = (1001000011000000)$$

$$\cup XR_2'$$

Row sum: (4,9)

$$X_3^6 E = (1001001000000000)$$

$$\cup XR_2'$$

Row sum: (3,9)

$$X_3^7 E = (0110100001000000)$$

$$\cup XR_2'$$

Row sum: (4,9)

$$X_3^8 E = (0110100000000000)$$

$$\cup XR_2'$$

Row sum: (3,9)

$$X_3^8 E = (0000000000000000)$$

$$\cup XR_2'$$

Row sum: (0,9)

Repeating the above process we get

$$X_4' = (1011101011100010)$$

$$\cup (1100111001011010)$$

$$X_5' = (1011101011100010)$$

$$\cup (1100111001011010) = X_4'$$

According to the IFCRMs method when the same threshold value occurs twice, the value is considered as the fixed point and the iteration and also the calculation gets terminated. Similarly we consider all the different input vectors on and find the hidden patterns for this IFCRMs model which are shown in table 3.

TABLE III. INDUCED PATTERN FOR E BY IFCRMS

Node	Input Vector	Limit Points	Induced Path
1	(1000000000000000)	(1000001011000000) \cup $\{(1100111001011010) (11010011)\}$	($C_1 \rightarrow C_4 \rightarrow C_1 \rightarrow C_4$) \cup ($D_1 \rightarrow D_{15} \rightarrow D_{15}$)
2	(0100000000000000)	(0110100000000000) \cup $\{(1100111001011010) (11010011)\}$	($C_2 \rightarrow C_{11} \rightarrow C_{11}$) \cup ($D_2 \rightarrow D_{15} \rightarrow D_{15}$)
3	(0010000000000000)	(0110100000000000) \cup $\{(0011011101101111) (00011001)\}$	($C_3 \rightarrow C_1 \rightarrow C_{11} \rightarrow C_4$) \cup ($D_3 \rightarrow D_3$)
4	(0001000000000000)	(0011001010000010) \cup $\{(1001010111101101) (00100110)\}$	($C_4 \rightarrow C_1 \rightarrow C_1$) \cup ($D_4 \rightarrow D_9 \rightarrow D_9$)
5	(0000100000000000)	(0110100000000000) \cup $\{(1100111001011010) (11010011)\}$	($C_5 \rightarrow C_{11} \rightarrow C_{11} \rightarrow C_4$) \cup ($D_5 \rightarrow D_{15} \rightarrow D_{15}$)
6	(0000010000000000)	(0000110100000101) \cup $\{(1100111001011010) (11010011)\}$	($C_6 \rightarrow C_{12} \rightarrow C_8 \rightarrow C_{12}$) \cup ($D_6 \rightarrow D_{15} \rightarrow D_{15}$)
7	(0000001000000000)	(1000001011000000) \cup $\{(0011011101101111) (00011001)\}$	($C_7 \rightarrow C_1 \rightarrow C_1$) \cup ($D_7 \rightarrow D_3 \rightarrow D_3$)
8	(0000000100000000)	(0000110100000101) \cup $\{(1001010111101101) (00100110)\}$	($C_8 \rightarrow C_{12} \rightarrow C_{12}$) \cup ($D_8 \rightarrow D_9 \rightarrow D_9$)
9	(0000000010000000)	(0011001010000010) \cup $\{(1001010111101101) (00100110)\}$	($C_9 \rightarrow C_1 \rightarrow C_1$) \cup ($D_9 \rightarrow D_9$)
10	(0000000001000000)	(0110000000000000) \cup $\{(1001010111101101) (00100110)\}$	($C_{10} \rightarrow C_5 \rightarrow C_5 \rightarrow C_4$) \cup ($D_{10} \rightarrow D_{19} \rightarrow D_9$)

11	(00000000000100000)	$(0110000000100000) \cup$ $\{(1001010111101101) (00100110)\}$	$(C_{11} \rightarrow C_5 \rightarrow C_5) \cup (D_{11} \rightarrow D_3$ $\rightarrow D_9)$
12	(0000000000010000)	$(0000110100000101) \cup$ $\{(1100111001011010) (11010011)\}$	$(C_{12} \rightarrow C_8 \rightarrow C_{12}) \cup (D_{12}$ $\rightarrow D_{15}$ $\rightarrow D_{15})$
13	(0000000000001000)	$(0000110100000101) \cup$ $\{(0001110101011111) (01100011)\}$	$(C_{13} \rightarrow C_8 \rightarrow C_{12} \rightarrow C_8)$ $\cup (D_{13}$ $\rightarrow D_{13})$
14	(0000000000000100)	$(0000110100000101) \cup$ $\{(0001110101011111) (01100011)\}$	$(C_{14} \rightarrow C_{12} \rightarrow C_8 \rightarrow C_{12}) \cup$ $(D_{14} \rightarrow D_{13} \rightarrow D_{13})$
15	(0000000000000010)	$(0000000000000000) \cup$ $\{(0001110101011111) (01100011)\}$	$(C_{15}) \cup$ $(D_{15} \rightarrow D_{13} \rightarrow D_{13})$
16	(0000000000000001)	$(0110000000100000) \cup$ $\{(0001110101011111) (01100011)\}$	$(C_{16} \rightarrow C_5 \rightarrow C_5) \cup$ $(D_{16} \rightarrow D_{13} \rightarrow D_{13})$

The above table helps us to study the triggering patterns of a particular node which are in *ON* state when the remaining nodes are in *OFF* state.

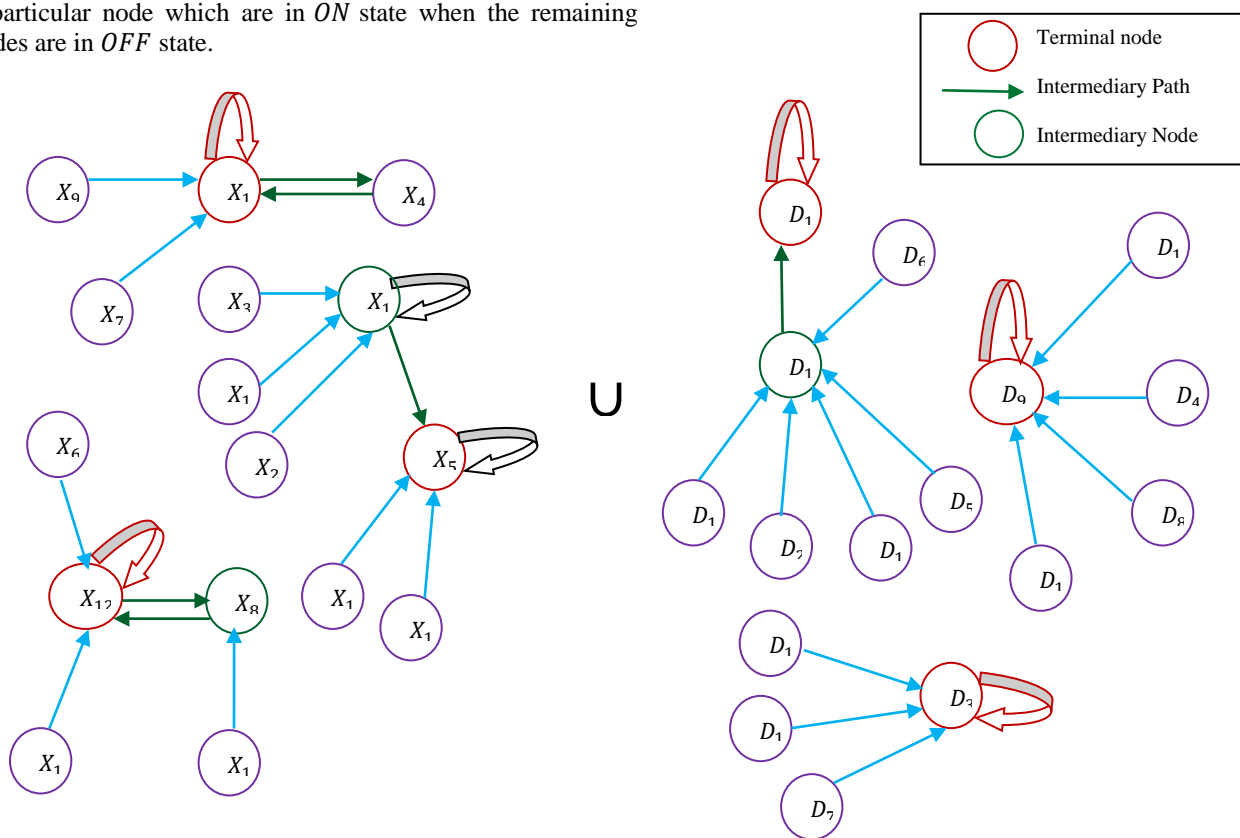


Fig. 2. Induced graph on directed bi-graph

The interrelationship between the nodes of the above diagram states that X_1 (pay with allowances and bonus to the employee), X_5 (average performance) and X_{12} (loss to the industry) is terminal node and X_{11} (neither profit nor loss to the industry), X_8 (employee works less number of hours) is the intermediary node of this discussed problem. Similarly D_{13} (opportunity for advancement), D_9 (status of the employee), D_3 (good inter personal relationship) and D_{15} (growth) are the intermediary nodes.

VIII. COMPARISONS BETWEEN FCRMS MODEL AND IFCRMS MODEL

FCMs have several advantage on various fuzzy model. The main advantage of this method is easy to handle and based on expert's opinion. It also helps to work when the data is unsupervised. This fuzzy model help us to find out the hidden pattern of any type of given problem in any situation. Although this FCMs method are so simple and unique, it has some limitation also. First, this model consists of lengthy procedure for calculation when the matrices has higher number of rows and columns. Second, the manual calculation is fully based on Expert's opinion which may lead the personal bias. According to FCRMs bi-model, the experts choose certain vectors on *ON* state and others are *OFF* state. If we have chosen many vectors as *ON* state at the input level, the resultant vector will have two many 1s as on *ON* state. There is no specific criteria or framework laid down to guide the experts while choosing the input vectors. To avoid this problem, IFCMs model predicates the appropriate results when comparing with FCRMs model. There are many advantages of IFCRMs model over FCRMs model.

1) Each vector is given its due importance by keeping it *ON* state.

2) The impact of all attributes are gathered into one induced bi-graph for the final analysis.

In the process it is possible to detect the interrelationship between the attributes and how one influences the other while reaching the equilibrium state.

The fixed point obtained will include the impact of all the mentioned attributes and the interpretation of the results will be complete solution rather than partial solution.

IX. CONCLUSION

In this section we have discussed employee--employer relationship which are evolved through IFCRMs method. The above discussed algorithm of the given problem focussed on the node that X_1 , X_5 and X_{12} which play role of fixed point and X_2 (only pay to the employee), X_3 (pay with allowance (or bonus) to the employee), X_4 (best performance), X_5 (average performance), X_7 (employee works more number of hours), X_9 (maximum profit to the industry), X_{15} (good relation between employee and employer), X_{16} (demand of the employee which is not fulfilled) are the major factor of this relationship. Similarly for the FRMs model D_3 , D_9 , D_{13} play role of fixed point and R_4 (structure work condition), R_5 (reward to the employee who are loyal to the organization), R_8 (good relationship of manager with other employees), R_3 (linked rewards and benefits to fulfilling job requirement), R_6 (Provide

opportunities for employee to develop technical skill), R_7 (achievement of the industry), R_2 (reinforce the need to follow organization policies and practice) are the major factors of this relationship. To increase strong employer employee relations in an any industry they should follow some remedial measures which are discussed in below:

1) Strong employment relations create a pleasant atmosphere within the work environment; its increase the employee motivation. Companies that have invested into employee relations programs have experienced increase in the productivity and therefore the increased productivity leads to increase in profits for the industry.

2) Creating the productive and pleasant work environment has a drastic effect on an employee's loyalty to the business; it encourages a loyal workforce. Having such workforce improves employee retention.

3) When a work environment is efficient and friendly, the extent of conflict within the workplace is reduced. Less conflict results in the employees being able to concentrate on the tasks at hand and they are therefore more productive.

4) Employer always motivate their employee through encouragement and incentives. It is known throughout all levels of management that happy employee make productive employees.

5) When creating a work environment with a an effective communication network there is one key factor i.e. employer's always keep their door open. Maintaining an open channel of communication will solve the problems quickly, which is beneficial for quick resolution.

6) Most employers aren't into equality as they would like to believe they are. But by embracing equality for all employees will create a fair and equal workplace environment for all. If every employee feels equal and important they are more likely to work harder and be more productive.

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