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Adaptation of Induced Fuzzy Cognitive Maps to the Problems Faced By the Farmers in Sriperumbudur Taluk Kanchi District

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Abstract - Agriculture is the backbone of Indian economy and it is an important primary activity. In this research we investigates how the rapid economic growth in services, industrial output, and non-agricultural sectors in Kancheepuram districts between 2000 to 2010 affects the growth of agriculture and the farmers, which in turn made them to drop their occupation(agriculture) in sriperumbudur, kancheepuram district. We analyze this problem using Induced Fuzzy Cognitive Maps (IFCMs). IFCMs are a fuzzy-graph modeling approach based on expert's opinion.

Keywords: Induced fuzzy Cognitive Maps (IFCMS), Gross Domestic Product, Irrigation, Real estates, unsupervised

I. INTRODUCTION

The earliest human civilization is developed in large river valleys. Agriculture is the key development that led to rise of these civilizations. Agriculture is an important primary activity. Here humans do not merely collect from nature but work with nature to produce their food. Agriculture includes preparation of land, seeding, irrigation, development of hybrid varieties etc in order to grow food to support large populations. Agriculture is the set of activities that transform the environment for the production of animals and plants for human use. A 2003 analysis of India's agricultural growth from 1970 to 2001, by Food and Agriculture Organization of the United Nations, identified systemic problems in Indian agriculture. For food staples, the annual growth rate in production during the six-year segments 1970-76, 1976–82, 1982–88, 1988–1994, 1994-2000 were found to be respectively 2.5, 2.5, 3.0, 2.6, and 1.8 % per annum. The low growth rates may constitute in part a response to inadequate returns to Indian farmers. The GDP share of agriculture has fallen from 43 to 16 %. This isn't because of reduced importance of agriculture, or a consequence of agricultural policy. This is largely because of the rapid economic growth in services, industrial output, and non-agricultural sectors in India between 2000 to 2010. Kancheepuram district is situated on the North East coast of Tamil Nadu. Agriculture is the main occupation of the people with 47% of the population engaged in it. Paddy is the major crop cultivated in this district.

Groundnuts, Sugarcane, Cereals & Millets and Pulses are the other major crops cultivated. 76.50 Metric Tonnes lands are cultivated in Fuel wood and 8.039 Tonnes in Cashew. Palar river along with Tanks and wells are the main sources of irrigation in this district. Major factors that affect agricultural diversity and distribution are climate, landforms, soils, availability of water and labour.Climatic factors like temperature and rainfall affect agriculture. Moisture availability determines the type of crop and the growing season. The seasonality of rainfall is important.

Crops require adequate rain for their growth but the timing of the rain affects crops differently. Seasonal variation of rainfall is important as different crops require water at different times. The amount of rainfall determines the types of crops grown in an area. Rice is grown wherever the rainfall is abundant, while millets grown in the drier regions. Where rainfall is inadequate or unreliable, irrigation is necessary for agriculture. Sriperumbudur taluk in kancheepuram district once contributed 20% in the production of rice but today Sriperumbudur is well-known for industries and Apartments. Many farm lands have been converted as plots and flats. Many tanks and lakes were encroached by industries. Due to this factor the farmers have dropped their traditional work farming and have turned as daily coolies. This paper has four sections. Introductory part is given in section one. In section two we recall the definition of Fuzzy Cognitive Maps, Induced Fuzzy Cognitive Maps and its properties. Section Three is devoted to the adaptation of the Induced Fuzzy Cognitive Maps to the Farmers. In section four we give the conclusion based on our study.

II. FCMS AND INDUCED FCMS

2.1 Basic Notions of Fuzzy Cognitive Maps

Fuzzy Cognitive Maps are techniques that attempt to depict and analyze the cognitive process of human thinking and human behavior on specific domains by creating models. These models are represented assigned directed graphs of concepts and by various casual relationships that exist between the concepts. In 1976 Axelrod proposed cognitive maps as a formal tool for decision-making. He used the matrix representation of the directed graph to represent and study the social scientific knowledge. In 1986 Kosko proposed FCMs based on the cognitive maps structure. In thus section we recall the notion of Fuzzy Cognitive Maps (FCMs), which was introduced by Bart Kosko in the year 1986.FCMs have major role to play mainly when the data concerned is an unsupervised one. Further this method is most simple and an effective one as it can analyze the data by directed graphs and connection matrices.

Definition2.1.1
An FCM is a directed graph with concepts like policies, events etc. as nodes and causalities as edges. It represents casual relationship between concepts.

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If increase (or decrease) in one concept, leads to increase (or decrease) in another, then give the value 1.

If there exists no relation between two concepts, then the value 0 is given. If increase (or decrease) in one causalities decreases (or increases) the other, then give the value -1.Thus FCMs are described in this way.

Definition 2.1.2
When the nodes of the FCM are fuzzy sets then they are called as fuzzy nodes.

Definition 2.1.3
FCMs with edge weights or causalities from the set {-1,0,1},are called simple FCMs.

Definition 2.1.4
Consider the nodes or concepts $C_1,\ldots,C_n$ of thee FCM. Suppose the directed graph is 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 the adjacency matrix of the FCM.

It is important to note that all matrices associated with an FCM are always square matrices with diagonal entries as zero.

Definition 2.1.5
Let $C_1, C_2, ..., C_n$ be the nodes of an FCM. $A = (a_1, a_2, ..., a_n), where\ a_i \in \{0,1\}$. A is called the instantaneous state vector and it denotes the on-off position of the node at an instant.

$$a_i = \begin{cases} 0 \text{ if } a_i \text{ is OFF} \\ 1 \text{ if } a_i \text{ is ON, where i} = 1,2,...n. \end{cases}$$

Definition 2.1.6
Let $C_1, C_2, ..., C_n$ be the nodes of an FCM. Let $\overline{C_1C_2}, \overline{C_2C_3}, ..., \overline{C_iC_j}$ be the edges of the FCM ($i \neq j$).then, the edges from a directed cycle. An FCM is said to be cyclic if it possesses a directed cycle. An FCM is said to be acyclic if it does not possess any directed cycle.

Definition 2.1.7
An FCM with cycles is said to have a feedback.

Definition 2.1.9
Let $\overline{C_1C_2}, \overline{C_2C_3}, ..., \overline{C_iC_j}$ be a cycle. When 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.

Definition 2.1.10
If the equilibrium state of dynamical system is a unique state vector, then it is called a fixed point.

Example
Consider a FCM with $C_1, C_2, ..., C_n$ as nodes. For example, let us start the dynamical system by switching ON C_1.Let us assume that that FCM settles down with C_1 and C_n ON that is ,the state vector remains as (1,0,0,….,0,1).This state vector (1,0,0,…,0,1) is called the fixed point.

Definition 2.1.11
If the FCM settles down with a state vector repeating in the form $A_1 \to A_2 \to A_3 ..... \to A_i ... \to A_1$,
Then this equilibrium is called a limit cycle.

Definition 2.1.12
We denote the combined FCM adjacency matrix by $E = E_1 + E_2 + ...E_p$.
Finite number of FCMs can be combined together to produce the joint effect of all the FCMs. Let $E_1, E_2, ...E_p$ be adjacency matrices of the FCMs with nodes $C_1, C_2, ..., C_n$ then the combined FCM is got by adding all the adjacency matrices $E_1, E_2, ...E_p$.

Notation
Suppose $A = (a_1, ..., a_n)$ is vector which is passed into a dynamical system E. Then $AE = (a_1', ...a_n')$. after thresholding and updating the vector suppose we get $(b_1, ..., b_n)$, we denote that by $(a_1', ...a_n') \hookrightarrow (b_1, ..., b_n)$. Thus, the symbol '↪' means the resultant vector has been threshold and updated.

2.2 Algorithmic Approach in Induced Fuzzy Cognitive Maps (IFCMs)

Even though IFCM is an advancement of FCM it follows the foundation of FCM, it has a slight modification only in Algorithmic approaches. To derive an optimistic solution to the problem with an unsupervised data, the following steps to be followed:

Step 1: For the given model (problem), collect the unsupervised data that is in determinant factors called nodes.
Step 2: According to the expert opinion, draw the directed graph.
Step 3: Obtain the connection matrix, M_1, from the directed graph (FCM). Here the number of rows in the given matrix = number of steps to be performed.
Step 4: Consider the state vector C_1.by setting C_1 in ON position that is assigning the first component of the vector to be 1 and the rest of the components as 0. Find $C_1 \times M$. The state vector is updated and threshold at each stage.
Step 5: Threshold value is calculated by assigning 1 for the values > 0 and 0 for the values < 1. The symbol '↪' represents the threshold value for the product of the result.
Step 6: Now each component in the C_1 vector is taken separately and product of the given matrix is calculated. The vector which has maximum number of one's is found. The

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vector with maximum number of one's which occurs first is considered as C_2.

Step 7: When the same threshold value occurs twice. The value is considered as the fixed point. The iteration gets terminated.

Step 8: Consider the state vector C_1 by setting C_2 in ON state that is assigning the second component of the vector to be 1 and the rest of the components as 0. Proceed the calculations discussed in Steps 4 to 6.

Step 9: Continue Step 9 for all the state vectors and find hidden pattern.

III. ADAPTATION OF INDUCED FUZZY COGNITIVE MAPS TO THE PROBLEMS FACED BY THE FARMERS IN KANCHEEPURAM DISTRICT, TAMIL NADU, INDIA.

We have made a sample survey of around 60 farmers resides at sriperumbudur taluk in kancheepuram district, Tamil Nadu.They were interviewed using a questionnaire and some research papers relevant to the topic. According to their views, some of the factors as indicators are considered for our studies are given as follows:

C_1 = Lack of knowledge in adapting new techniques in agriculture due to Illiteracy

C_2 = Low profit per unit area

C_3 = Due to the growth of real estates that results in land encroachments in tanks and canals This in turn affects the irrigation process for agriculture.

C_4 = Growth of industrialization pollutes the water which affects the yield of paddy per unit Area.

C_5 = Due to over usage of underground water for apartments and industries, encroachments, Lack of rainfall and improper maintenance of tanks and canals leads to water scarcity.

C_6 =Poverty

C_7 = less wages and industrial growth leads to lack of manual labors.

C_8 = Price hike in fertilizers, pesticides, electricity bill (for usage of pumps and motors) and Transports.

3.1 The Directed Graph Related to the Problems faced by the Farmers

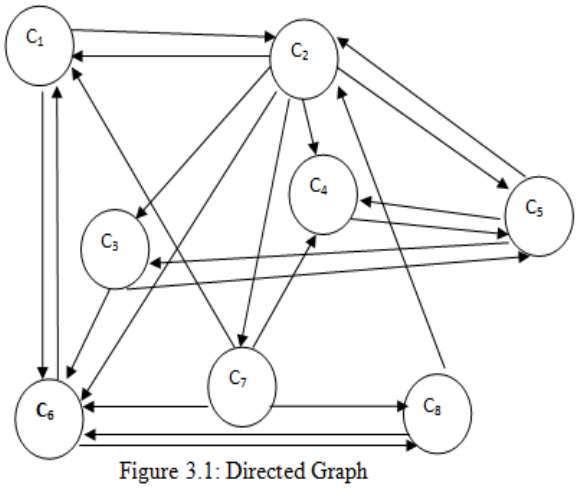

Figure 3.1: Directed Graph

3.2 Implementation of IFCMs Model to the study

Based on the expert's opinion, the directed diagram is drawn and the corresponding connection matrix is

$$M = \begin{pmatrix} 0 & 1 & 0 & 0 & 0 & 1 & 0 & 0 \\ 1 & 0 & 1 & 1 & 1 & 1 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 1 & 1 & 1 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \\ 1 & 0 & 0 & 1 & 0 & 1 & 0 & 1 \\ 0 & 1 & 0 & 0 & 0 & 1 & 0 & 0 \end{pmatrix}$$

Now using the matrix M we determine the problems. Let us start Illiteracy is taken as the ON state and all the other nodes are in the OFF state.

(i.e) C_1 = (1 0 0 0 0 0 0 0)

Product of C_1 and M is calculated.

C_1M = (0 1 0 0 0 1 0 0)

↪(1 1 0 0 0 1 0 0) = C_1'

Threshold value is calculated by assigning 1 for the values > 1 and 0 for the values < 0. The symbol ↪ represents the threshold value for the product of the result.

Now as per Induced Fuzzy Cognitive Map methodology, each component in the C_1' vector is taken separately and product of the given matrix is calculated. The vector which has the maximum number of one's which occur first is considered as C_2.

The symbol ~ denotes the calculation performed with the respective vector, here C_1'

C_1' X M = (1 0 0 0 0 0 0 0)M=(0 1 0 0 0 1 0 0)

C_1' X M = (0 1 0 0 0 0 0 0)M =(1 0 1 1 1 1 1 0)

C_1' X M = (0 0 0 0 0 1 0 0) M = (1 0 0 0 0 0 0 1)

Therefore C_2=(1 0 1 1 1 1 1 0)

Now Product of C_2 and M is calculated

C_2 X M=(1 0 1 1 1 1 1 0)M=(2 2 1 2 2 3 0 2)

↪ (1 1 1 1 1 1 0 1) = C_2'

C_2' X M = (1 0 0 0 0 0 0 0)M=(0 1 0 0 0 1 0 0)

C_2' X M = (0 1 0 0 0 0 0 0)M=(1 0 1 1 1 1 1 0)

C_2' X M = (0 0 1 0 0 0 0 0)M=(0 0 0 0 1 1 0 0)

C_2' X M = (0 0 0 1 0 0 0 0)M=(0 0 0 0 1 0 0 0)

C_2' X M = (0 0 0 0 1 0 0 0)M=(0 1 1 1 0 0 0 0)

C_2' X M = (0 0 0 0 0 1 0 0)M=(1 0 0 0 0 0 0 1)

C_2' X M = (0 0 0 0 0 0 0 1)M=(0 1 0 0 0 1 0 0)

Therefore C_3=(1 0 1 1 1 1 1 0) $=C_2$.

When the same threshold value occurs twice, the value is considered as the fixed point. The iteration gets terminated and the calculation gets terminated. Likewise any state vector can be taken and its effect can be analyzed. Therefore the fixed point is C_3=(1 0 1 1 1 1 1 0) and the triggering pattern is $C_1 \rightarrow C_2 \rightarrow C_2$ when the first attribute is kept in ON state. The

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following table gives when other attributes are kept in ON state consecutively.

Table 3.1 Induced Patterns for M by IFCMs

NUMBER	ATTRIBUTE IN ON STATE	TRIGGERING PATTERN
Step 1	C_1;(1 0 0 0 0 0 0 0)	$C_1 \rightarrow C_2 \rightarrow C_2$
Step 2	C_2;(0 1 0 0 0 0 0 0)	$C_2 \rightarrow C_2$
Step 3	C_3;(0 0 1 0 0 0 0 0)	$C_3 \rightarrow C_5 \rightarrow C_5$
Step 4	C_4;(0 0 0 1 0 0 0 0)	$C_4 \rightarrow C_5 \rightarrow C_7 \rightarrow C_2 \rightarrow C_2$
Step 5	C_5;(0 0 0 0 1 0 0 0)	$C_5 \rightarrow C_2 \rightarrow C_2$
Step 6	C_6;(0 0 0 0 0 1 0 0)	$C_6 \rightarrow C_1 \rightarrow C_7 \rightarrow C_2 \rightarrow C_2$
Step 7	C_7;(0 0 0 0 0 0 1 0)	$C_7 \rightarrow C_7$
Step 8	C_8;(0 0 0 0 0 0 0 1)	$C_8 \rightarrow C_2 \rightarrow C_2$

IV. CONCLUSION

In this section we have summarized the major findings in section three using IFCMs. While analyzing with IFCMs we observe that when Illiteracy is in ON state the triggering pattern are $C_1 \rightarrow C_2 \rightarrow C_2$ i.e. the resultant vector is (1 0 1 1 1 1 1 0). We have observed that when any one of the problems faced by the farmers (attributes) is switched onto ON state, C_2 goes to ON state. We observe that the effects of other attributes always lead to the low profit per unit area which ultimately makes the farmer to discontinue cultivation. The Induced FCM method clearly highlights the interrelationship between the attributes to the causes and the problems faced by the farmers.

We notice in the cycles that lead to attribute C_2, namely low profit from agriculture are emanating from C_1, C_5, C_7 and C_8 namely lack of knowledge to adapt to new situations and techniques, dried up water resources, higher salary from industrial sectors than farming sectors leading to lack of labourers and ever raising price of fertilizers respectively. From the result it is easy to observe that growth in industrialization and real estate's affects the irrigation for agriculture and also due to encroachment in tanks and canals leads to water scarcity. Illiteracy and poverty are also the major problems to the farmers. The Government should adapt new agricultural policies and should give importance to the welfare of the farmers and in the growth of agriculture.

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