On the Health Hazards of the Sugarcane Using IFRM Model

T. Pathinathan¹, S. Johnson Savarimuthu²
¹Department of Mathematics, Loyola College, Chennai, India
²Department of Mathematics, St. Joseph’s College, Cuddalore, India
Email: johnson22970@gmail.com

Abstract: In this paper, we use Induced Fuzzy Relational Mappings (IFRM) to analyze the problem of health hazards faced by the sugarcane cultivators due to chemical pollution. Based on our study, we made conclusions and suggest some remedial measures.

Keywords: Health Hazards, FRM, IFRM, Fixed Point, Limit Cycle, Hidden Pattern

I. INTRODUCTION

Fuzzy Models are mathematical tools. They have been introduced to study and analyze political decisions, neural networks, social problems etc., [1,2,6]. Among the various fuzzy models, some of the important models which have been used to study these problems are Fuzzy Associative Memories (FAM), Fuzzy Cognitive Maps (FCM), Fuzzy Relational Maps (FRM) and Bi-directional Associative Memories (BAM) [3,4]. The FRM model was introduced because this model is more applicable when the data in the first place is an unsupervised one. It is used to model several types of problems varying from gastric appetite behavior, popular political development etc. It is also used to model in robotics like plant control. This model works on the opinion of experts. These models have been used to study various social problems. In particular, the problem of health hazards caused by chemical industries, the causes for school dropouts which ultimately lead to child labour have been studied in the literature. In order to bring out much stronger relationship among the attributes, a new model called Induced Fuzzy Relational Maps (IFRM) was proposed [5].

Many agriculture labourers are affected by health hazards due to chemical pollutants. As most of the chemicals applied for the eradication of pests and different diseases can cause serious health hazards, it will be wiser to plant variety of crops that can resist diseases and pests. Pesticides are particularly hazardous for farmers and farm workers. There are no comprehensive systems for tracking pesticide illnesses, and research shows that farmers and farm workers face risks of both short-term poisonings and long-term illness. Pesticides can be dangerous if they are working in fields that have been treated or sprayed with them or when handling and applying them. Pesticides can enter our body in many ways. Simple contact through skin and clothes is one of the main ways that chemicals enter our body. Another way is through breathing mist, dust, fumes or smoke containing pesticides and chemicals. In this paper, we use Induced Fuzzy Relational Mappings (IFRM) to analyze the problem of health hazards faced by the agricultural labourers especially the sugarcane cultivators due to chemical pollution. In order to make an analysis of these we have taken sample study from fifteen villages in Cuddalore district. The data was gathered from these people by using a linguistic questionnaire and this linguistic questionnaire consisting of casual associations was transformed into a fuzzy data. Based on our study, we made conclusions and suggest some remedial measures. This paper has been organized as follows: After giving the introduction in section 1, we give the basic notions and definitions relevant to this paper in section 2. The description of the problem is given in Section 3 and in section 4 we analyze the problem using IFRM. In section 5 we draw the conclusions from our study and propose remedial measures.

II. FUZZY RELATIONAL MAPS (FRM)

Initially the casual associations are divided into two disjoint units. To define a Fuzzy Relational map these two disjoint units are taken as a domain space and a range space. Here the term disjoint we mean the sense of concepts which we have taken. Further it is assumed that no intermediate relations exist among the domain elements itself and within the elements of the range space. In general, the number of elements in the range space need not be equal to the number of elements in the domain space. In this discussion, the elements of the domain space are taken from the real vector space of dimension n and that of the range space are from the real vector space of dimension m. That is, m ≠ n. These domain space and the range space is denoted by D and R respectively. Thus D= [D₁, D₂, …., Dₙ] is the domain space, where each Dᵢ=[(x₁, x₂, …., xₙ)/xᵢ=0 or 1], for i=1,2, …., n. Similarly R= [R₁, R₂, …., Rₘ] is the range space, where Rᵢ=[(x₁, x₂, …, xₙ)/xᵢ=0 or 1], for i=1,2, …., m.

A. Definition

A FRM is a directed graph or a map from D to R with concepts like policies or events etc., as nodes and causalities as edges. It represents casual relations between spaces D and R. Let Di and Rj denote the two nodes of a FRM. The directed edge from D to R denotes the causality of D on R, called relation. Every edge in the FRM is weighted with the number from the set [0,1]. Let eᵢⱼ be the weight of the edge Dᵢ,Rⱼ, eᵢⱼЄ [0,1].

The weight of the edge Dᵢ,Rⱼ = 1 if increase in Dᵢ implies increase in Rⱼ or decrease in Di implies decrease in Rⱼ and that of Dᵢ,Rⱼ=0 if Dᵢ does not have any effect on Rⱼ. The cases when increase in Di implies decrease in Rⱼ or decrease in Di implies increase in Rⱼ are not taken here for discussion.

B. Definition

If the nodes of the Fuzzy Relational Mappings are fuzzy sets, then they are called fuzzy nodes.
C. Definition
If the edge weights of Fuzzy Relational Mappings are only \([0,1]\), then they are called simple Fuzzy Relational Mappings.

D. Definition
Let \(D_1,\ldots,D_n\) be nodes of the domain space \(D\) and let \(R_1,\ldots,R_m\) be the nodes of the range space \(R\) for a Fuzzy Relational Mapping. The relational matrix \(M\) for this Fuzzy Relational Mapping model is defined as \(M=(e_{ij})\) where \(e_{ij}\) is the weight of the directed edge \(D_iR_j\) (or \(R_jD_i\)). Let \(A = (a_1,\ldots,a_n)\), \(a_i \in \{0,1\}\). \(A\) is called the instantaneous state vector of the domain space and it denotes the ON-OFF position of the nodes at any instant. Similarly let \(B = (b_1,\ldots,b_m)\), \(b_i \in \{0,1\}\). \(B\) is called the instantaneous state vector of the range space and it denotes the ON-OFF position of the nodes at any instant. For any \(i\), \(a_i = 0\) or \(1\) if \(a_i\) is ON or OFF respectively, \(i=1,\ldots,n\). Similarly \(b_j = 0\) or \(1\) if \(b_j\) is ON or OFF respectively, \(j=1,\ldots,m\).

E. Definition
Feedback in FRM - A Fuzzy Relational Mapping with cycles is said to have a feedback.

F. Definition
Dynamical System - If there is a feedback in the Fuzzy Relational Mapping, that is, if there are casual relations flow through a cycle in a revolutionary manner, then we say Fuzzy Relational Mapping model is said to be dynamic.

G. Definition
Hidden Pattern - Let \(D_iR_j\) (or \(R_jD_i\)), \(1 \leq j \leq m\), \(1 \leq i \leq n\). when \(R_j\) (or \(D_i\)) is switched ON and if causality flows through edges of the cycle and if it again causes \(R(D_i)\), then it is said that the dynamical system goes round and round. This is true for any node \(R_j\) (or \(D_i\)) for \(1 \leq j \leq m\), \(1 \leq i \leq n\). the equilibrium state of this dynamical system is called the hidden pattern.

H. Definition
Fixed point - If the equilibrium state of the dynamical system is a unique state vector, then it is called a fixed point. Consider a FRM with \(R_1,\ldots,R_m\) and \(D_1,\ldots,D_n\) as nodes. For example, start the dynamical system by switching on \(R_1\) or \(D_1\). Also assume that the FRM settles down with \(R_1\) and \(R_m\) (or \(D_1\) and \(D_n\)) ON, that is, the state vector remains as \((1,0,\ldots,0)\) in \(R\) (or \((1,0,\ldots,0)\) in \(D\)), this state vector is called the fixed point.

I. Definition
Limit cycle - If a Fuzzy Relational Mapping settles down with a state vector repeating in the form \(A_1, A_2,\ldots, A_i\) (or \(B_1, B_2,\ldots, B_j\)), then this equilibrium is called a limit cycle. Determination of hidden pattern: Let \(R_1,\ldots,R_m\) and \(D_1,\ldots,D_n\) be the nodes of a FRM with feedback. Let \(M\) be the relational matrix. Find a hidden pattern when \(D_1\) is switched ON, that is, when an input is given as vector \(A_1 = (1000\ldots0)\) in \(D\) the data should pass through the relational Matrix \(M\). This is obtained by multiplying \(A_1\) with the relational matrix \(M\). Let \(A1M = (f_1,\ldots,f_n)\).

After teresholding and updating the resulting vector \(A_1M\), we get a vector \(B\). Now we pass on \(B\) into \(M^T\) to obtain \(BM^T\). We update and threshold the vector \(BM^T\) so that the thresholded \(BM^T\) is equal to \(D\). This procedure is repeated till we get a limit cycle or a fixed point.

III. DESCRIPTION OF THE PROBLEM
Sugarcane is the most cultivated crop in Tamilnadu. Sugarcane is used as a main grocery in many types of food. The cultivation of sugarcane is done mainly by the farmer belonging to the southern region. Unfortunately lot of risk factor is involved in the cultivation of sugarcane. During the process of cultivation, the farmers are affected by many health hazards and these diseases are taken as the attributes for the domain space of the IFRM model and the process of cultivation of sugarcane has different stages. The different types of works at different stages are taken as the attributes for the range space of a IFRM model.

Thus the attributes for the domain space \(D\) are:

- \(D_1\): Asthma
- \(D_2\): Dermatitis
- \(D_3\): Respiratory distress
- \(D_4\): Nasal discharges
- \(D_5\): Pneumonia
- \(D_6\): Insect bites
- \(D_7\): Snake bites
- \(D_8\): Fever
- \(D_9\): Irritation in Eye
- \(D_{10}\): Dust allergy
- \(D_{11}\): Wound injuries
- \(D_{12}\): Inhalation of toxic pesticides

The attributes for the range space \(R\) are:

- \(R_1\): Pudding
- \(R_2\): Adding minerals before planting
- \(R_3\): Plantation of sugarcane transplants
- \(R_4\): Adding chemical fertilizer
- \(R_5\): Removal of weeds
- \(R_6\): Protecting the sugarcane plants from other animals
- \(R_7\): Controlling microbial diseases
- \(R_8\): Harvesting
- \(R_9\): Transportation to sugar mills
- \(R_{10}\): Burning of weeds

Expert opinion is obtained through some relationship between the set of diseases and the different types of works at different stages. The concepts in the domain space are taken as \(D_1,\ldots,D_{12}\) and the attributes in the range space are taken as \(R_1,\ldots,R_{10}\) and thus the connection matrix is given as follows:

![Figure:1](image-url)
IV. ANALYSIS USING INDUCED FRM

Let $R_1, \ldots, R_m$ and $D_1, \ldots, D_n$ be the nodes of a FRM with feedback. Let $M$ be the relational matrix. The hidden pattern of an IFRM when $D_1$ is switched on is obtained as follows. Initially, pass the state vector $C_1$ through the connection matrix $M$. A particular attribute, say, $D_1$ is kept on ON state and all other components are kept off. Let $C_1M$ yield $C_1'$, to convert this into a signal function, choose the first two highest values to ON state and other values to OFF state with 1 and 0 respectively. Now allow each component of the vector $C_1'$ through $M$ repeatedly for each positive entry 1 and the symbol → is used to convert into signal function. Then choose a vector which contains the maximum number of 1’s. That is, a vector which causes the maximum number of attributes to ON state, then choose the first vector as $C_2$. If two or more vectors with maximum number of 1’s are on ON state, then choose the first vector as $C_2$. Repeat the same procedure for $C_2$ 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 vectors into ON state. Thus the hidden pattern either from the limit cycle or from the fixed point is obtained. One can observe a pattern which leads one to another and it ends up, may be in one vector or a cycle. Next choose the vector by keeping the second component on ON state and repeat the same procedure to get another cycle and select for all the vectors separately. The hidden pattern of some on the health hazards of the sugarcane cultivators using IFRM Model 7 vectors found in all or in many cases is observed. Inference from this hidden pattern summarizes or highlights the causes.

Let the input be

$C_1 = (1 0 0 0 0 0 0 0 0 0 0 0 0)\\
\text{Now } (1 0 0 0 0 0 0 0 0 0 0 0 0)\\
\rightarrow (1 1 0 0 1 1 1 1 0 0)\\
(1 1 0 0 1 1 1 1 0 0)$

$M' = (6 2 5 5 5 2 2 4 5 2 3 2)\\
\rightarrow (1 0 1 1 1 1 0 0 1 0 0 0 0) = C_2$

The new vectors are $C_2^1 = (1 0 0 0 0 0 0 0 0 0 0 0 0)\\
C_2^2 = (0 0 1 0 0 0 0 0 0 0 0 0 0)\\
C_2^3 = (0 0 0 1 0 0 0 0 0 0 0 0 0)\\
C_2^4 = (0 0 0 0 1 0 0 0 0 0 0 0 0)$

Case: 1

$C_1^{(1)} M = (1 0 0 0 0 0 0 0 0 0 0 0 0)\\
\text{Now } (1 0 0 0 1 1 1 1 0 0)\\
\rightarrow (1 1 0 0 1 1 1 1 0 0)\\
(1 1 0 0 1 1 1 1 0 0)$

$M' = (6 2 5 5 5 2 2 4 5 2 3 2)\\
\rightarrow (1 0 1 1 1 1 0 0 1 0 0 0 0)$

\text{SUM is 5}$

Case: 2

$C_1^{(2)} M = (0 0 1 0 0 0 0 0 0 0 0 0 0)\\
\text{Now } (1 1 0 0 1 1 1 1 0 0)\\
\rightarrow (1 1 0 0 1 1 1 1 0 0)\\
(1 1 0 0 1 1 1 1 0 0)$

$M' = (5 2 5 5 5 2 1 4 4 1 2 2)\\
\rightarrow (1 0 1 1 1 0 0 1 1 0 0 0 0)$

\text{SUM is 6}$

Case: 3

$C_1^{(3)} M = (0 0 0 1 0 0 0 0 0 0 0 0 0)\\
\text{Now } (1 1 0 0 1 1 0 1 0 0)\\
\rightarrow (1 1 0 0 1 1 0 1 0 0)\\
(1 1 0 0 1 1 0 1 0 0)$

$M' = (5 2 5 5 5 2 1 4 4 1 2 2)\\
\rightarrow (1 0 1 1 1 0 0 1 1 0 0 0 0)$

\text{SUM is 6}$

Case : 4

$C_1^{(4)} M = (0 0 0 0 0 0 0 1 0 0 0 0 0)\\
\text{Now } (1 1 1 1 1 1 1 0 1 1 1)\\
\rightarrow (1 1 1 1 1 1 1 1 1 1 1 1 1)$

$M' = (5 4 4 4 4 3 3 6 9 5 6 3)\\
\rightarrow (0 0 0 0 0 0 0 1 1 0 1 0)$

\text{SUM is 3}$

Therefore the new input vector $C_2$ to be multiplied with $M$ is:

$C_2 = (1 0 1 1 1 0 0 1 1 0 0 0 0)\\
\text{Now } C_2 M = (1 0 1 1 1 0 0 1 1 1 0 0 0 0)$

$M = (6 6 2 2 6 5 2 5 1 2)\\
\rightarrow (1 1 0 0 1 1 0 1 0 0)\\
(1 1 0 0 1 1 0 1 0 0)$

$M' = (5 2 5 5 5 2 1 4 4 1 2 2)\\
\rightarrow (1 0 1 1 1 0 0 1 1 0 0 0 0)$

$C_2' = (1 0 1 1 1 0 0 1 1 1 0 0 0 0)$

$C_2^{(1)} = (1 0 0 0 0 0 0 0 0 0 0 0 0)\\
C_2^{(2)} = (0 0 1 0 0 0 0 0 0 0 0 0 0)\\
C_2^{(3)} = (0 0 0 1 0 0 0 0 0 0 0 0 0)\\
C_2^{(4)} = (0 0 0 0 1 0 0 0 0 0 0 0 0)$

$\cdots$

Repeating the above process, we get the new input vector $C_3$ to be multiplied with $M$ as:

$C_3 = (10 1 1 1 1 1 1 0 0 0 0)\\
\text{Now } C_3 M = (10 1 1 1 1 1 0 0 1 1 0 0 0 0)$

$M = (6 6 2 2 6 5 2 5 1 2)\\
\rightarrow (1 1 0 0 1 1 0 1 0 0)\\
(1 1 0 0 1 1 0 1 0 0)$

$M' = (5 2 5 5 5 2 1 4 4 1 2 2)\\
\rightarrow (1 0 1 1 1 1 0 0 1 1 0 0 0 0)$

$C_3' = C_2'$

Therefore the pair of limit point is:

$\cdots\rightarrow$
Figure 1. The Graph for the Triggering Patterns

For various input vectors, we get different triggering patterns and all these triggering patterns are given in the table. The triggering patterns for these limit points are shown in figure 1.

<table>
<thead>
<tr>
<th>S.no</th>
<th>Input Vector</th>
<th>Limit Point</th>
<th>Triggering Pattern</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1100110100</td>
<td>C₂ → C₃ → C₃</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>010000000000</td>
<td>0001101010</td>
<td>C₂ → C₂ → C₂</td>
</tr>
<tr>
<td>3</td>
<td>001000000000</td>
<td>1100110100</td>
<td>C₃ → C₃ → C₃</td>
</tr>
<tr>
<td>4</td>
<td>110010010000</td>
<td>000100000000</td>
<td>C₃ → C₃ → C₃</td>
</tr>
<tr>
<td>5</td>
<td>1100110100</td>
<td>C₃ → C₃</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>001001000000</td>
<td>1100110100</td>
<td>C₃ → C₃ → C₃</td>
</tr>
<tr>
<td>7</td>
<td>000010000000</td>
<td>1100100100</td>
<td>C₃ → C₃ → C₃</td>
</tr>
<tr>
<td>8</td>
<td>000010000000</td>
<td>001001000000</td>
<td>C₄ → C₄ → C₄</td>
</tr>
<tr>
<td>9</td>
<td>000010000000</td>
<td>0011101010</td>
<td>C₄ → C₄ → C₄</td>
</tr>
<tr>
<td>10</td>
<td>000001000000</td>
<td>0011101010</td>
<td>C₄ → C₄ → C₄</td>
</tr>
<tr>
<td>11</td>
<td>000000100000</td>
<td>0011101010</td>
<td>C₄ → C₄ → C₄</td>
</tr>
<tr>
<td>12</td>
<td>000000010000</td>
<td>0011110000</td>
<td>C₄ → C₄ → C₄</td>
</tr>
</tbody>
</table>

V. CONCLUSION

Through the analysis using IFRM Model we observed that the main diseases which affect the sugarcane cultivators are respiratory distress (D₃) and wound injuries (D₁₁) while they are doing cultivation like Pudding (R₁), Adding minerals before planting (R₂), Removing the weeds (R₅) and protecting the sugarcane plants from other animals (R₆). Based on the above conclusion we suggest the following: Working conditions should be improved and the health hazard reduced through increased mechanization where possible. Ergonomic interventions to organize the work and working equipment and systematic training of the body and its movements to ensure good working methods are essential. 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. Improvement of housing, sanitary standards, accessible potable water, nutritional environment hygiene and economic stability are essential for the quality of sugarcane field workers. Uses of protective equipment as long rubber boots, mask, gloves, and glasses have big values in protecting against different parasites and chemical agents.

REFERENCES