Mathematical modelling of lifestyle disease faced by adults in Tamilnadu using Fuzzy Relational Maps (FRMs)

R. Shanmugapriya, B. KomalaDurga, T. Gunasekar

Abstract: The adults in Tamilnadu are commonly under the risk of many diseases such as diabetes, hypertension, obesity, cardiac related diseases etc., due to their modern lifestyle. The relationship between lifestyle and disease risk factor using FRM is obtained in this article. The paper consists of three sections. In section 1, we recall some preliminary definitions. In section 2, we will describe and analyze the problem. In section 3, the study-based conclusion is presented.

Keywords: FRMs, domain space, range space, hidden pattern, limit cycle, fixed point.

1. INTRODUCTION

Professor L.A. Zadeh at the University of California at Berkeley in 1965 suggested Fuzzy set theory to quantitatively and efficiently deal with the issues of this nature. Kosko B [1,2] introduces some essential concepts, terminology, notations, and arithmetic of Fuzzy logic. Vasantha et al. launched a fresh concept called Fuzzy Relational Maps (FRMs)[4,5&7]. An FRM, a domain space, and a range space are disconnected in the sense of concepts need to be identified. That is, the number of components in the space must not be equal to the number of components of domain space. In addition, it is supposed that there are no intermediate relationships within the domain element or domain space. A comparable study of the impact of the communication sector by shanmugapriya et al [3,8] has been carried out. In the same regard, the study continued to use FRMs and Fuzzy intuitionistic Fuzzy sets to analysis relationship with teacher students by Udayakumar’s [6].

The beneficial and negative effect of mass media on indivduals, kids, and young learners using the FRM model was discussed in this article.

1.1 Fuzzy relational maps:

The elements of the domain space are taken from the real vector space of dimension n in Fuzzy relational maps (FRMs) and that of the range space are real vectors of the vector dimension m (m generally does not need to be equal to n).

Denote R as the set of nodes \( R_1, \ldots, R_m \) of the range space, where \( R = \{ x_1, \ldots, x_m \mid x_j = 0 \text{ or } 1 \} \) for \( j = 1, 2, \ldots, m \).

\[ \text{if } x_j = 1 \text{ it means that the node } R_j \text{ is in the ON state and if } x_j = 0 \text{ it means that the node } R_j \text{is in the OFF state.} \]

Similarly D denotes the nodes \( R_1, \ldots, R_m \) of the domain space, where \( D = \{ (x_1, \ldots, x_n) | x_i = 0 \text{ or } 1 \} \) for \( i = 1, 2, \ldots, n \).

\[ \text{if } x_i = 1 \text{ it means that the node } D_i \text{is in the ON state and if } x_i = 0 \text{ it means that the node } D_i \text{ is in the OFF state.} \]

Definition 1.1.1:

Let \( D(R_i, D_i) \) where \( 1 \leq j \leq m \) and \( 1 \leq i \leq n \) be the edges of an FRM. When \( D \) is switched on and if causality flows through the edges and if it again causes \( D_i \), then the equilibrium state of this dynamical system is called the hidden pattern.

Definition 1.1.2:

If the equilibrium state of a dynamical system is a unique state vector then it is called fixed point. Example: -Let us assume a dynamical system by switching on \( R_1 \) or \( D_1 \). FRM settles down with \( R_i \) and \( R_m \) (or \( D_i \) and \( D_m \)) on, i.e. state vector remains as \( (1, 0, \ldots, 0, 1) \) in \( R \) [or \( (1, 0, \ldots, 0, 1) \) in \( D \)]. This state vector is called the fixed point.

Definition 1.1.3:

If the FRM settles down with a state vector in the form

\[ D_1 \rightarrow D_2 \rightarrow \ldots \rightarrow D_i \rightarrow D_1 \text{ (or } R_1 \rightarrow R_2 \rightarrow \ldots \rightarrow R_i \rightarrow R_1) \]

This equilibrium is called a limit cycle.

Methods of determining the hidden pattern

Let \( R_1, \ldots, R_n \) and \( D_1, D_2, \ldots, D_n \) be the nodes of FRM with feedback. Let \( E \) be the relational matrix. Let us assume that \( D \) is switched on i.e. the input is given as \( \text{veco} A_1 = (1, 0, \ldots, 0) \) in 1. The data should pass through the relational matrix \( E \). This is done by finding \( A_1 E \). Let \( A_1 E = (r_1, r_2, \ldots, r_m) \). After thresholding and updating the resultant vector, we have \( A_1 E \in R \). Now let \( B = A_1 E \). Passing \( B \) into \( E^T \) by obtaining \( BE^T \). After thresholding and updating the vector, we have \( BE^T \in D \). The procedure is repeated till we get a fixed point or limit cycle.

1.2 Risk factors of the Lifestyle disease:
II. MODEL

Domain Space:
Attributes related to the Lifestyle
\( D_1: \) Diabetes  
\( D_2: \) Nephrosis  
\( D_3: \) Hyper tension  
\( D_4: \) Obesity  
\( D_5: \) Cardiac disease

Range Space:
Attributes related to habitude
\( R_1: \) High carb diet  
\( R_2: \) Lack of exercise  
\( R_3: \) Medications like anti-depressants  
\( R_4: \) Psychological factors  
\( R_5: \) Social issues  
\( R_6: \) Legal recreational drugs like smoking and alcohol consumption  
\( R_7: \) Stress  
\( R_8: \) Sleep deprivation  
\( R_9: \) Engineered junk food and food addiction.

We have to use hidden pattern of the state vector \( X_1 = (1 \ 0 \ 0 \ 0) \) is derived by the following process.
\[ X_1 = (1 \ 0 \ 0 \ 0) \]
\[ E_1 X_1 = (1 \ 0 \ 0 \ 0 \ 0 \ 0 \ 0 \ 0) = Y_1 \]
\[ E_1^T Y_1 = (1 \ 0 \ 0 \ 1 \ 0) = X_2 \]
\[ E_1 X_2 = (1 \ 1 \ 0 \ 0 \ 0 \ 0 \ 0) = Y_2 \]
\[ E_1^T Y_2 = (1 \ 0 \ 0 \ 1 \ 0) = X_3 \]
\[ E_1 X_3 = (1 \ 1 \ 0 \ 0 \ 0 \ 0 \ 0) = Y_3 \in R \]
\[ E_1^T Y_3 = (1 \ 0 \ 0 \ 1 \ 0) = X_3 \in D \]

Now from the Expert’s opinion, the Directed Graph is drawn and the relational matrix is framed from it by taking the attributes related to Lifestyle i.e. \( D_1, D_2, ..., D_5 \) as the rows and attributes related to the dengue virus i.e. \( D_1, D_2, ..., D_5 \) as the columns.

III. FUZZY ANALYSIS OF THE PROBLEM BY FRM:

In this section we use the two experts to form the FRM model to analyse the problem.

First Expert’s opinion: (Doctor)

The relational map is given by the First Expert opinion

\[ \begin{align*}  
E_1 &= \begin{bmatrix} 1 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 & 0 \\ 0 & 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 \\ 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 1 \\ 0 & 0 & 0 & 1 & 0 \\ 1 & 0 & 0 & 1 & 0 \end{bmatrix}  
\end{align*} \]

The Fuzzy matrix \( E_1 \) is obtained from the above relational maps is as follows.

Now, we make the state \( D_1 \) as on state (‘Adults suffering from Diabetes’) and remaining all nodes are off state in the domain space.

\[ A_1 \rightarrow B_1 \rightarrow A_2 = B_1 \rightarrow A_2 \]

Second Expert’s opinion: (Adult medicine specialist)

The relational map is given by the Second Expert opinion

\[ \begin{align*}  
E_2 &= \begin{bmatrix} 1 & 1 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 1 & 0 & 0 & 1 & 0 \end{bmatrix}  
\end{align*} \]

\[ A_1 \rightarrow B_1 \rightarrow A_2 = B_1 \rightarrow A_2 \]

\[ \text{i.e.} A_2 \text{ is a fixed point} \]

The view of first expert (Doctor), if the first and fourth nodes are diabetes and obesity are on state, we discover the resultant vector as the adults consume high carb diet and lack of exercise, addition to the engineered junk food etc. so they must ensure the minimal consumption of high carb diets and avoid the junk food, also regular exercise should be followed.

The below method is used to derive the hidden pattern of the state vector \( A_1 = (0 \ 0 \ 0 \ 1 \ 0) \).

\[ E_1 A_1 = (1 \ 1 \ 0 \ 0 \ 0 \ 0 \ 0 \ 0 \ 0) = B_1 \]
\[ E_1^T B_1 = (1 \ 0 \ 0 \ 1 \ 0) = A_2 \]
\[ E_1 A_2 = (1 \ 1 \ 0 \ 0 \ 0 \ 0 \ 0 \ 0 \ 0) = B_1 \in R \]
\[ E_1^T B_1 = (1 \ 0 \ 0 \ 1 \ 0) = A_2 \in D \]

We get the outcome vector, after thrsh holding and updating process of the following chain.

\[ A_1 \rightarrow B_1 \rightarrow A_2 = B_1 \rightarrow A_2 \]
The Fuzzy matrix $E_2$ is obtained from the above relational maps is as follows.

$$E_2=egin{bmatrix}
1 & 0 & 0 & 1 & 0 \\
0 & 1 & 0 & 1 & 0 \\
0 & 0 & 0 & 0 & 0 \\
0 & 1 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 1 \\
0 & 0 & 0 & 0 & 1 \\
0 & 0 & 1 & 0 & 1 \\
1 & 0 & 1 & 0 & 0 \\
0 & 1 & 0 & 0 & 0
\end{bmatrix}$$

Now, we make the state $D_3$ as on state ('Hyper tensed people') and remaining all nodes off state in the domain space.

We have to use hidden pattern of the state vector $L_1 = (0 \ 0 \ 1 \ 0 \ 0 \ 0)$ is derived by the following process.

$$L_1 = (0 \ 0 \ 1 \ 0 \ 0 \ 0)$$

$$E_2L_1 = (0 \ 0 \ 0 \ 0 \ 0 \ 1 \ 0) = M_1$$

$$E_2^TM_2 = (1 \ 0 \ 1 \ 0 \ 1) = L_2 \in D$$

$$E_2L_2 = (1 \ 0 \ 0 \ 1 \ 1 \ 1 \ 1 \ 0) = M_2 \in R$$

We get the limit cycle, after thresh holding and updating of the outcome vector.

$$L_1 \rightarrow M_1 \rightarrow L_2 \rightarrow M_2 = L_2 \rightarrow M_2$$

i.e.$L_2$ is a fixed point

Now the state vector $R_3$ is on state ('public experiencing fromsevere stresses') and remaining nodes are off state in the range space.

We have to use hidden pattern of the state vector $P_1 = (0 \ 0 \ 0 \ 0 \ 0 \ 1 \ 0 \ 0)$ is derived by the following process.

$$E_2P_1 = (0 \ 0 \ 1 \ 0 \ 0) = Q_1$$

$$E_2^TQ_1 = (0 \ 0 \ 0 \ 0 \ 0 \ 1 \ 1 \ 0) = P_2$$

$$E_2P_2 = (0 \ 0 \ 1 \ 0 \ 1) = Q_2 \in D$$

$$E_2^TQ_2 = (0 \ 0 \ 0 \ 0 \ 1 \ 0 \ 1 \ 0) = P_3 \in R$$

$$E_2P_3 = (0 \ 0 \ 1 \ 0 \ 1 \ 0) = Q_3 \in D$$

$$E_2^TQ_3 = (0 \ 0 \ 0 \ 0 \ 1 \ 1 \ 0 \ 1 \ 0) = P_4 = P_5 \in R$$

The resultant vector after thresh holding and updating the following chain.

$$P_1 \rightarrow Q_1 \rightarrow P_2 \rightarrow Q_2 \rightarrow P_3 = P_3 \rightarrow Q_2$$

i.e. $Q_2$ is a fixed point

According to the second expert (Adult medicine specialist), if the third node is on state, we attain the resultant vector is $P_3$, i.e. the hyper tensed people face the problem due to social issues like addiction to alcohol and smoking and over stress and sleep deprivation. If the seventh node (stress) is on state in the range space, we find the resultant vector is hyper tension and heart disease. These kind of people were advised to be stress free and to have sound sleep. Also they should have control over their drinking habits.

### IV. CONCLUSION

In this paper using this FRMs model, we discover that due to the modern lifestyle of the people, like consuming high carb diet and lack of exercise, addition to the engineered junk food etc. are suffering serious diabetes and obesity. They must ensure the minimal consumption of high carb diets and avoid the junk food, also regular exercise should be followed. Also the hyper tensed people face the problem due to social issues like addiction to alcohol and smoking and over stress and sleep deprivation. These kind of people were advised to be stress free and to have sound sleep. Also they should have control over their drinking habits.

### REFERENCES