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Problems Faced by Road Workers Using Induced Fuzzy Relational Mapping (IFRM)

Research Article*

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Abstract: In this paper, we have dealt with the problems faced by Road workers in Cuddalore by using the Fuzzy Relational Mapping (FRM) and Induced Fuzzy Relational Mapping (IFRM). We have used the method of thresholding to discuss the problems of the road workers which we have mentioned. Based on our study we made our conclusions on the problems of the road workers and suggested few remedial measures.

Keywords: FRM, IFRM, Health hazards, Road workers, limit cycle, hidden pattern.

1. Introduction

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, engineer, scientists, industrialists and statisticians. There are various type of fuzzy models. In this paper we use Induced fuzzy relational mapping (IFRM) and fuzzy relational mapping (FRM). 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. In FRM we divide the very casual associations into two disjoint units, like for example the relation between a teacher and a student or relation; between an employee and an employer or a relation; between the parent and the child in the case of school dropouts and so on. In these situations we see that we can bring out the casual relations existing between an employee and employer or parent and child and so on. Thus for us to define a FRM we need a domain space and a range space which are disjoint in the sense of concepts. We further assume no intermediate relations exist within the domain and the range space. The number of elements in the range space need not in general be equal to the number of elements in the domain space. These model have been used to study various social problems. In particular, the problem of health hazards faced by road workers. In order to bring out much stronger relationship among the attributes a new modes called Induced fuzzy relational maps (IFRM) was proposed. Road worker plays a major role in the society . They face many problems in their day-to-day life. The major problems of Road workers are working for more number of hours, staying away from home, bad habits, absence of social

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security, misunderstanding, argument with partners, stress and fatally injured in work zones. In this paper, we analyze the problems faced the Road worker in cuddalore by using Induced fuzzy relational mappings (IFRM).

1.1. Illustrations of Fuzzy Relational Maps (FRM)

Fuzzy relational mappings are constructed analogous to FCMs. In FCMs correlations between casual associations among concurrently active units are promoted. But in FRMs the casual associations are divided into two disjoint units. Thus a domain space and a range space which are disjoint in the sense of concepts are needed to define an FRM. The elements of the domain space are taken from the real vector space of dimension 'n' and that of the range are real vectors from the vector space of dimension m (m in general need not be equal to n). D denotes the nodes D_1, D_2,...,D_n of the domain space where $D = \{(x_1, x_2, \ldots, x_n)$ / $x_j = 0$ *or* $1\}$ for $i = 1, 2 \ldots, n$. If $x_i = 1$ it means that the node D_i is in the on state and if $x_i = 0$ it means that the node D_i is in the off state. We denote by R the set of nodes $R_1, \ldots, R_m$ of the range space, where $R = \{(x_1, \ldots, x_m)$ / $x_j = 0$ *or* $1\}$ for $j = 1, 2, \ldots, m$. If $x_i = 1$ it means that the node R_i is in the on state and if $x_i = 0$ it means that the node R_i is in the off state.

1.2. Definitions

Definition 1.1 (Fuzzy Relational Maps (FRMS)). *A FRM is a directed graph or a map from domain space D to range space R with concepts like policies or events etc, as nodes and casualities as edges. It represents casual relations between spaces D and R. Let D_i and R_j denote that the two nodes of an FRM. The directed edge from D_i to R_j denotes the casuality of the D_i on R_j called relations. Every edge in the FRM is weighted with a number in the set $\{0, \pm 1\}$. Let e_{ij} be the weight of the edge D_iR_j, $e_{ij} \in \{0, \pm 1\}$. The weight of the edge D_iR_j is positive if increase in D_i implies increase in R_j or decrease in D_i implies decrease in R_j i.e) casuality of D_i on R_j is 1. If $e_{ij} = 0$ then does not have any effect on R_j. We do not discuss the cases when increase in D_i implies decrease in R_j or decrease in D_i implies increase in R_j.*

Definition 1.2 (Fuzzy Nodes). *If the nodes of the Fuzzy Relational mappings are fuzzy sets, then they are called fuzzy nodes.*

Definition 1.3 (Simple Fuzzy Relational Mapping). *If the edge weights of Fuzzy Relational Mappings are only $\{0, 1\}$, then they are called simple Fuzzy Relational Mappings.*

Definition 1.4 (Relational Matrix). *Let D_1, D_2,...,D_n be nodes of the domain space D and let R_1,...,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 instanteous state vector of the range space and it denotes the ON-OFF position of the nodes at any instant, $a_i = 0$ or 1 if a_i is ON or OFF respectively, for $i = 1, \ldots, n$. Similarly $b_i = 0$ or 1 if b_i is ON or OFF respectively, for $I = 1, \ldots, m$.*

Definition 1.5 (Directed Cycle). *Every fuzzy relational mapping can be viewed directed bipartite graph. If this bipartite graph has a directed cycle, then we say that the corresponding fuzzy relational mapping has a directed cycle.*

Definition 1.6 (Feedback in FRM). *A Fuzzy Relational Mapping with cycles is said to have a feedback.*

Definition 1.7 (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.*

Definition 1.8 (Hidden Pattern). *Let D_iR_j (or R_jD_i), $1 < j < m$, $1 < i < n$. when R_j (or D_i) is switched ON and if casuality flows through edges of the cycle and if it again causes $R_i(D_j)$, then it is said that the dynamical system goes round and round. This is true for any node R_j(or D_j) for $1 < i < m$, (or $1 < j < n$) the equilibrium state of this dynamical system is called the hidden pattern.*

Definition 1.9 (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,...,0,1) as in R (1,0,...,0,1). This state vector is called the fixed point.

Definition 1.10 (Limit Cycle). *If the FRM settles down with a state vector in the forms: $D_1 \to D_2 \to \cdots \to D_i \to D_1$ ($R_1 \to R_2 \to \cdots \to R_i \to R_1$). This form is called limit cycle.*

Definition 1.11 (Combined FRMS). *Let us $E_1, E_2, \ldots, E_p$ be the relational matrices of the FRMs. Combined FRMs denotes be the relational matrix by $E = E_1 + \ldots + E_p$.*

Definition 1.12 (Methods of Determining the Hidden Pattern). *Let $R_1, \ldots, R_m$ and $D_1, D_2, \ldots, D_n$ be the nodes of FRM. Let us assume D_1 is switched on i.e) when an input is given as vector $A_1 = (1, 0 \ldots, 0)$ in D_1 and the relational matrix is E. Now $A_1E = (r_1, r_2 \ldots, r_m)$ after thresholding and updating the resultant vector $A_1E \in R$. Now let $B = A_1E$ passing 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.*

Definition 1.13 (Application of FRMS). *FRM are used in the following areas:*

- *Relation between doctor and patient.*
- *Relation between quality condition and academic condition of students.*
- *Relation between teacher and poor rural students in city colleges.*
- *Study of employee-employer relationship.*
- *Finding out the solution for problems faced by Road workers in cuddalore.*

2. Description of the Problem

Road worker plays a major role in the society . They face many problems in their day-to-day life. The major problems of Road workers are working for more number of hours, staying away from home, bad habits, absence of social security, misunderstanding, argument with partners, stress and fatally injured in work zones The collected data from the Road workers in cuddalore regarding their problems and the reason for the problems and we call them as attributes. Thus the attribute for domain space D are

D_1−Working for many hours

D_2−staying away from home

D_3−Bad habits

D_4−Absence of social security

D_5−Misunderstanding

D_6−Arguments with partners

D_7−Stress

D_8−Skin problems

D_9−Sexual behavior and Sexual health problems

D_{10}−Physical health problems

D_{11}−Poor safety attitude

D_{12}−Not providing necessary and periodic medical preventions.

The attributes for range space R are

R_1−The Road workers have to work more than eight hours to earn money for their live hood.

R_2−The Road workers are generally migrant laborers and they have to live in tents near the road construction site temporarily.

R_3−Consumption of gutka, alcohol, bidi, ganja, addiction of drugs and etc.

R_4−The Road workers do have no social security and benefits in terms of labor welfare measures and provisions.

R_5−In work zone, a situation where something is not understood properly.

R_6−Quarrel or disagreement between spouses or co-workers.

R_7−Stress occurs when a person's brain feels a threat from bursts of hormones. Certain triggers, such as heavy work load, a job loss or death can cause these threats.

R_8−Road workers handle the taar which has constituents to create irritant, contact dermatitis (redness, itching and etc) and lead to allergic contact dermatitis from ingredients such as chromium.

R_9−Road workers are victims of multiple complications due to unstable nature of their employment, vulnerable living conditions, death of health care facilities and lack of health awareness.

R_{10}−Physical health problems includes respiratory diseases from inhaling dust, muscular skeletal disorder, injuries, from heavy load , noise induced hearing loss.

Expert opinion is obtained through some relationship between the set of diseases and the reason for the diseases and the concepts in the domain space are taken as $D_1, D_2, \ldots, D_{12}$ and the attributes in the range space are taken as $R_1, R_2, \ldots, R_{10}$ and thus the connection matrix is given as follows.

$$M = \begin{array}{c|cccccccccc} & R_1 & R_2 & R_3 & R_4 & R_5 & R_6 & R_7 & R_8 & R_9 & R_{10} \\ D_1 & 1 & 0 & 1 & 1 & 1 & 0 & 0 & 0 & 0 & 1 \\ D_2 & 0 & 0 & 1 & 0 & 0 & 0 & 1 & 1 & 0 & 0 \\ D_3 & 1 & 0 & 1 & 1 & 1 & 0 & 0 & 0 & 0 & 1 \\ D_4 & 1 & 0 & 1 & 1 & 1 & 0 & 0 & 0 & 0 & 1 \\ D_5 & 1 & 0 & 1 & 1 & 1 & 0 & 0 & 0 & 0 & 1 \\ D_6 & 0 & 0 & 0 & 1 & 1 & 1 & 0 & 0 & 1 & 0 \\ D_7 & 1 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 1 & 0 \\ D_1 & 1 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 1 & 0 \\ D_9 & 1 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 1 & 0 \\ D_{10} & 1 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 1 & 0 \\ D_{11} & 1 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 1 & 0 \\ D_{12} & 0 & 0 & 0 & 1 & 1 & 1 & 0 & 0 & 1 & 0 \end{array}$$

3. 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 on OFF state.
- Let C_1M yields C_1^1 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_1^1 through M repeatedly for each positive entry 1 and the symbol $\rightarrow$ 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 numbers 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 cause to another and its 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 it is repeated for all the vectors separately.

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). Now (1 0 0 0 0 0 0 0 0 0 0 0 0)M =(1 0 1 1 1 0 0 0 0 1)$\hookrightarrow$(1 0 1 1 1 0 0 0 0 1)

(1 0 1 1 1 0 0 0 0 1)M^T =(5 2 1 2 4 5 3 4 4 1 1 1)$\hookrightarrow$(1 0 0 0 1 1 0 1 1 0 0 0)= C_1^1.

The new vectors are

C_1^1 =(1 0 0 0 0 0 0 0 0 0 0 0)

C_1^2 =(0 0 1 0 0 0 0 0 0 0 0 0)

C_1^3 =(0 0 0 1 0 0 0 0 0 0 0 0)

C_1^4 =(0 0 0 0 1 0 0 0 0 0 0 0)

C_1^5 =(0 0 0 0 0 0 0 0 1 0 0 0)

Case 1:

$C_1^{(1)}M$ =(1 0 0 0 0 0 0 0 0 0 0 0)M =(1 0 1 1 1 0 0 0 0 1)$\hookrightarrow$(1 0 1 1 1 0 0 0 0 1)

(1 0 1 1 1 0 0 0 0 1)M^T =(5 2 1 2 4 5 3 4 4 1 1 5)(1 0 0 0 1 1 0 1 1 0 0 1) Sum is 6.

Case 2:

$C_1^{(2)}M$ =(0 0 1 0 0 0 0 0 0 0 0 0)M =(1 0 1 1 1 0 0 0 0 1)$\hookrightarrow$(1 0 1 1 1 0 0 0 0 1)

(1 0 1 1 1 0 0 0 0 1)M^T =(5 2 1 2 4 5 3 4 4 1 1 5)(1 0 0 0 1 1 0 1 1 0 0 1) Sum is 6.

Case 3:

$C_1^{(3)}M$ =(0 0 0 1 0 0 0 0 0 0 0 0)M =(1 0 1 1 1 0 0 0 0 1)$\hookrightarrow$(1 0 1 1 1 0 0 0 0 1)

(1 0 1 1 1 0 0 0 0 1)M^T =(5 2 1 2 4 5 3 4 4 1 1 5)(1 0 0 0 1 1 0 1 1 0 0 1) Sum is 6.

Case 4:

$C_1^{(4)}M$ =(0 0 0 0 1 0 0 0 0 0 0 0)M =(1 0 1 1 1 0 0 0 0 1)↪(1 0 1 1 1 0 0 0 0 1)

(1 0 1 1 1 0 0 0 0 1)M^T =(5 2 1 2 4 5 3 4 4 1 1 5)(1 0 0 0 1 1 0 1 1 0 0 1) Sum is 6.

Case 5:

$C_1^{(5)}M$ =(0 0 0 0 0 0 0 0 1 0 0 0)M =(1 0 0 0 0 0 1 0 1 0)↪(1 0 0 0 0 0 1 0 1 0)

(1 0 0 0 0 0 1 0 1 0)M^T =(4 7 3 6 2 3 7 5 9 2 8 5)(0 0 0 0 0 0 0 0 1 0 1 0) Sum is 2.

Therefore the new input vector C_2 to be multiplied with M is (1 0 0 0 1 1 0 1 1 0 0 1)

Now C_2M =(1 0 0 0 1 1 0 1 1 0 0 1)M =(5 2 5 5 5 3 2 2 0 4)↪(1 0 1 1 1 0 0 0 0 1)

(1 0 1 1 1 0 0 0 0 1)M^T =(6 1 2 3 5 5 2 5 6 2 3 5)↪(1 0 0 0 1 1 0 1 1 0 0 1) = C_2^1.

The new vectors are

$C_2^{(1)}$ =(1 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)

$C_2^{(3)}$ =(0 0 0 1 0 0 0 0 0 0 0 0)

$C_2^{(4)}$ =(0 0 0 0 1 0 0 0 0 0 0 0)

$C_2^{(5)}$ =(0 0 0 0 0 0 0 1 0 0 0 0)

$C_2^{(6)}$ =(0 0 0 0 0 0 0 0 1 0 0 0)

Repeating the above process, we get the new input vector C_3 to be multiplied with M as (1 0 0 0 1 1 0 1 1 0 0 1)

C_3M =(1 0 0 0 1 1 0 1 1 0 0 1)M =(5 2 5 5 5 3 2 2 0 4)↪(1 0 1 1 1 0 0 0 0 1)

(1 0 1 1 1 0 0 0 0 1)M^T =(6 1 2 3 5 5 2 5 6 2 3 5)(1 0 0 0 1 1 0 1 1 0 0 1)= $C_3^1 = C_2^1$.

Therefore the pair of limit point is : (1 0 0 0 1 1 0 1 1 0 0 1) (1 0 1 1 1 0 0 0 0 1). For various input vectors, we get different trigerring patterns are given in the table.

s.no	Input vector	Limit point	Trigerring pattern
1.	(1 0 0 0 0 0 0 0 0 0 0 0)	(1 0 1 1 1 0 0 0 0 1) (1 0 0 0 1 1 0 1 1 0 0 1)	$C_1 \to C_3 \to C_3$
2.	(0 1 0 0 0 0 0 0 0 0 0 0)	(0 0 1 0 0 0 1 1 0 0) (0 1 0 0 0 0 0 1 1 0 0 0)	$C_2 \to C_2 \to C_2$
3.	(0 0 1 0 0 0 0 0 0 0 0 0)	(1 0 1 1 1 0 0 0 0 1) (1 0 0 0 1 1 0 1 1 0 0 1)	$C_3 \to C_3 \to C_3$
4.	(0 0 0 1 0 0 0 0 0 0 0 0)	(1 0 1 1 1 0 0 0 0 1) (1 0 0 0 1 1 0 1 1 0 0 1)	$C_4 \to C_3 \to C_3$
5.	(0 0 0 0 1 0 0 0 0 0 0 0)	(1 0 1 1 1 0 0 0 0 1) (1 0 0 0 1 1 0 1 1 0 0 1)	$C_5 \to C_3 \to C_3$
6.	(0 0 0 0 0 1 0 0 0 0 0 0)	(0 0 0 1 1 1 0 0 1 0) (1 0 0 0 0 1 0 1 1 0 0 0)	$C_6 \to C_6 \to C_6$
7.	(0 0 0 0 0 0 1 0 0 0 0 0)	(1 0 0 0 0 0 1 0 1 0) (0 0 0 0 0 0 0 0 1 0 1 0)	$C_7 \to C_9 \to C_9$
8.	(0 0 0 0 0 0 0 1 0 0 0 0)	(1 0 0 0 0 0 1 0 1 0) (0 0 0 0 0 0 0 0 1 0 1 0)	$C_8 \to C_9 \to C_9$
9.	(0 0 0 0 0 0 0 0 1 0 0 0)	(1 0 0 0 0 0 1 0 1 0) (0 0 0 0 0 0 0 0 1 0 1 0)	$C_9 \to C_9 \to C_9$
10.	(0 0 0 0 0 0 0 0 0 1 0 0)	(1 0 0 0 0 0 1 0 1 0) (0 0 0 0 0 0 0 0 1 0 1 0)	$C_{10} \to C_9 \to C_9$
11.	(0 0 0 0 0 0 0 0 0 0 1 0)	(1 0 0 0 0 0 1 0 1 0) (0 0 0 0 0 0 0 0 1 0 1 0)	$C_{11} \to C_9 \to C_9$
12.	(0 0 0 0 0 0 0 0 0 0 0 1)	(0 0 0 1 1 1 0 0 1 0) (1 0 0 0 0 1 0 1 1 0 0 0)	$C_{12} \to C_6 \to C_6$

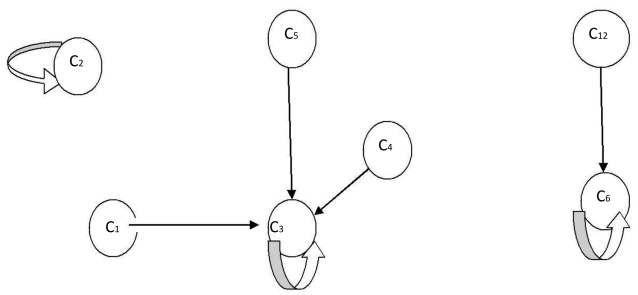

Figure 1. **The Graph for the Triggering patterns**

4. Conclusion

The problem of Road worker were studied based on IFRM. Based on IFRM, it is noticed that if road workers work for more number of hours then they have to stay away from home for more number of days and other factors like bad habits, misunderstanding, argument with partners, stress, skin problems, physical health problems will increase, whereas sexual behavior & sexual health problems is in indeterminate state. Again, when absence of social security increase or is on state, the following nodes namely , work for more number of hours, staying away from home, skin problems, sexual behavior & sexual health problems is in indeterminate state, whereas misunderstanding, addiction of drugs, argument with partners, stress,and health problems will increase or are on states. If new situation arises in the construction sector, new concepts need to be incorporated for modeling the Road workers problems and that can be easily done by introducing new nodes. However, government should implement "Regulation of Employment & Condition of service Act, 1996 to protect the rights of Road workers and government should provide them education regarding their profession in order to avoid professional hazards.

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