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Analysis of Health Problems Faced by Residents Around Sipcot in Cuddalore Using Induced Fuzzy Associative Memory (IFAM) Model

Research Article*

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Abstract: In this paper we have analyzed the impact of the pollution in sipcot cuddalore by using Induced Fuzzy Associative Memory (IFAM) model and Fuzzy Associative Memory (FAM) model. The sipcot chemical industrial estate in cuddalore is one among many such clusters of polluting industries in India. Residents living in and around the sipcot chemical industrial estate had the problem of health hazards due to chemical pollutions. Based on our study we made our conclusions and suggested some remedial measures.

Keywords: IFAM, FAM, Health hazards, sipcot cuddalore, limit cycle, hiddern pattern.

1. Introduction

The fuzzy model is a finite set of fuzzy relations that form an algorithm for determine the output of a process from finite number of past inputs and outputs. L.A. Zadeh[4] has introduced a mathematical model in 1965. In the 1976, Political scientist R. Axelord [1] used this fuzzy model to study decision making in social and political systems. Fuzzy Associative memories (FAM) were introduced by Bart Kosko [3] in 1997. There are so many fuzzy models to deal with these problems. Some of them are bi associative memories (BAM), Fuzzy Cognitive maps (FCM) and Fuzzy relational maps (FRM). FAM gives gradation among the attributes chosen by the expert. The research on FAM results many modified models such as Adaptive FAM (AFAM), Fuzzy Hebb FAM, Binary input-output FAM (BIOFAM) and adaptive BIOFAM, Recurrent Fuzzy associative memories (RFAM), Fuzzy Morphological associative memories (FMAM) and Induced FAM.

FAM is much useful if learning algorithm is applied because it allows rules to be updated easily. FAM has been used by many researchers to study evolutionary computation to predict stock price index, to study the application of neural network and fuzzy system to pharmacokinetic / pharmaco dynamic modelling and optimal drig dozing to recognize time series patterns contained ambiguity and to predict cement quality. In this paper we first use FAM model and then IFAM model to analyse the health problems faced by residents around the sipcot in cuddalore. Due to chemical pollutions, Residents who are living in and around the sipcot chemical industrial estate had the problem of health hazards. This model is most suitable to find the relationship between the causes. We have also given some remedial measures and suggestions.

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2. Fuzzy Associative Memories

Here we have presented the definitions and the basic notions relevant to this paper.

Definition 2.1. *Let X be a non-empty set. A fuzzy set A in X is characterized by and its membership function. $\mu_A : X \to [0,1]$ and $\mu_A(x)$ is interpreted as the degree of membership of element x in fuzzy set A for each $x \in X$.*

Definition 2.2. *A fuzzy set defines a point in unit hypercube and set of all fuzzy subsets equals the unit hypercube $I^n = [0,1]^n$. The geometry of fuzzy set involves both domain $X = \{x_1, x_2, \ldots, x_n\}$ and the range [0, 1] of mappings $mA : X \to [0,1]$. Here (X, I^n) defines the fundamental measurable space of fuzzy theory. Vertices of the cube I^n define non fuzzy sets. Within cube we are interested in the distance between points within the unit hypercube $I^n = [0,1]$ which led to measures of size and fuzziness of fuzzy set and more fundamentally to a measure.*

Definition 2.3. *A fuzzy system S maps fuzzy sets to fuzzy sets. Thus a fuzzy system S is a transformation $S : I^n \to I^p$. The n-dimensional unit hypercube I^n houses all the fuzzy subsets of the domain space, or input universe of discourse, $X = \{x_1, \ldots, x_n\}$. I^p houses all the fuzzy subsets of the range space, or output universe of discourse, $Y = \{y_1, \ldots, y_p\}$. X and Y can also be subsets of R^n and R^p.*

In general a fuzzy system S maps families of fuzzy sets, thus $S : I^{n1} \times \cdots \times I^{nr} \to I^{p1} \times \cdots \times I^{ps}$. We can extend the definition of a fuzzy system to allow arbitrary products of arbitrary mathematical spaces to serve as the domain or range spaces of the fuzzy sets.

Fuzzy systems $S : I^n \to I^p$ that map balls of fuzzy sets in I^n to balls of fuzzy sets in I^p. These continuous fuzzy systems behave as associative memories and map close inputs to close outputs. We shall refer to them as fuzzy associative memories, or FAMs.

Definition 2.4. *The fuzzy set association (A_i, B_i) is also named as a "rule". The antecedent term A_i and the consequent term B_i in the fuzzy set association (A_i, B_i) are known as input associant and output associant respectively. The FAM system maps points A_J near A_i to points B_j near B_i. If A_j is closer to A_i, then point (A_j, B_j) is closer to (A_i, B_i) in the product space $I^n \times I^p$. In this sense FAMs map balls in I^n to balls in I^p. Using the rule between the antecedent A_i and consequent B_i, we get the connection matrix M. FAM gives the gradation among the attributes chosen by the expert. In this paper an attempt is made to analize the health problems faced residents around sipcot in cuddalore caused by chemical pollution and suggest some remedial measures.*

3. Adaptation of FAM to the Problem

The collected data from the residents around the sipcot in cuddalore regarding their diseases and the reason for the disease and we call them as attributes. Suppose that there are n attributes $x_1, x_2, \ldots, x_n$ where n is finite associated with the diseases and let $y_1, y_2, \ldots, y_p$ be the attributes associated with impact of pollution. The connection matrix M of order $n \times p$ is obtained through the expert. The data collected from residents around sipcot in cuddalore, the disease and reason for the disease are divided as following attributes.

3.1. The attribute related to reasons for the diseases

N_1−People who live and pass near the industry would inhale the toxicated air.

N_2−Even cooked food and water acquired the chemical smell.

N_3−Children fall ill and vomit after eating.

N_4-Metal utensils used for storing water become red in colour due to chemical content in the bore well water.

N_5-Delayed puberty and infertility of women.

N_6-Exposure to the clouds of smoke emitted by factories.

N_7-Unwanted noise from industry will affect the ear drum.

N_8-Fish and other creatures in the sea were contaminated and eventually residents of this area who consumed the fish suffered from intoxication.

N_9-Such high levels of chemicals in ambient air near factories are also indicative of poor housekeeping within the industries.

The expert is a medical officer.

3.2. The attribute related to disease

R_1-Asthma

R_2-Kidney disease

R_3-Diarrhoea and Dysentery

R_4-Cancer

R_5-Uterine cancer

R_6-Chest tightness

R_7-Hearing problems

R_8-Genetic disorder

R_9-Giddiness

$R_{10}-$Throat irritation and burning sensation in eyes.

The expert's opinion is given in the form a matrix M.

$$M = \begin{array}{c} \\ N_1 \\ N_2 \\ N_3 \\ N_4 \\ N_5 \\ N_6 \\ N_7 \\ N_8 \\ N_9 \end{array} \begin{array}{cccccccccc} R_1 & R_2 & R_3 & R_4 & R_5 & R_6 & R_7 & R_8 & R_9 & R_{10} \\ 0.4 & 0.5 & 0.7 & 0.6 & 0.2 & 0.6 & 0.8 & 0.0 & 0.0 & 0.4 \\ 0.5 & 0.6 & 0.5 & 0.5 & 0.3 & 0.2 & 0.5 & 0.6 & 0.2 & 0.3 \\ 0.2 & 0.4 & 0.8 & 0.6 & 0.2 & 0.5 & 0.4 & 0.2 & 0.0 & 0.3 \\ 0.3 & 0.2 & 0.4 & 0.5 & 0.0 & 0.5 & 0.6 & 0.2 & 0.1 & 0.2 \\ 0.6 & 0.4 & 0.5 & 0.4 & 0.1 & 0.6 & 0.8 & 0.1 & 0,3 & 0.3 \\ 0.4 & 0.2 & 0.4 & 0.6 & 0.2 & 0.4 & 0.8 & 0.2 & 0.3 & 0.6 \\ 0.8 & 0.5 & 0.7 & 0.9 & 0.8 & 0.5 & 0.2 & 0.4 & 0.6 & 0.0 \\ 0.4 & 0.3 & 0.2 & 0.5 & 0.1 & 0.5 & 0.6 & 0.2 & 0.0 & 0.1 \\ 0.3 & 0.6 & 0.8 & 0.4 & 0.4 & 0.3 & 0.6 & 0.1 & 0.1 & 0.2 \end{array}$$

3.3. Analysis Using FAM

Let the initial state vector be $N_1 = (1\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0)$. The effect of N_1 in dynamical system M is

$N_1M = (.4\ .5\ .7\ .6\ .2\ .6\ .8\ 0\ 0\ .4) \hookrightarrow (0\ 0\ 1\ 0\ 0\ 0\ 1\ 0\ 0\ 0) = B_1$

The result of B_1M^T of order 1×9 is $(.8\ .5\ .8\ .6\ .8\ .8\ .7\ .6\ .8) \hookrightarrow (1\ 0\ 1\ 0\ 1\ 1\ 1\ 0\ 1) = N_2$

Now N_1 is not equal to N_2. Hence we proceed further to get the limit point as follows. The effect of N_2 in dynamical system M is

$N_2M = (.8\ .6\ .8\ .9\ .8\ .6\ .8\ .4\ .6\ .6) \hookrightarrow (1\ 0\ 1\ 1\ 1\ 0\ 1\ 0\ 0\ 0) = B_2$

The result of B_2M^T of order 1×9 is

$(.8\ .5\ .8\ .6\ .8\ .8\ .9\ .6\ .8) \hookrightarrow (1\ 0\ 1\ 0\ 1\ 1\ 1\ 0\ 1) = N_3$

Now $N_2 = N_3$. Hence the pair of limit point is (1 0 1 1 1 0 1 0 0 0) (1 0 1 0 1 1 1 0 1). The set of limit points corresponding to different input vectors are given in Table 1.

Input vector	Limit point
(1 0 0 0 0 0 0 0 0)	(1 0 1 1 1 0 1 0 0 0) (1 0 1 0 1 1 1 0 1)
(0 1 0 0 0 0 0 0 0)	(1 0 1 1 1 0 1 0 0 0) (1 0 1 0 1 1 1 0 1)
(0 0 1 0 0 0 0 0 0)	(1 0 1 1 1 0 1 0 0 0) (1 0 1 0 1 1 1 0 1)
(0 0 0 1 0 0 0 0 0)	(1 0 1 1 1 0 1 0 0 0) (1 0 1 0 1 1 1 0 1)
(0 0 0 0 1 0 0 0 0)	(1 0 1 1 1 0 1 0 0 0) (1 0 1 0 1 1 1 0 1)
(0 0 0 0 0 1 0 0 0)	(1 0 1 1 1 0 1 0 0 0) (1 0 1 0 1 1 1 0 1)
(0 0 0 0 0 0 1 0 0)	(1 0 1 1 1 0 1 0 0 0) (1 0 1 0 1 1 1 0 1)
(0 0 0 0 0 0 0 1 0)	(1 0 1 1 1 0 1 0 0 0) (1 0 1 0 1 1 1 0 1)
(0 0 0 0 0 0 0 0 1)	(1 0 1 1 1 0 1 0 0 0) (1 0 1 0 1 1 1 0 1)

Table 1. **The set of limit points corresponding to different input vectors**

4. Description of Induced Fuzzy Associative Memories (IFAM)

Model: Consider there are n attributes, say $x_1, x_2, \ldots, x_n$ where n is finite, associated with the diseases and let $y_1, y_2, \ldots, y_p$ be the attributes associated with impact of pollution. The connection matrix M of order $n \times p$ is obtained. Let N_1 be the initial input vector $1 \times n$. Here the particular component N_1 is kept on ON state and all other components on OFF state and pass the state vector N_1 through the connection matrix M. To convert the resultant vector into signal function, choose the first two highest values to ON state and other values to OFF state with 1 and 0 respectively. Denote this process by the symbol $\hookrightarrow$. The resulting vector is multiplied with M^T and thresholding gives a new vector N_1. This vector is related with the matrix and that vector which gives the highest number of attributes to ON state is chosen as N_2 for each positive entry we get a set of resultant vectors, among these vectors a vector which contains maximum number of 1s is chosen as N_2. If there are two or equal number of 1s as ON state, choose the first occurring one as N_2. Repeat the same procedure till a fixed point or a limit cycle is obtained. This process gives importance to each vector separately as one vector induces another or many more vectors into ON state. Get the hidden pattern by the limit cycle. Next choose the vector with its second component in ON state and repeat the same to get another cycle. This process has been repeated for all the vectors separately and the hidden pattern of some vectors found in many cases. Inference from this hidden pattern highlights the causes.

Let the input vector be $N_1 =$(1 0 0 0 0 0 0 0 0). Now

(1 0 0 0 0 0 0 0 0)M=(.4 .5 .7 .6 .2 .6 .8 0 0 .4)$\hookrightarrow$(0 0 1 0 0 0 1 0 0 0) (0 0 1 0 0 0 1 0 0 0)M^T =(.8 .5 .8 .6 .8 .8 .7 .6 .8)$\hookrightarrow$(1 0 1 0 1 1 1 0 1)= N_1. The new vectors are

$N_1^{(1)}$ =(1 0 0 0 0 0 0 0 0)

$N_1^{(2)}$ =(0 0 1 0 0 0 0 0 0)

$N_1^{(3)}$ =(0 0 0 0 1 0 0 0 0)

$N_1^{(4)}$ =(0 0 0 0 0 1 0 0 0)

$N_1^{(5)}$ =(0 0 0 0 0 0 1 0 0)

$N_1^{(6)}$ =(0 0 0 0 0 0 0 0 1)

Case 1:

$N_1^{(1)} M$ =(1 0 0 0 0 0 0 0 0)M =(.4 .5 .7 .6 .2 .6 .8 0 0 .4)$\hookrightarrow$(0 0 1 0 0 0 1 0 0 0)

$(0\ 0\ 1\ 0\ 0\ 0\ 1\ 0\ 0\ 0)M^T = (.8\ .5\ .8\ .6\ .8\ .8\ .7\ .6\ .8) \hookrightarrow (1\ 0\ 1\ 0\ 1\ 1\ 1\ 0\ 1)$ Sum is 6.

Case 2:

$N_1^{(2)}M = (0\ 0\ 1\ 0\ 0\ 0\ 0\ 0\ 0)M = (.2\ .4\ .8\ .6\ .2\ .5\ .4\ .2\ 0\ .3) \hookrightarrow (0\ 0\ 1\ 1\ 0\ 0\ 0\ 0\ 0\ 0)$

$(0\ 0\ 1\ 1\ 0\ 0\ 0\ 0\ 0\ 0)M^T = (.7\ .5\ .8\ .5\ .5\ .6\ .9\ .5\ .8) \hookrightarrow (0\ 0\ 1\ 0\ 0\ 0\ 1\ 0\ 1)$ Sum is 3.

Case 3:

$N_1^{(3)}M = (0\ 0\ 0\ 0\ 1\ 0\ 0\ 0\ 0)M = (.6\ .4\ .5\ .4\ .1\ .6\ .8\ .1\ .3\ .3) \hookrightarrow (1\ 0\ 0\ 0\ 0\ 1\ 1\ 0\ 0\ 0)$

$(1\ 0\ 0\ 0\ 0\ 1\ 1\ 0\ 0\ 0)M^T = (.8\ .5\ .5\ .6\ .2\ .8\ .4\ .2\ .6) \hookrightarrow (1\ 0\ 0\ 1\ 0\ 1\ 0\ 0\ 1)$ Sum is 4.

Case 4:

$N_1^{(4)}M = (0\ 0\ 0\ 0\ 0\ 1\ 0\ 0\ 0)M = (.4\ .2\ .4\ .6\ .2\ .4\ .8\ .2\ .3\ .6) \hookrightarrow (0\ 0\ 0\ 1\ 0\ 0\ 1\ 0\ 0\ 1)$

$(0\ 0\ 0\ 1\ 0\ 0\ 1\ 0\ 0\ 1)M^T = (.8\ .5\ .6\ .6\ .8\ .8\ .9\ .6\ .6) \hookrightarrow (1\ 0\ 0\ 0\ 1\ 1\ 1\ 0\ 0)$ Sum is 4.

Case 5:

$N_1^{(5)}M = (0\ 0\ 0\ 0\ 0\ 0\ 1\ 0\ 0)M = (.8\ .5\ .7\ .9\ .8\ .5\ .2\ .4\ .6\ 0) \hookrightarrow (1\ 0\ 0\ 1\ 1\ 0\ 0\ 0\ 0\ 0)$

$(1\ 0\ 0\ 1\ 1\ 0\ 0\ 0\ 0\ 0)M^T = (.6\ .5\ .6\ .5\ .6\ .6\ .9\ .5\ .4) \hookrightarrow (1\ 0\ 1\ 0\ 1\ 1\ 1\ 0\ 0)$ Sum is 5.

Case 6:

$N_1^{(6)}M = (0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 1)M = (.3\ .6\ .8\ .4\ .4\ .3\ .6\ .1\ .1\ .2) \hookrightarrow (0\ 1\ 1\ 0\ 0\ 0\ 1\ 0\ 0\ 0)$

$(0\ 1\ 1\ 0\ 0\ 0\ 1\ 0\ 0\ 0)M^T = (.8\ .6\ .8\ .6\ .8\ .8\ .7\ .6\ .8) \hookrightarrow (1\ 0\ 1\ 0\ 1\ 1\ 1\ 0\ 1)$ Sum is 6.

Therefore the new input vector N_2 to be multiplied with M is (1 0 1 0 1 1 1 0 1).Now,

$N_2M = (1\ 0\ 1\ 0\ 1\ 1\ 1\ 0\ 1)M = (.8\ .6\ .8\ .9\ .8\ .6\ .8\ .4\ .6\ .6) \hookrightarrow (1\ 0\ 1\ 1\ 1\ 0\ 1\ 0\ 0\ 0)$

$(1\ 0\ 1\ 1\ 1\ 0\ 1\ 0\ 0\ 0)M^T = (.8\ .5\ .8\ .6\ .8\ .8\ .9\ .6\ .8) \hookrightarrow (1\ 0\ 1\ 0\ 1\ 1\ 1\ 0\ 1) = N_2 = N_1$. Hence the pair of limits is: (1 0 1 0 1 1 1 0 1) (1 0 1 1 1 0 1 0 0 0). For various input vectors, we get different triggering patterns and all these triggering patterns are given in table 2.

Input vector	Limit point	Triggering pattern
(1 0 0 0 0 0 0 0 0)	(1 0 1 0 1 1 1 0 1)(1 0 1 1 1 0 1 0 0 0)	$N_1 \Rightarrow N_1$
(0 1 0 0 0 0 0 0 0)	(1 0 1 0 1 1 1 0 1)(1 0 1 1 1 0 1 0 0 0)	$N_2 \Rightarrow N_1 \Rightarrow N_1$
(0 0 1 0 0 0 0 0 0)	(1 0 1 0 1 1 1 0 1)(1 0 1 1 1 0 1 0 0 0)	$N_3 \Rightarrow N_1 \Rightarrow N_1$
(0 0 0 1 0 0 0 0 0)	(1 0 1 0 1 1 1 0 1)(1 0 1 1 1 0 1 0 0 0)	$N_4 \Rightarrow N_1 \Rightarrow N_1$
(0 0 0 0 1 0 0 0 0)	(1 0 1 0 1 1 1 0 1)(1 0 1 1 1 0 1 0 0 0)	$N_5 \Rightarrow N_1 \Rightarrow N_1$
(0 0 0 0 0 1 0 0 0)	(1 0 1 0 1 1 1 0 1)(1 0 1 1 1 0 1 0 0 0)	$N_6 \Rightarrow N_1 \Rightarrow N_1$
(0 0 0 0 0 0 1 0 0)	(1 0 1 0 1 1 1 0 1)(1 0 1 1 1 0 1 0 0 0)	$N_7 \Rightarrow N_1 \Rightarrow N_1$
(0 0 0 0 0 0 0 1 0)	(1 0 1 0 1 1 1 0 1)(1 0 1 1 1 0 1 0 0 0)	$N_8 \Rightarrow N_1 \Rightarrow N_1$
(0 0 0 0 0 0 0 0 1)	(1 0 1 0 1 1 1 0 1)(1 0 1 1 1 0 1 0 0 0)	$N_9 \Rightarrow N_1 \Rightarrow N_1$

Table 2. **Different triggering for various input vectors**

Hence the triggering patterns for these limit point are shown in Figure 1 and the merged graph is shown in Figure 2.

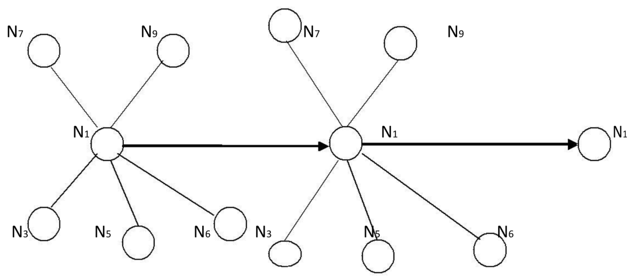

Figure 1. **The triggering patterns**

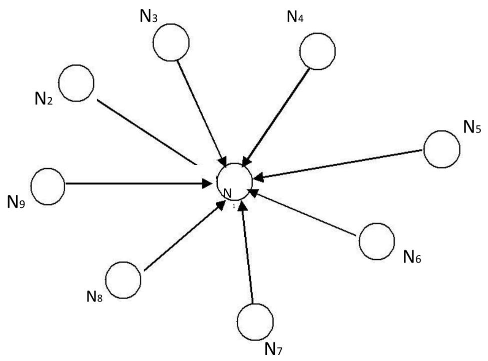

Figure 2. **The merged graph**

5. Conclusion and Suggestions

Health problems faced by residents around SIPCOT in cuddalore have been analysed by using IFAM model. It is observed N_1, N_4 and N_8 is the main case for above mentioned health hazards. Hence it is concluded health hazards are mainly due to chenmical pollution. Similarly the main diseases which affect the residents around SIPCOT in Cuddalore are Asthma, skin cancer, Genetic disorder. From the triggering pattern it is noted all nodes of graph has converged to node N1 is major cause. To avoid this problem we suggest the following measures.

(1). Health care facilities: The Health department should set up specialized health care facilities to cater to the special needs of pollution impacted communities.

(2). Hospital Infrastructure in the areas near polluting industries should have trained personnel and equipment to deal with cases of industrial injury and poisoning.

(3). Provide clean piped drinking water to SIPCOT villagers. The water should be provided by panchayat and be paid for by the industries.

(4). The government must create awareness among the residents that most chemicals enter the body mainly through skin contact and inhaling of polluted air.

(5). Free medical camps must be organized at least once in three months. A 24 hour hospital with all required facilities and qualified doctors must be set up in the area.

(6). Polluted lands and the contaminated aquifers must be rehabilitated at the cost of the polluter.

(7). Stop exposure by stopping pollution and pollution control acts are often not enforced rigorously as a concession to industries.

(8). The Health department should play a proactive role in ensuring that practices to prevent harm are followed among the residents of SIPCOT in cuddalore.

(9). The government should provide clean mask to people of that area to prevent from the toxic air.

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