IFAM model approach on the impact of pesticides on agricultural labourers

K. Balasangu[1], K. Thirusangu[2] and V. R. Dare[3]
Department of Mathematics, T. K. G. Arts College, Vriddhachalam, TN, India
Department of Mathematics, SIVET College, Gowrivakkam, Chennai-600073, India
Department of Mathematics, Madras Christian College, Tambaram, Chennai-600059, India
kthirusangu@gmail.com

Abstract

We use fuzzy associative memories (FAM) and induced fuzzy associative memories (IFAM), to analyze the causes for health hazards faced by agriculture labourers. Based on our study, we made conclusions and suggested some remedial measures.
Keywords: Health hazards, FAM, IFAM, fixed point, limit cycle, hidden pattern.
2000 Mathematics subject classification: 91B96, 92B20

Introduction

Fuzzy models are mathematical tools introduced by Zadeh (1965). In 1976, Axelord used the fuzzy tools to study political decisions. Later in 1986, using the concepts of neural networks and fuzzy logic, Bart Kosko proposed many more models (Kosko, 1986). Among the various fuzzy models, bi associative memories (BAM), fuzzy cognitive maps (FCM) and fuzzy relational maps (FRM) are some of the important models which have been used to study these problems. Fuzzy associative memories (FAM) were introduced by Bart Kosko in 1997. FAM yields gradation among the attributes (Kosko, 2001). 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 memory (RFAM), fuzzy morphological associative memories (FMAM) and induced FAM (IFAM) (Pathinathan *et al.*, 2005). FAM is much useful if learning algorithms are applied, because it allows rules to be updated easily. FAM has been used by many researchers to study evolutionary computation, to predict cement quality, to predict stock price index and to study the application of neural networks and fuzzy systems. In Balasangu *et al.* (2010) using IFCM model, it is shown that the pollution and the health hazards are mainly due to spray of pesticides and manuring the fields with chemical fertilizers. They have also used IBAM model, IFRM model and neural net work model to analyze this problem (Balasangu *et al.,* 2007; Balasangu *et al.,* 2008; Balasangu *et al.,* 2009a, b). In this paper, we first use FAM model and then IFAM model to analyze the methods of using pesticides which results health hazards to agriculture labourers caused by pesticides. Thus we have shown that this model is most suitable to find the effective relationship between the causes. We also provide some remedial measures.

Fuzzy associative memories

In this section we present the definitions and the basic notions relevant to this paper.
Definition: A fuzzy set is a map $\mu: X \to [0, 1]$, where X is any set called the domain and [0, 1] the range. For every element $x \in X$, μ assigns membership value in the interval [0, 1]. The geometry of fuzzy sets aids us to describe fuzziness, to define fuzzy concepts and to prove fuzzy theorems. Visualizing this geometry may by itself provide the most powerful argument for fuzziness.

Definition: The n-dimensional unit hypercube is denoted as $I^n = [0, 1]^n = [0, 1] \times \dots \times [0, 1]$. A fuzzy set defines a point in the cube I^n. Vertices of the cube I^n are non-fuzzy sets. The n-dimensional unit hyper cube I^n houses all the fuzzy subsets of the form $X = x_1, \dots, x_n$.

Here we are interested in the distance between points within the unit hypercube $I^n = [0, 1]^n$ which led to measures of size and fuzziness of a fuzzy set and more fundamentally to a measure.

Definition: Fuzzy system defines mappings between cubes. Fuzzy system S maps fuzzy sets to fuzzy sets. That is, $S: I^n \to I^p$, where n and p are finite positive integers. The n-dimensional unit hypercube I^n consists of all the fuzzy subsets of the domain space $X = \{ (x_1, \dots, x_n) \mid x_i \in R, \ i = 1, \dots, n \}$. Similarly I^p consists of all the fuzzy subsets of the range space $Y = \{ (y_1, \dots, y_p) \mid y_i \in R, \ i = 1, \dots, p \}$. Hence X denotes a subset of R^n and Y denotes the subset of R^p. The system maps similar inputs to similar outputs. Thus the fuzzy system S maps balls of fuzzy sets in I^n to balls of fuzzy sets in I^p. These continuous fuzzy systems behave as an associative memory known as fuzzy associative memory. Thus fuzzy associative memories are transformations. In this paper, the fuzzy sets A and B are points in unit hypercube, which are viewed as natural vectors. These A and B are represented by numerical fit vectors.
Let $A = \{ a_1, \dots, a_n \}$ and $B = \{b_1, \dots, b_p \}$, where $a_i = \mu_A(x_i)$ and $b_j = \mu_B(y_j)$.

Definition: The fuzzy set association (A_i, B_i) is 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 the 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 causes as per the attributes chosen by the expert. In this paper we analyze the health problems of agriculture labourers and coolies caused by pesticides and suggest some remedial measures.

Adaptation of FAM to the problem

We collected data from farmers regarding their diseases and the reasons for the diseases and we call them as attributes. Suppose that there are n attributes, $x_1, \ldots ,x_n$ where n is finite, associated with the diseases and let $y_1, \ldots ,y_p$ be the attributes associated methods of using pesticides. The connection matrix M of order n × p is obtained through the expert. From the data collected from farmers, the diseases and the reasons for the diseases are divided as the following attributes.   The attributes related to reasons are: 1. The pesticide inhalation during the spraying of pesticides in agricultural lands; 2. Improper mixing; 3. Eating and drinking during pesticide application; 4. Wiping sweat off the face; 5. Spraying against the wind; 6. Reentering recently sprayed area; 7. Using pesticide for more number of years; 8. Washing pesticide containers before selling and 9. Use of contaminated cloths.

The expert is a medical officer. The attributes connections with diseases are: 1. Hypertension; 2. Diabetics; 3. Kidney disease; 4. Asthma; 5. Dermatitis; 6. Cancer; 7. Blurring of vision; 8. Allergy; 9. Giddiness and 10. Neurological problems

Denote the attributes associated with the diseases as C1, C2, C3, C4 , C5 , C6, C7,C8 and C9 and denote the attributes associated with the reasons for the diseases as P1, P2, P3, P4 , P5 , P6, P7, P8, P9 and P10.

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

$$
M = \begin{array}{c|cccccccccc}
 & P_1 & P_2 & P_3 & P_4 & P_5 & P_6 & P_7 & P_8 & P_9 & P_{10} \\
\hline
C_1 & 0.2 & 0.0 & 0.0 & 0.8 & 0.6 & 0.2 & 0.6 & 0.7 & 0.5 & 0.4 \\
C_2 & 0.3 & 0.2 & 0.2 & 0.5 & 0.5 & 0.3 & 0.5 & 0.5 & 0.6 & 0.5 \\
C_3 & 0.3 & 0.0 & 0.2 & 0.6 & 0.5 & 0.2 & 0.4 & 0.8 & 0.4 & 0.2 \\
C_4 & 0.2 & 0.1 & 0.2 & 0.6 & 0.5 & 0.0 & 0.5 & 0.7 & 0.2 & 0.3 \\
C_5 & 0.3 & 0.3 & 0.1 & 0.8 & 0.6 & 0.1 & 0.4 & 0.5 & 0.4 & 0.4 \\
C_6 & 0.0 & 0.3 & 0.2 & 0.8 & 0.4 & 0.2 & 0.6 & 0.4 & 0.3 & 0.4 \\
C_7 & 0.0 & 0.1 & 0.3 & 0.9 & 0.5 & 0.3 & 0.7 & 0.7 & 0.5 & 0.8 \\
C_8 & 0.1 & 0.0 & 0.2 & 0.6 & 0.5 & 0.1 & 0.5 & 0.6 & 0.2 & 0.4 \\
C_9 & 0.2 & 0.1 & 0.1 & 0.6 & 0.4 & 0.2 & 0.4 & 0.8 & 0.6 & 0.3 \\
\end{array}
$$

Analysis using FAM

Let the initial state vector be C_1= (1 0 0 0 0 0 0 0 0)
The effect of C1 in dynamical system M is
C1M=(2 0 0 .8 .6 .2 .6 .7 .5 .4) $\longmapsto$ (0 0 0 1 0 0 0 1 0 0)=A_1
The result of A_1 M^T of order 1 × 9 is
(.8 .5 .8 .7 .8 .8 .9 .6 .8) $\longmapsto$ (1 0 1 0 1 1 1 0 1) = C2

Now C1 is not equal to C2. Hence we proceed further to get the limit point as follows.
The effect of C2 in dynamical system M is
C2M = (.3 .3 .3 .9 .6 .3 .7 .8 .6 .8) $\longmapsto$ (0 0 0 1 0 0 0 1 0 1) = A2
The result of A_2 M^T of order 1 × 9 is
(.8 .5 .8 .7 .8 .8 .9 .6 .8) $\longmapsto$ (1 0 1 0 1 1 1 0 1) = C3
Now C2 = C3.
Hence the pair of limit point is:
(0 0 0 1 0 0 0 1 0 1) (1 0 1 0 1 1 1 0 1)
 The set of limit points corresponding to different input vectors are given in Table 1.

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

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

Description of induced fuzzy associative memories (IFAM) model

Suppose that 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 methods of using pesticides. The connection matrix M of order n × p is obtained through the expert. Let C_1 be the initial input vector 1 × n. A particular component, say c_1, is kept on ON state and all other components on OFF state and pass the state vector C_1 through the connection matrix M. To convert the resultant vector into a 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 $\longmapsto$.   The resulting vector is multiplied with M^T and thresholding yields a new vector D_1. This vector is related with the connection matrix and that vector which gives the highest number of attributes to ON state is chosen as C_2. That is, 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 C_2. If there are two or more vectors with equal number of 1s as ON state, choose the first occurring one as C_2. Repeat the same procedure 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 more vectors into ON state. Get the hidden pattern by the limit cycle or by getting a fixed point.

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. We observe the hidden pattern of some vectors found in all or many cases. Inference from this hidden pattern highlights the causes.

Let the input vector be C_1= (1 0 0 0 0 0 0 0 0)
Now (1 0 0 0 0 0 0 0 0) M = (.2 0 0 .8 .6 .2 .6 .7 .5 .4) ↪ (0 0 0 1 0 0 0 1 0 0)
(0 0 0 1 0 0 0 1 0 0) M^T = (.8 .5 .8 .7 .8 .8 .9 .6 .8) ↪ (1 0 1 0 1 1 1 0 1) = C_1.

The new vectors are
$C_1^{(1)}$ = (1 0 0 0 0 0 0 0 0)
$C_1^{(2)}$= (0 0 1 0 0 0 0 0 0)
$C_1^{(3)}$ = (0 0 0 0 1 0 0 0 0)
$C_1^{(4)}$= (0 0 0 0 0 1 0 0 0)
$C_1^{(5)}$= (0 0 0 0 0 0 1 0 0)
$C_1^{(6)}$ = (0 0 0 0 0 0 0 0 1)

Case 1:
$C_1^{(1)}$M = (1 0 0 0 0 0 0 0 0)M = (.2 0 0 .8 .6 .2 .6 .7 .5 .4) ↪ (0 0 0 1 0 0 0 1 0 0).
(0 0 0 1 0 0 0 1 0 0) M^T = (.8 .5 .8 .7 .8 .8 .9 .6 .8) ↪ (1 0 1 0 1 1 1 0 1)

SUM is 6

Case 2:
$C_1^{(2)}$M = (0 0 1 0 0 0 0 0 0)M = (.3 0 .2 .6 .5 .2 .4 .8 .4 .2) ↪ (0 0 0 1 0 0 0 1 0 0)
(0 0 0 1 0 0 0 1 0 0)) M^T= (.8 .5 .8 .7 .8 .8 .9 .6 .8) ↪ (1 0 1 0 1 1 1 0 1)

SUM is 6

Case 3:
$C_1^{(3)}$M = (0 0 0 0 1 0 0 0 0)M = (.3 .3 .1 .8 .6 .1 .4 .5 .4 .4) ↪ (0 0 0 1 1 0 0 0 0 0)
(0 0 0 1 1 0 0 0 0 0)M^T= (.8 .5 .6 .6 .8 .8 .9 .6 .6) ↪ (1 0 0 0 1 1 1 0 0)

SUM is 4

Case 4:
$C_1^{(4)}$ M = (0 0 0 0 0 1 0 0 0)M = (0 .3 .2 .8 .4 .2 .6 .4 .3 .4) ↪ (0 0 0 1 0 0 1 0 0 0)
(0 0 0 1 0 0 1 0 0 0)M^T = (.8 .5 .6 .6 .8 .8 .9 .6 .6) ↪ (1 0 0 0 1 1 1 0 0)

SUM is 4

Case 5:
$C_1^{(5)}$ M = (0 0 0 0 0 0 1 0 0)M = (0 .1 .3 .9 .5 .3 .7 .7 .5 .8) ↪ (0 0 0 1 0 0 0 0 0 1)
(0 0 0 1 0 0 0 0 0 1)M^T= (.8 .5 .6 .6 .8 .8 .9 .6 .6) ↪ (1 0 0 0 1 1 1 0 0)

SUM is 4

Case 6:
$C_1^{(6)}$ M = (0 0 0 0 0 0 0 0 1)M = (.2 .1 .1 .6 .4 .2 .4 .8 .6 .3) ↪ (0 0 0 1 0 0 0 1 1 0)
(0 0 0 1 0 0 0 1 0 0)M^T= (.8 .5 .8 .7 .8 .8 .9 .6 .8) ↪ (1 0 1 0 1 1 1 0 1)

SUM is 6

Therefore the new input vector C2 to be multiplied with M is: (1 0 1 0 1 1 1 0 1)

Now C2M = (1 0 1 0 1 1 1 0 1) M = (.3 .3 .3 .9 .6 .3 .7 .8 .6 .8) ↪ (0 0 0 1 0 0 0 1 0 1)
(0 0 0 1 0 0 0 1 0 1)M^T = (.8 .5 .8 .7 .8 .8 .9 .6 .8) ↪ (1 0 1 0 1 1 1 0 1) = C_2=C_1

Hence the pair of limit point is: (1 0 1 0 1 1 1 0 1) (0 0 0 1 0 0 0 1 0 1)
For various input vectors, we get different triggering patterns and all these triggering patterns are given in Table 2.

Table 2. Different triggering for various input vectors.

Input vector	Limit point	Triggering pattern
(100000000)	(101011101) (0001000101)	$C_1 \Rightarrow C_1$
(010000000)	101011101) (0001000101)	$C_2 \Rightarrow C_1 \Rightarrow C_1$
(001000000)	(101011101) (0001000101)	$C_3 \Rightarrow C_1 \Rightarrow C_1$
(000100000)	(101011101) (0001000101)	$C_4 \Rightarrow C_1 \Rightarrow C_1$
(000010000)	(101011101) (0001000101)	$C_5 \Rightarrow C_1 \Rightarrow C_1$
(000001000)	(101011101) (0001000101)	$C_6 \Rightarrow C_1 \Rightarrow C_1$
(000000100)	(101011101) (0001000101)	$C_7 \Rightarrow C_1 \Rightarrow C_1$
(000000010)	(101011101) (0001000101)	$C_8 \Rightarrow C_1 \Rightarrow C_1$
(000000001)	(101011101) (0001000101)	$C_9 \Rightarrow C_1 \Rightarrow C_1$

The triggering patterns for these limit points are shown in Fig. 1. The merged graph is given in Fig. 2. Since the IFAM gives a gradation, we are able to get the triggering pattern between the attributes which causes the

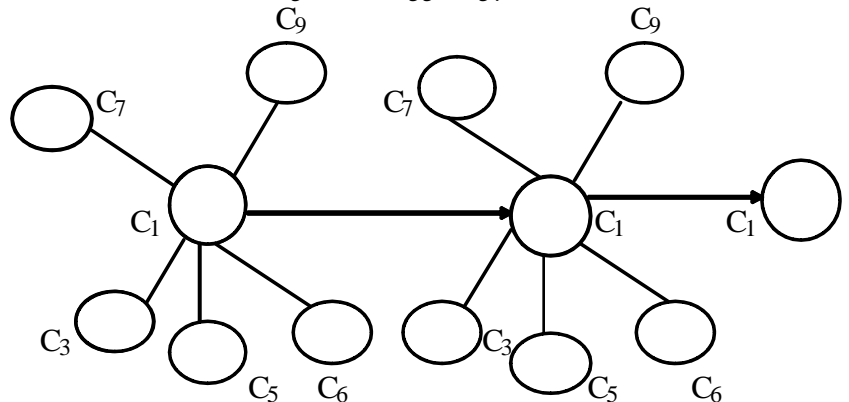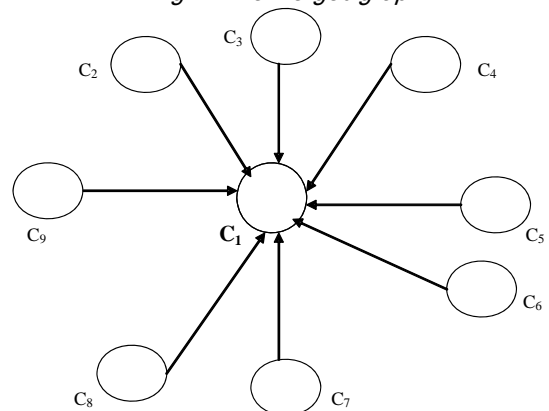*Fig. 1. The triggering pattern.*

Fig. 2. The merged graph.

diseases.

Conclusion and suggestions

We analyzed the health problems of agriculture labourers and coolies. It is observed from the limit point that the major diseases which attack the farmer's are asthma, allergy and neurological problems. This is mainly due to the following reasons:

1. The pesticide inhalation during the spraying of pesticides in agricultural lands; eating and drinking during pesticide application; spraying against the wind; reentering recently sprayed area; using pesticide for more number of years and use of contaminated cloths.

But from the triggering pattern, it is noted that all the nodes of the graph is converged to the node C_1. Thus the attribute corresponding to C_1 is the major cause. Thus we conclude that the root cause for all these diseases is the inhalation of pesticides during the spraying of pesticides in agricultural lands. To avoid this problem we suggest the following measures:

1. Either through the sellers or through agriculture officers, the government should educate agriculture labourers about the safe use of pesticides to reduce the health effects of them.
2. The government must create awareness among the farmers that most chemicals enter the body mainly through skin contact. The farmers should be given training to learn how, when and where most pesticides enter the body. The training takes away the misconception that breathing is the most common way of poisoning.
3. After applying pesticides, the farmers should always take a thorough bath or shower to clean the body.
4. Observe the wind direction when spraying and make sure to stay above the wind to minimize contact with the spray mist. When spraying, use protective clothing to prevent the spray mist coming in contact with the body. Protective clothing includes the use of gloves and masks.
5. The amount of pesticides used can be decreased by spraying lower dosages (e.g. spray on a moment when the pest is most vulnerable, young caterpillars are easier to kill than bigger ones).
6. The amount of pesticides used can be reduced by using spot application (e.g. don't spray the whole field if only a part of the field is infested, don't spray the entire plant if the pest only occupies a part of the plant).
7. They should aware of symptoms of poisoning: headache, nausea, trembling hands, etc. If you notice any symptom or if you don't feel well, immediately see a doctor and inform which product (active ingredient) you used, or bring the pesticide container with label to the doctor.

References

1. Axelrod R (1976) Structure of decision: The cognitive maps of political elites, Princeton University press, New Jersey.
2. Balasangu K, Thirusangu K and Dare VR (2010) IFCM model approach on the health hazards faced by the agriculture labourers. *Int. J. Analyzing Methods Components Combinatorial Biol. Maths*. (IJAMCCBM) (To appear).
3. Balasangu K, Thirusangu K and Rajkumar Dare V (2007) A fuzzy approach on the analysis of health hazards faced by the agriculture labourers due to chemical pollutions, Proc. Of the Indian conf. on intelligent systems (Allied publishers), pp:123-128.
4. Kosko B (1986) Fuzzy cognitive maps. *Int. J. Man-Machine Studies*. 34, 65-75.
5. Kosko B (2001) Neural networks and fuzzy systems: A dynamical systems approach to machine intelligence. Prentice Hall publishers.
6. Pathinathan T, Thirusangu K and Mary John (2005) On causes for school dropouts- A fuzzy approach. *Acta Ciencia Indica,* 31(4), 1279-1299.
7. Thirusangu K, Balasangu K and Dare VR (2008) On the causes of health hazards faced by the agriculture labourers using IBAM model. *Int. J. Analyzing Methods Components Combinatorial Biol. Maths* (IJAMCCBM), 1(2), 145-153.
8. Thirusangu K, Balasangu K and Dare VR (2009a) On the health hazards of the rice cultivators using IFRM model. *Int. J. Analyzing Methods of Components Combinatorial Biol. Maths* (IJAMCCBM), 1(1), 1-10.
9. Thirusangu K, Balasangu K and Dare VR (2009b) A neural network model approach on the health hazards of agriculture farmers. Int. J. Analyzing Methods Components Combinatorial Biol. Maths (IJAMCCBM), 1(1), 11-18.
10. Zadeh LA (1965) Fuzzy sets. *Information Control*. 8, 338-353.