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Kosko Hamming Distance in the Analysis of FCMs to Study the Problems of Locals due to Dumping of solid waste in Kodungaiyur

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Abstract.

In this paper we for the first time define a new notion called Kosko - Hamming distance in the study of several experts using Fuzzy Cognitive Maps(FCMs)model. This new concept finds how two experts opinions differ using a distance function d_k between each of the individual experts. Here we study the health problems faced by the locals due to the dumping of solid waste. This study was carried out by taking a sample survey from around 40 persons living in and around the Kodungaiyur area. We have analysed the data using FCMs by taking 6 experts opinion.

Key words: Fuzzy Cognitive Maps (FCMs) model, hidden pattern, state vectors, fixed point and limit cycle, Kosko- Hamming distance (KH-distance denoted by d_k).

1. Introduction

This paper has five sections. Section one is introductory in nature. Section two introduces a new concept of Kosko - Hamming distance d_K of the resultant state vectors which depends on the same initial state vector. Section three describes the problem and gives justification for using the FCMs model. Section four analyses this problem using FCMs. The final section gives the table of comparison using Kosko - Hamming distance function d_k and conclusions based on the study. When the data under investigation is an unsupervised one and when it involves feelings or emotions of a person be it psychological or otherwise the existing statistical methods cannot analyse the problem. The best model to study this type of unsupervised data is the Fuzzy Cognitive Maps (FCMs) model. FCMs can give the hidden pattern of the dynamical system.

This paper makes use of FCMs and for more about FCMs refer[1-7].

2. Kosko - Hamming Distance:

In this section we define a new type of distance on the state vectors in $Z_2^n = \{(a_1, a_2, \dots, a_n) / a_i \in Z_2\}$ depending on some fixed initial state vector. We know on Z_2^n the usual Hamming distance has been defined[8].

However the Kosko – Hamming distance cannot be defined for any pair of vectors in Z_2^n as in case of Hamming distance which can defined for any pair of vectors in Z_2^n.

Definition 2.1: Let $S = \{(a_1, a_2, \dots, a_n) / a_i \in \{0,1\}; 1 \le i \le n\}$. *S is the set of state vectors of an FCMs of any dynamical system functioning on a set of n distinct attributes.*

Let $X_i = (0,\dots,x_i,0,\dots,0)$ *be the state vector with only in the on state and all other nodes are in the off state (that is* $x_i = 1$*). Suppose two experts work on the same collection of attributes using the FCMs with the same* X_i*, the initial state vector and if* Y_1 *and* Y_2 *are the resultant state vector of the initial state vector* X_i *(That is the hidden patterns of the state vector* X_i*) given by two different experts. Then the Hamming distance* $d_k(Y_1, Y_2) = k \ge 0$ *is defined as the Kosko-Hamming distance.* d_k *measures the Kosko-Hamming distance of 2 state vectors which has a prior basic relation. The Kosko-Hamming distance measures how far two experts agree or disagree on a resultant of the same initial state vector associated with the FCMs model. Thus the Kosko-Hamming distance can be defined only under these conditions.*

- *(i) For Kosko-Hamming distance* d_k *to be defined we should have a problem which adopts the Fuzzy Cognitive Maps model.*
- *(ii) If* $x \in Z_2^n = \{(a_1, a_2, \dots, a_n) / a_i \in Z_2; 1 \le i \le n\}$ *then we cannot find* $d_k(x, y)$ *for any* $x, y \in Z_2^n$.
- *(iii) We can define* d_k *only for a special pair of state vectors x,y in* Z_2^n *where both x and y are resultant state vectors of the same initial state vector associated with the FCM model.*
- *(iv)* $d_k(x, y) = d(x, y)$ *where d is the Hamming distance on* Z_2^n*. But however* $d_k(x, y)$ *is dependent on the FCM model, on the hidden pattern, on the expert opinion and on the same basic initial state vector.*

Since the distance cannot be or is not defined for any pair of vectors in S and is defined only for this type of special pairs, to honour Kosko the authors call this distance for these appropriate pair of state vectors associated with a FCMs model as the Kosko Hamming distance.

Illustrations and the use of this new distance d_k is described and developed in the final section of this paper.

3. Description of the problem and justification for using the FCMs model:

In this section we just describe the problem, the related attributes and give justification for using the FCMs model.

People living in and around Kodungaiyur area North Chennai are generally affected by malaria, elephantiasis, dengue, diarrhea and other diseases due to the polluted water and air. This area serves as the waste disposal place. Waste from neighbouring areas are dumped in Kodungaiyur. To dispose these solid wastes they are continuously burnt so air is always polluted by the smoke; due to constant burning of this waste. So here we study the health hazards suffered by the people living in and around Kodungaiyur due to environmental pollution caused by dumping of waste. Since the attributes related with all the facts of this problem cannot be described by numbers and reasons cannot be given as a statistical data and as the data in hand is an unsupervised one, we are justified in using Fuzzy Cognitive Maps (FCMs) model.

To build the model we use the following 9 nodes suggested by several of the experts who analyse the problem:

C_1 – Lung disease like cold, breathlessness etc

C_2 – Malaria

C_3 – Elephantiasis

C_4 – Stagnant water near by the dumped waste

C_5 – Diarrhea

C_6 – Dengue

C_7 – Hypertension and headache

C_8 – Burning solid waste so acute environment pollutions

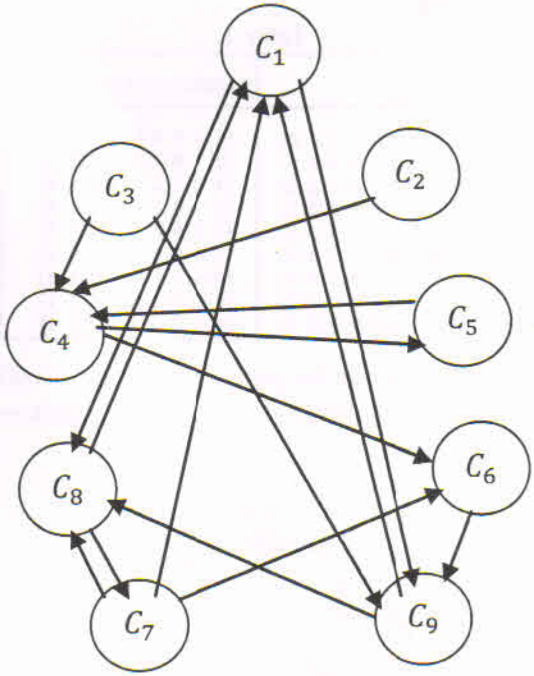
C_9 – Unbearable foul smell due to the decaying of waste.

4. Analysis of the problem using FCMs:

Here we have taken six experts opinion to analyse the problem; they are, local politician and NGO working for the welfare of local people, representation of a youth club, school teacher of the local school and two medical experts working in Kodungaiyur.

All them work only on the attributes mentioned in section three of this paper using FCMs model. Here the first expert opinion is given in the following.

Let C_1 represent the graph given by the first expert who is a local politicion.



Graph C_1

Let E_1 be the connection matrix related with the graph G_1 which is as follows:

$$E_1 = \begin{pmatrix} 0&0&0&0&0&0&0&1&1 \\ 0&0&0&1&0&0&0&0&0 \\ 0&0&0&1&0&0&0&0&1 \\ 0&0&0&0&1&1&0&0&0 \\ 0&0&0&1&0&0&0&0&0 \\ 0&0&0&0&0&0&0&0&1 \\ 1&0&0&0&0&1&0&1&0 \\ 1&0&0&0&0&0&1&0&0 \\ 1&0&0&0&0&0&0&1&0 \end{pmatrix}.$$

The on state of the nodes

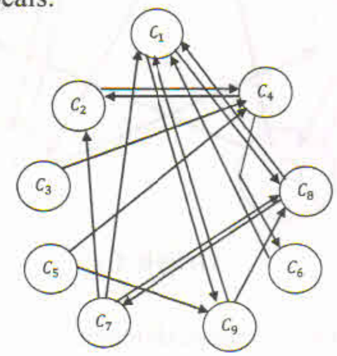
$C_1 = (1\,0\,0\,0\,0\,0\,0\,0\,0)$, $C_2 = (0\,1\,0\,0\,0\,0\,0\,0\,0)$, $C_3 = (0\,0\,1\,0\,0\,0\,0\,0\,0)$, $C_4 = (0\,0\,0\,1\,0\,0\,0\,0\,0)$, $C_5 = (0\,0\,0\,0\,1\,0\,0\,0\,0)$, $C_6 = (0\,0\,0\,0\,0\,1\,0\,0\,0)$, $C_7 = (0\,0\,0\,0\,0\,0\,1\,0\,0)$, $C_8 = (0\,0\,0\,0\,0\,0\,0\,1\,0)$, $C_9 = (0\,0\,0\,0\,0\,0\,0\,0\,1)$

and the resultant hidden pattern using the dynamical system E_1 are calculated using the connection matrix E_1 and are tabulated in the following

Table 1.

C_i's	Hidden pattern using E_1
(1 0 0 0 0 0 0 0 0)	(1 0 0 0 0 1 1 1 1)
(0 1 0 0 0 0 0 0 0)	(1 1 0 1 1 1 1 1 1)
(0 0 1 0 0 0 0 0 0)	(1 0 1 1 1 1 1 1 1)
(0 0 0 1 0 0 0 0 0)	(1 0 0 1 1 1 1 1 1)
(0 0 0 0 1 0 0 0 0)	(1 0 0 1 1 1 1 1 1)
(0 0 0 0 0 1 0 0 0)	(1 0 0 0 0 1 1 1 1)
(0 0 0 0 0 0 1 0 0)	(1 0 0 0 0 1 1 1 1)
(0 0 0 0 0 0 0 1 0)	(1 0 0 0 0 1 1 1 1)
(0 0 0 0 0 0 0 0 1)	(1 0 0 0 0 1 1 1 1)

Let G_2 represent the graph given by the second expert who is an NGO working for the welfare of the locals.



Graph G_2

E_2 be the connection matrix related with the graph G_2 is as follows:

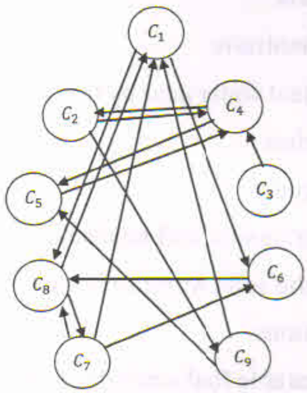
$$E_2 = \begin{pmatrix} 0&0&0&0&0&0&0&1&1 \\ 0&0&0&1&0&0&0&0&0 \\ 0&0&0&1&0&0&0&0&0 \\ 0&1&0&0&0&1&0&0&0 \\ 0&0&0&1&0&0&0&0&1 \\ 1&0&0&0&0&0&0&0&0 \\ 1&1&0&0&0&0&0&1&0 \\ 1&0&0&0&0&0&1&0&0 \\ 1&0&0&0&0&0&0&1&0 \end{pmatrix}.$$

The on state of the nodes $C_1, C_2, \ldots, C_9$, and the resultant hidden pattern calculated using the dynamical system E_2 are tabulated as follows:

Table 2

C_i s	Hidden pattern using E_2
(1 0 0 0 0 0 0 0 0)	(1 1 0 0 0 0 1 1 1)
(0 1 0 0 0 0 0 0 0)	(1 1 0 1 0 1 1 1 1)
(0 0 1 0 0 0 0 0 0)	(1 1 1 1 0 1 1 1 1)
(0 0 0 1 0 0 0 0 0)	(1 1 0 1 0 1 1 1 1)
(0 0 0 0 1 0 0 0 0)	(1 1 0 1 1 1 1 1 1)
(0 0 0 0 0 1 0 0 0)	(1 1 0 1 0 1 1 1 1)
(0 0 0 0 0 0 1 0 0)	(1 1 0 1 0 1 1 1 1)
(0 0 0 0 0 0 0 1 0)	(1 1 0 1 0 1 1 1 1)
(0 0 0 0 0 0 0 0 1)	(1 1 0 1 0 1 1 1 1)

Let G_3 represent the graph given by the third expert who is a representative of a youth club.



Graph G_3

E_3 be the connection matrix related with the graph given G_3 in the following.

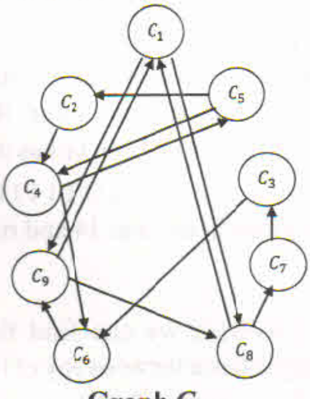
$$E_3=\begin{pmatrix} 0&0&0&0&0&1&0&1&0\\ 0&0&0&1&0&0&0&0&1\\ 0&0&0&1&0&0&0&0&0\\ 0&1&0&0&1&0&0&0&0\\ 0&0&0&1&0&0&0&0&0\\ 0&0&0&0&0&0&0&1&0\\ 1&0&0&0&0&1&0&1&0\\ 1&0&0&0&0&0&1&0&0\\ 1&0&0&0&1&0&0&0&0 \end{pmatrix}.$$

The on state of the nodes $C_1, C_2, \ldots, C_9$, and the resultant hidden pattern calculated using the dynamical system E_3 are tabulated in the following:

Table 3

C_i 's	Hidden pattern using E_3
(1 0 0 0 0 0 0 0 0)	(1 0 0 0 0 0 0 0 0)
(0 1 0 0 0 0 0 0 0)	(0 1 0 0 0 0 0 0 0)
(0 0 1 0 0 0 0 0 0)	(0 0 1 0 0 0 0 0 0)
(0 0 0 1 0 0 0 0 0)	(0 0 0 1 0 0 0 0 0)
(0 0 0 0 1 0 0 0 0)	(0 0 0 0 1 0 0 0 0)
(0 0 0 0 0 1 0 0 0)	(0 0 0 0 0 1 0 0 0)
(0 0 0 0 0 0 1 0 0)	(0 0 0 0 0 0 1 0 0)
(0 0 0 0 0 0 0 1 0)	(0 0 0 0 0 0 0 1 0)
(0 0 0 0 0 0 0 0 1)	(0 0 0 0 0 0 0 0 1)

Let G_4 represent the graph given by the fourth expert who is a school teacher of the local school.



Graph G_4

E_4 be the connection matrix related with the graph G_4:

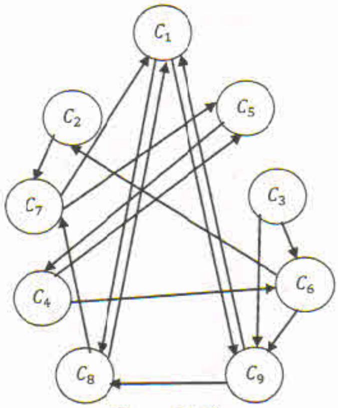
$$E_4=\begin{pmatrix} 0&0&0&0&0&0&0&1&1\\ 0&0&0&1&0&0&0&0&0\\ 0&0&0&0&0&1&0&0&0\\ 0&0&0&0&1&1&0&0&0\\ 0&1&0&1&0&0&0&0&0\\ 0&0&0&0&0&0&0&0&1\\ 0&0&1&0&0&0&0&0&0\\ 1&0&0&0&0&0&1&0&0\\ 1&0&0&0&0&0&0&1&0 \end{pmatrix}.$$

The on state of the nodes $C_1, C_2, \ldots, C_9$, and the resultant hidden pattern calculated using the dynamical system E_4 are tabulated below in table 4.

Table 4

C_i 's	Hidden pattern using E_3
(1 0 0 0 0 0 0 0 0)	(1 0 1 0 0 0 1 1 1)
(0 1 0 0 0 0 0 0 0)	(0 1 0 1 1 1 0 0 0)
(0 0 1 0 0 0 0 0 0)	(1 0 1 0 0 1 1 1 1)
(0 0 0 1 0 0 0 0 0)	(1 1 1 1 1 1 1 1 1)
(0 0 0 0 1 0 0 0 0)	(1 1 1 1 1 1 1 1 1)
(0 0 0 0 0 1 0 0 0)	(1 0 1 0 0 1 1 1 1)
(0 0 0 0 0 0 1 0 0)	(1 0 1 0 0 1 1 1 1)
(0 0 0 0 0 0 0 1 0)	(1 0 1 0 0 0 1 1 1)
(0 0 0 0 0 0 0 0 1)	(1 0 1 0 0 0 1 1 1)

Let G_5 represent the graph given by the fifth expert who is a medical expert working in Kodungaiyur.



Graph G_5

E_5 be the connection matrix related with the graph G_5.

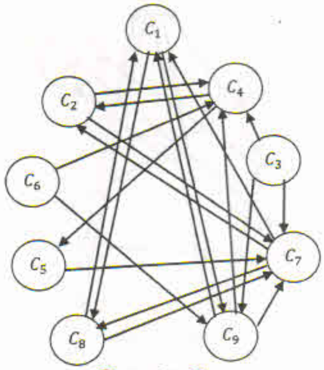
$$E_5 = \begin{pmatrix} 0&0&0&0&0&0&0&1&1\\ 0&0&0&0&0&0&1&0&0\\ 0&0&0&0&0&1&0&0&1\\ 0&0&0&0&1&1&0&0&0\\ 0&0&0&1&0&0&0&0&0\\ 0&1&0&0&0&0&0&0&1\\ 1&0&0&0&1&0&0&0&0\\ 1&0&0&0&0&0&1&0&0\\ 1&0&0&0&0&0&0&1&0 \end{pmatrix}.$$

The on state of the nodes $C_1, C_2, \ldots, C_9$, and the resultant hidden pattern calculated using the dynamical system E_5 are tabulated as follows:

Table 5

C_i's	Hidden pattern using E_5
(1 0 0 0 0 0 0 0 0)	(1 1 0 1 1 1 1 1 1)
(0 1 0 0 0 0 0 0 0)	(1 1 0 1 1 1 1 1 1)
(0 0 1 0 0 0 0 0 0)	(1 1 1 1 1 1 1 1 1)
(0 0 0 1 0 0 0 0 0)	(1 1 0 1 1 1 1 1 1)
(0 0 0 0 1 0 0 0 0)	(1 1 0 1 1 1 1 1 1)
(0 0 0 0 0 1 0 0 0)	(1 1 0 1 1 1 1 1 1)
(0 0 0 0 0 0 1 0 0)	(1 1 0 1 1 1 1 1 1)
(0 0 0 0 0 0 0 1 0)	(1 1 0 1 1 1 1 1 1)
(0 0 0 0 0 0 0 0 1)	(1 1 0 1 1 1 1 1 1)

Let G_6 represent the graph given by the sixth expert who again a local doctor.



Graph G_6

E_6 be the connection matrix related with the graph G_6.

$$E_6 = \begin{pmatrix} 0&0&0&0&0&0&0&1&1\\ 0&0&0&1&0&0&1&0&0\\ 0&0&0&1&0&0&1&0&1\\ 0&1&0&0&1&0&0&0&0\\ 0&0&0&0&0&0&1&0&0\\ 0&0&0&1&0&0&0&0&1\\ 1&1&0&0&0&0&0&1&0\\ 1&0&0&0&0&0&1&0&0\\ 1&0&0&1&0&0&1&0&0 \end{pmatrix}.$$

The on state of the nodes $C_1, C_2, \ldots, C_9$, and the resultant hidden pattern obtained by the dynamical system E_6 are tabulated in the following:

Table 6

C_i's	Hidden pattern using E_6
(1 0 0 0 0 0 0 0 0)	(1 1 0 1 1 0 1 1 1)
(0 1 0 0 0 0 0 0 0)	(1 1 0 1 1 0 1 1 1)
(0 0 1 0 0 0 0 0 0)	(1 1 1 1 1 0 1 1 1)
(0 0 0 1 0 0 0 0 0)	(1 1 0 1 1 0 1 1 1)
(0 0 0 0 1 0 0 0 0)	(1 1 0 1 1 0 1 1 1)
(0 0 0 0 0 1 0 0 0)	(1 1 0 1 1 1 1 1 1)
(0 0 0 0 0 0 1 0 0)	(1 1 0 1 1 0 1 1 1)
(0 0 0 0 0 0 0 1 0)	(1 1 0 1 1 0 1 1 1)
(0 0 0 0 0 0 0 0 1)	(1 1 0 1 1 0 1 1 1)

5. Conclusion

We find the Kosko-Hamming distance between the appropriate hidden patterns. Now for instance consider the initial state vector $C_3 = (0\ 0\ 1\ 0\ 0\ 0\ 0\ 0\ 0)$ in tables 4 and 6, we have $d_k[(1\,0\,1\,0\,0\,1\,1\,1\,1), (1\,1\,1\,1\,1\,0\,1\,1\,1)] = 4$ which is given in column 14 and row three of Table 7.

Likewise we can find the Kosko-Hamming distance between any of the relevant C_i's the first column of all the 6 tables. While comparing table t with table s we denote it by $d_k(E_t, E_s); 1 \le t, s \le 6$ and the column with nine entries are given in Table 7 as $d_k(E_t, E_s)$; $1 \le t, s \le 6$. In Table seven $d_k(E_t, E_s)$ is denoted by (t, s) which is the first row of the table. Now using the tables 1 to 6, we make a comparison of all the hidden patterns given in the last column of these tables using Kosko-Hamming distance appropriately and obtain the Table 7.

Table 7

1, 2	1, 3	1, 4	1, 5	1, 6	2, 3	2, 4	2, 5	2, 6	3, 4	3, 5	3, 6	4, 5	4, 6	5, 6
2	1	2	3	4	3	2	3	2	3	4	5	5	4	1
1	0	4	0	1	1	5	1	2	4	0	1	4	5	1
2	1	2	1	2	1	2	1	2	3	0	1	3	4	1
2	1	2	1	2	1	2	1	2	1	0	1	1	2	1
1	1	2	1	2	0	1	0	1	1	0	1	1	2	1
2	1	1	3	3	3	3	1	1	2	4	4	4	4	0
2	1	1	3	4	3	3	1	2	2	4	5	4	5	1
2	1	2	3	4	3	4	1	2	4	4	5	5	4	1
2	3	2	3	4	1	4	1	2	5	0	1	5	4	1

From table 7 it is clearly seen most of the $d_k(E_i, E_j)$ (denoted by i, j) ≤ 4, which show at large the experts agree on the predictions as given by the resultant state vector only in 7 places we get 5 as the difference[8].

However it is mainly due to the difference in experts expertise as two of the experts are from medical field, who have a different view on the entire problem as it relates to study of health hazards of the people. The resultant as justly said in [1] describes or records the intelligence or ignorance of the expert. So here when the Kosko-Hamming distance is equal to five we only attribute it to the above statement. Out of the 15 columns we see only columns 7, 10, 12, 13 and 14 have 5 and these 5 values occur mainly for the initial state vector C_1, C_2, C_7, C_8 and C_9. Finally the new metric helps one to analyse the closness or the deviation of the experts opinion.

Hence we conclude that experts opinion do not have big deviation and thus giving the overall conclusion which is as follows:

According to the experts opinion lung problems like cold, breathlessness etc may also suffer from malaria, dengue, hypertension and headache which is due to burning of the waste and the foul smell.

Thus it is important on the part of the government to take proper steps to dispose the waste without polluting the environment and thereby saving the locals from health hazards.

References

1. Kosko, B., Neural Networks and Fuzzy Systems, A Dynamical Systems Approach to Machine intelligence, Prentice Hall of

India (1997).

2. Vasantha Kandasamy, W.B. and Smarandache, F., Fuzzy Cognitive Maps and Neutrosophic Cognitive Maps, *Xiquan,* USA, (2003).
3. Vasantha Kandasamy, W.B., and M. Ram Kishore. Symptom – Disease Model in children using FCM, *Ultra Sci., 11,* 318 – 324 (1999).
4. Vasantha Kandasamy, W.B., and P. Pramod. Parent Children model using FCM to study Dropouts in Primary Education. *Ultra Sci., 13*, 174 – 183 (2000).
5. Vasantha Kandasamy, W.B., and S. Uma. Fuzzy Cognitive Map of Socio – Economic Model, *Appl. Sci. Periodical, 1,* 129 – 136 (1999).
6. Vasantha Kandasamy, W.B., and V. Indira. Applications of Fuzzy Cognitive maps to determine the Maximum Utility of a Route. *J. of Fuzzy Maths,* Publ. by the Fuzzy Mat. Inst. *8,* 65 – 77 (2000).
7. Vasantha Kandasamy, Florentin Smarandache and K. Kandasamy, Fuzzy and Neutrosophic Analysis of Periyar's views on Untouchability, Hexis, Arizona, USA, (2005).
8. William J. Gilbert, Modern Algebra with Applications, Wiley, India, (2008).