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Induced Plithogenic Cognitive Maps with Combined Connection Matrix to investigate the glitches of online learning system

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Abstract: Plithogenic Cognitive Maps (PCM) introduced by Nivetha and Smarandache are extensively applied in decision making. This research work extends PCM to Induced PCM by introducing the concept of combined connection matrix (CCM). The proposed induced PCM decision making model with CCM is applied to examine the glitches of online learning system. It was observed that expert's opinion on the associational impact between the factors considered for study in the form combined connection matrix is more advantageous on comparison with conventional connection matrix representation, as CCM is a mixture of crisp/fuzzy/intuitionistic/neutrosophic representations. The proposed model will certainly facilitate the decision makers in designing optimal solutions to the real time problems and it shall be extended based on the needs of the decision makers and employed in various other decision making environment. The shortcomings of the model are also discussed in brief.

Keywords: Plithogenic Cognitive Maps, Induced Plithogenic Cognitive maps, combined connection matrix, glitches, online learning system.

1. Introduction

The prime objective of the decision making scenario is to devise optimal solution to the problem by determining the contributing factors and its associational impacts. Cognitive maps introduced by Robert Axelrod [1] are the excellent key graphical structures that comprises of vertices representing the factors of the decision making problem and edges representing the associations. The edge weights belongs to the set {-1,0,1}. If the edge that connects two vertices assume the weight 1 then the factors have positive influence over one another, if the edge weight is -1 then the factors have negative influence and if the edge weight is 0 then the factors have no influence over one another. The association between the factors are represented in the form of a connection matrix with crisp values. Cognitive maps are applied by researchers extensively. Kwon et al [2] has described the role of Cognitive maps in influencing the decision maker's semantic and syntactic comprehension in problem solving. The approach of cognitive maps lacks the ability in handling incomplete and imprecise information. To handle uncertainty scenario in decision making, Kosko [3] extended cognitive maps to fuzzy cognitive maps (FCM). In FCM models the edge weight assume values in the range [-1,1] and the connection matrix consists of fuzzy values. FCM models are applied in pattern recognition. Gonzalo Pajares [4] applied FCM in stereovision matching . Papakostas et al [5] made the first attempt in developing the FCM model for pattern recognition. Papakostas and Koulouriotis [6] presented the classifying of patterns using FCM. Claudio Lucchiari [7] used FCM in diagnostic decisions. FCM models are extensively applied by the researchers to make optimal decisions.

Fuzzy Cognitive models are extended to intuitionistic FCM models in which the connection matrix has intuitionistic values that comprises of membership and non-membership values. Papageorgiou and Dimitris [8] extended CM models to Intuitionistic Fuzzy Cognitive Maps (IFCM) and applied in process control and decision support applications. Luo et al [9] discussed time series predictions based on IFCM and this model is also applied in making decisions on target business strategies. Intuitionistic Fuzzy Cognitive models are extended to neutrosophic cognitive map (NCM) models in which the connection matrix is neutrosophic in nature. The neutrosophic sets consists of truth, indeterminacy and falsity membership values which is comprehensive than intuitionistic sets. Neutrosophic sets are used in resolve the complications in IOT entrprises [10], appraise green SCM [11], choosing optimal the supplier [12], smart medical devise [13] , project [14], designing feasible solutions to the problem of resource levelling [15]. The extended NCM's are first introduced by Vasantha Kandasamy and Smarandache [16]. Aasim Zafar and Mohd Anas [17] applied NCM in situation analysis. Al-Subhi et al [18] extended NCM models to new Neutrosophic Cognitive Maps model. Ferreira [19] has applied NCM to make decision on supply chain management. The researchers of FCM have extended these decision making models based on the circumstances of decision making and also made need based customization. The another comprehensive extension of FCM, IFCM and NCM models is Plithogenic Cognitive Maps (PCM) and it was developed by Nivetha Martin and Smarandache [20]. The concept of plithogeny introduced by Smarandace [21-22] was discussed in various fields and different concepts such as concentric plithogenic hypergraph, plithogenic hyper soft sets, combined plithogenic hypersoft sets, plithogenic fuzzy whole hypersoft set have been evolved. The efficiency of the proposed concepts Plithogenic sets are widely applied in several decision making scenarios of supply chain sustainability [23], multi attribute decision making, medical diagnosis [24]. In the developed PCM model the connection matrix is plithogenic in nature and the contradiction degree of the factors was considered. Sujatha et al [25] applied PCM models in making feasible decisions in analysis on Novel Corona virus by considering contradiction degree of the experts. Nivetha et al [26] developed a COVID-19 diagnostic model to investigate the mediating effects of the factors with new plithogenic sub cognitive maps approach. The PCM models are gaining momentum amidst the researchers at recent times.

Another comprehensive extension of FCM model is Induced Fuzzy Cognitive Maps model which has the similar approach of FCM. The induced FCM models differ from FCM models in determining the fixed point of the dynamical system. Induced FCM models are applied by different researchers as follows: Ritha et al [27] to determine the predictor's interest in cosmetic surgery, Narayanamoorthy et al [28] to make decisions on the problems faced by hand loom workers, Devadoss et al [29-31] to study the miracles in Holy Bible, work-life imbalance and Periyar philosophy of self-respect. Pathinathan et al [32-33] to explore the hazards of plastic pollution, road accidents by adolescences and problems faced by the farmers. Charles et al [34] to investigate the health of women in Chennai slums. Thirusangu et al [35] developed new induced bidirectional associative FCM model. Saraswathi et al [36] used the approach of fuzzy matrix analysis to study induced FCM models. Dhrubajyoti Ghosh et al [37-39] proposed induced Fuzzy Bi-Model to analyse the industrial relationship between employee and employer, real world problems and the impact of social networking in students. Sujatha et al [40] to model the traffic flow, Lily et al [41] to examine the symptoms of migraine. Induced FCM models with intuitionistic and neutrosophic representations are also developed by researchers. To mention a few, Induced FCM is applied in the field of agriculture to identify the effects of Endosulfan [42], to examine the causes of road accidents [43], to investigate the disappearance of house sparrow [44], to study the symptoms of tuberculosis, cancer [45-46], to explore the concepts of semantics extraction [47].

The feasibility of Plithogenic Cognitive Maps has motivated the authors to develop Induced Plithogenic Cognitive maps model. The developed model is the first attempt of formulating induced PCM and it is applied to examine the glitches in online learning system. In general the connection matrix representing the relation between the factors contains only same kind of values which may be crisp/fuzzy/intuitionistic/ neutrosophic in nature and on other hand it many contain linguistic values and it may be quantified using various kind of fuzzy numbers. But in this paper the concept of combined connection matrix is introduced in which the connection matrix comprises of a combination of crisp, fuzzy, intuitionistic and neutrosophic values. The combined connection matrix is more comprehensive in nature and it is highly reflective in sense, the association between the factors say F1 and F2 may be crisp in nature, F3 and F4 may be fuzzy in nature but in conventional connection matrix the association between all the factors are of same kind. The opinion of the experts are unconstrained in combined connection matrix and it is restricted to one kind of value in conventional matrix. In this proposed model four expert's opinion are considered and the aggregate combined connection matrix is obtained using plithogenic aggregate operators by taking contradiction degree of the experts into account.

The paper is structured as follows: section 2 presents the basic preliminaries; section 3 consists of the methodology; section 4 comprises of the application of the developed model; section 4 discusses the results and the last section concludes the work.

2. Preliminaries

This section comprises of the basic definitions related to the research work.

2.1. Definition [20]

Plithogenic Cognitive Maps (PCM) is a directed graph with nodes, edges and contradiction degree. The nodes are represented as $D_1,D_2,D_3,..D_n$ and the edge weights as e_{ij} respectively. The connection matrix or the adjacency matrix comprises of the plithogenic edge weight between the directed edge D_iD_j.

2.2. Definition [20]

The instantaneous vector V = ($a_1,a_2,\ldots a_n$) , $a_i \in\{0,1\}$. If a_i = 1 or 0 then it indicates the ON/OFF position of the node at a particular instant of time respectively.

2.3. Definition [20]

PCM with directed cycles is called as cyclic and it is also called as dynamical system if the causal relations flow through the cycle in revolutionary manner and the attainment of equilibrium state is called as the fixed point.

2.4. Definition [20]

The settling of the vector in a PCM of the form $V_1 \rightarrow V_2 \rightarrow V_3 \rightarrow \cdots . V_i \rightarrow .. V_1$

indicates the dynamical system has limit cycle.

2.5. Definition [20]

The plithogenic aggregate operators are defined as a $\wedge_P$ b = (1-c) [a $\wedge_F$ b] + c [a $\vee_F$ b], where c represents the contradiction degree, a $\wedge_F$ b is the t_{norm} defined as ab and a $\vee_F$ b is the t_{conorm} defined as a+b-ab.

2.6. Definition [22]

The neutrosophic set N_A of the form (T, I, F) is transformed to intuitionistic fuzzy set (T, f) by the method of impression membership method, where f is computed as follows

$$f_A = \begin{cases} F_A + \frac{[1-F_A-I_A][1-F_A]}{[F_A+I_A]} & if\ F_A = 0 \\ F_A + \frac{[1-F_A-I_A][F_A]}{[F_A+I_A]} & if\ 0 < F_A \leq 0.5 \\ F_A + [1-F_A-I_A]\left[0.5 + \frac{F_A-0.5}{F_A+I_A}\right] & if\ 0.5 < F_A \leq 1 \end{cases}$$

By using median membership fuzzy values are computed as <Δ(A)> = <$\frac{T_A}{[T_A+f_A]}$>.

3. Methodology of Plithogenic Induced Cognitive Maps with Combined Connection matrix

Plithogenic Induced Cognitive Maps are similar to the approach of Plithogenic Cognitive Maps and this section presents the steps involved in the proposed method.

Step 1: The factors of the problem and its causal relationship are determined with the help of the expert's opinion.

Step 2: The combined connection matrix M represents the associations and inter impact between the factors. The values in the matrix may be crisp, fuzzy, intuitionistic and neutrosophic. The combined connection matrix reflects the expert's perception on the association between the factors. The different combined connection matrices of the experts considering contradiction degree is aggregated using plithogenic aggregate operators as defined in and defuzzified using

Step 3: Let C be the instantaneous state vector and it is passed on to the combined connection matrix M, the new resultant vector C1 is obtained as discussed briefly in [20]. The same procedure is applied to the resultant vector until the fixed point is determined in Plithogenic Cognitive Maps, but in induced Plithogenic Cognitive Maps, the newly obtained resultant vector C1 is subjected to component wise computations. The vector C1 is threshold by assigning 1 to the values greater than or equal to 0.5 and 0 to the values lesser than 0.5. If the vector C1 is of the form (1 00 1001001) then the components of vector C1 are taken as (1000000000), (0001000000), (0000001000), (0000000001) and each of the component is passed on the M with the same PCM approach and the resultant threshold vector with maximum 1's is taken as the next new vector and the procedure is repeated to find the fixed point.

Thus the procedure of plithogenic induced cognitive maps differ from plithogenic cognitive maps in determining the fixed point.

4. Factors contributing to the glitches of online learning system

This section presents the factors that hinders the online learning system based on four expert's opinion and determines its associational impacts. The combined connection matrix represent the association and the interrelational impacts between the factors. It is combined in nature, the elements in the matrix are of varied kinds such as crisp, fuzzy, intuitionistic and neutrosophic and it reflects the association existing between factors in the perception of the experts. The factors are as follows

O1 High rate of difficulties in adapting to the new learning system

O2 Largely Confined to Elite Class of society

O3 Lack of proper network channels

O4 Deficit of computer literacy

O5 Monotonous content delivery

O6 No space for enhancing social skills

O7 The affective domain of the students is kept refrained

O9 Unable to cater the diverse needs of the learners

O10 Longer exposure to digital gadgets detains health

O11 Weaker interaction with faculty and peer

O12 Holistic development of learners has less scope

The combined connection matrix of the first expert

	O 1	**O 2**	**O 3**	**O 4**	**O 5**	**O 6**	**O 7**	**O 8**	**O 9**	**O 10**	**O 11**	**O 12**
O1	0	0.8	0	1	1	0	0	1	0	1	1	0
O2	1	0	(0.2,0.7)	1	0	0	1	1	1	0	0	1
O3	0	0	0	0	0	(0.8,0.1)	0	0	0	0	0	0.7

O4	(0.7,0.2)	1	0	0	0	0	1	0	0	0	1	0.4
O5	1	0	0	0	0	1	0	0	0	0	0.6	1
O6	0	0	1	0	1	0	0	0	0	0	0	0
O7	0	1	0	0.8	0	0	0	1	0	0	0.8	1
O8	0.9	1	0	0	0	0	(0.5,0.3)	0	0	1	1	1
O9	0	0.7	0	0	0	0	0	0	0	0	1	1
O10	1	0	0	0	0	0	0	1	0	0	1	(0.8,0.1,0.1)
O11	0.9	0	0	(0.6,0.1,0.3)	1	0	1	1	1	(0.7,0.1,0.2)	0	1
O12	0.8	0.8	1	0.9	1	0	1	0.6	1	1	0.7	0

Fig.4.1 represents the graphical representation of first expert in various forms

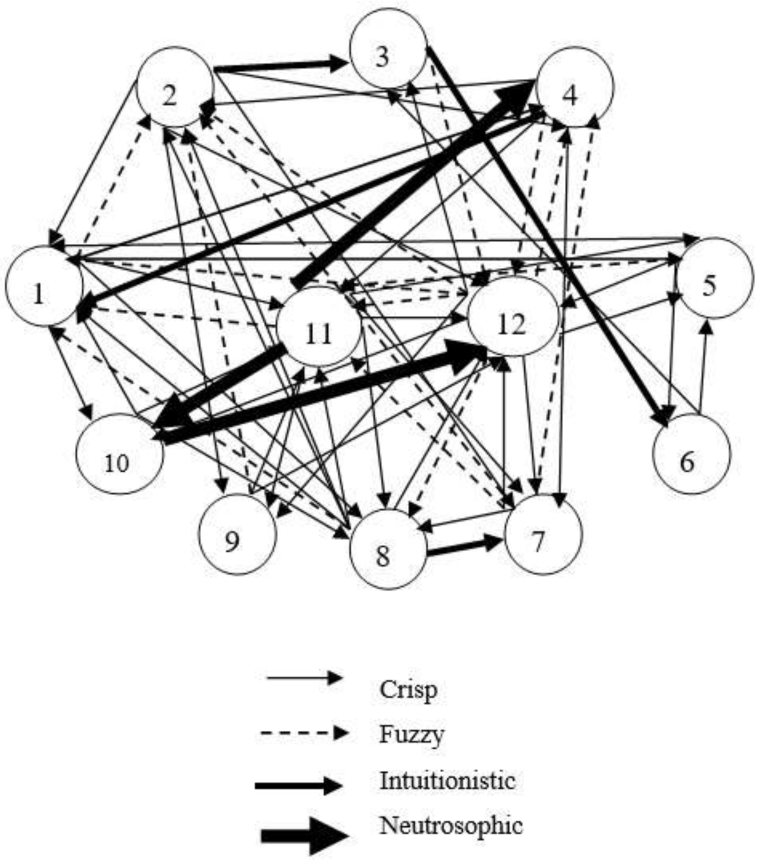

Fig.4.1 Graphical representation of first expert in various forms

The combined connection matrix of the second expert

	O 1	O 2	O 3	O 4	O 5	O 6	O 7	O 8	O 9	O 10	O 11	O 12
O1	0	(0.8,.2)	0	1	.5	0	0	1	0	1	1	0
O2	1	0	(0.2,0.7, .3)	1	0	0	1	.4	1	0	0	1
O3	0	0	0	0	0	(0.5,0.1)	0	0	0	0	0	0.7
O4	(.5,.2)	1	0	0	0	0	1	0	0	0	1	0.5
O5	1	0	0	0	0	1	0	0	0	0	(.6,.2, .3)	1
O6	0	0	1	0	1	0	0	0	0	0	0	0
O7	0	1	0	1	0	0	0	1	0	0	0.8	1
O 8	0.9	1	0	0	0	0	0.3	0	0	1	1	1
O 9	0	0.7	0	0	0	0	0	0	0	0	.8	1
O 10	1	0	0	0	0	0	0	.5	0	0	1	(.8,.1,.3)
O 11	0.5	0	0	(.3,.4)	1	0	.4	1	1	(.7,.2)	0	.3
O 12	0	(.8,.3)	1	(.5,.3)	1	0	.3	1	1	.2	0.4	0

Fig.4.2 represents the graphical representation of second expert in various forms

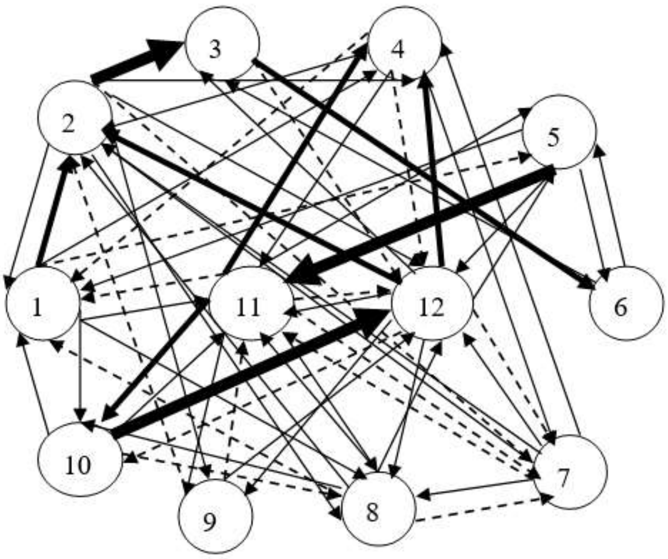

Fig.4.2 Graphical representation of second expert

The combined connection matrix of the third expert

	O 1	O 2	O 3	O 4	O 5	O 6	O 7	O 8	O 9	O 10	O 11	O 12
O1	0	(0.8,.2,.5)	0	1	.3	0	0	1	0	1	1	0
O2	1	0	(0.2,0.1)	1	0	0	.3	.4	1	0	0	.4
O3	0	0	0	0	0	1	0	0	0	0	0	(0.3,.4)
O4	(.5,.2,.1)	1	0	0	0	0	1	0	0	0	.5	(0.3,.2)
O5	.6	0	0	0	0	1	0	0	0	0	(.4,.3)	.4
O6	0	0	.8	0	1	0	0	0	0	0	0	0
O7	0	1	0	1	0	0	0	1	0	0	0.8	1
O 8	(0.5,.3)	1	0	0	0	0	(0.3,. 2)	0	0	1	.7	1
O 9	0	(0.5,.3)	0	0	0	0	0	0	0	0	(.8..2)	1
O 10	1	0	0	0	0	0	0	.5	0	0	1	(.8,.1,.3)
O 11	0.5	0	0	.3	1	0	.6	1	.6	.2	0	.3
O 12	(0.7,0.2, 0.5)	(.4,.3)	1	.5	1	0	(.3,.2)	1	.5	(.3,.2)	0.5	0

Fig.4.3 represents the graphical representation of third expert in various form

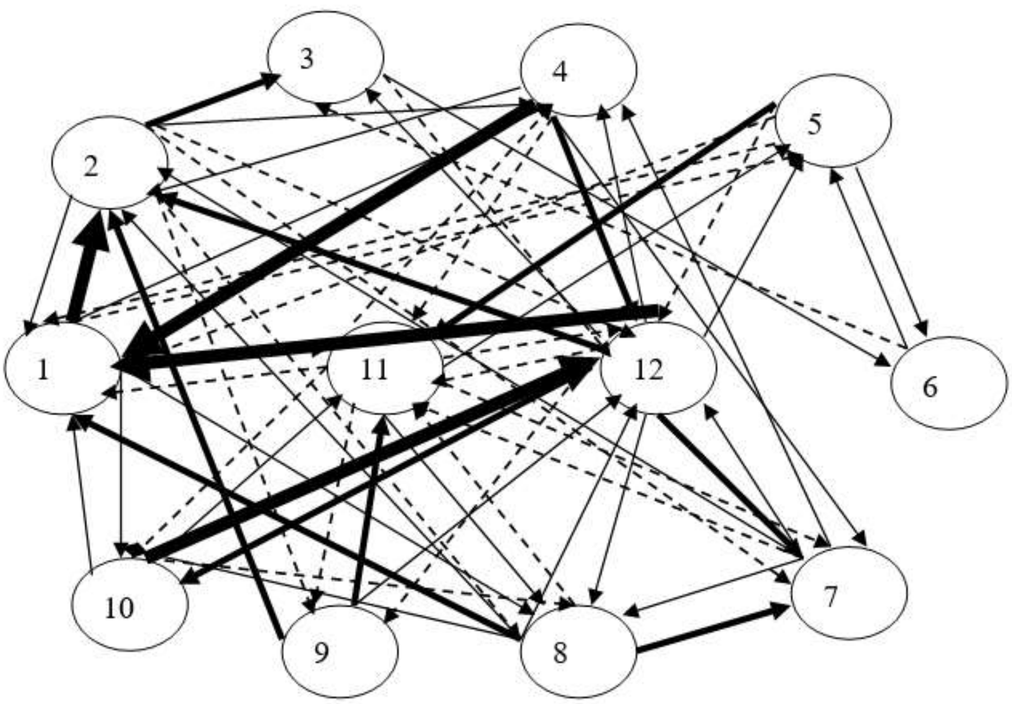

Fig.4.3 Graphical Representation of Third Expert

The combined connection matrix of the fourth expert

	O 1	O 2	O 3	O 4	O 5	O 6	O 7	O 8	O 9	O 10	O 11	O 12
O1	0	.3	0	1	.5	0	0	.8	0	1	.2	0
O2	1	0	(0.7,.4)	1	0	0	.3	.3	1	0	0	.5
O3	0	0	0	0	0	.6	0	0	0	0	0	(0.3,.4)
O4	(.3,.2,.5)	1	0	0	0	0	.6	0	0	0	1	1
O5	1	0	0	0	0	1	0	0	0	0	(.5,.3)	1
O6	0	0	(.5,.6)	0	1	0	0	0	0	0	0	0
O7	0	1	0	1	0	0	0	(.3,.2)	0	0	1	1
O 8	1	1	0	0	0	0	(0.2,.3)	0	0	1	1	1
O 9	0	(0.5,.6)	0	0	0	0	0	0	0	0	1	1
O 10	.6	0	0	0	0	0	0	.5	0	0	1	(.3,.7)
O 11	0.5	0	0	(.5,.4)	1	0	.4	.5	1	(.3,.2)	0	.3
O 12	1	(.4,.3,.1)	1	(.2,.3)	1	0	.7	1	1	.3	1	0

Fig.4.4 represents the graphical representation of fourth expert in various forms

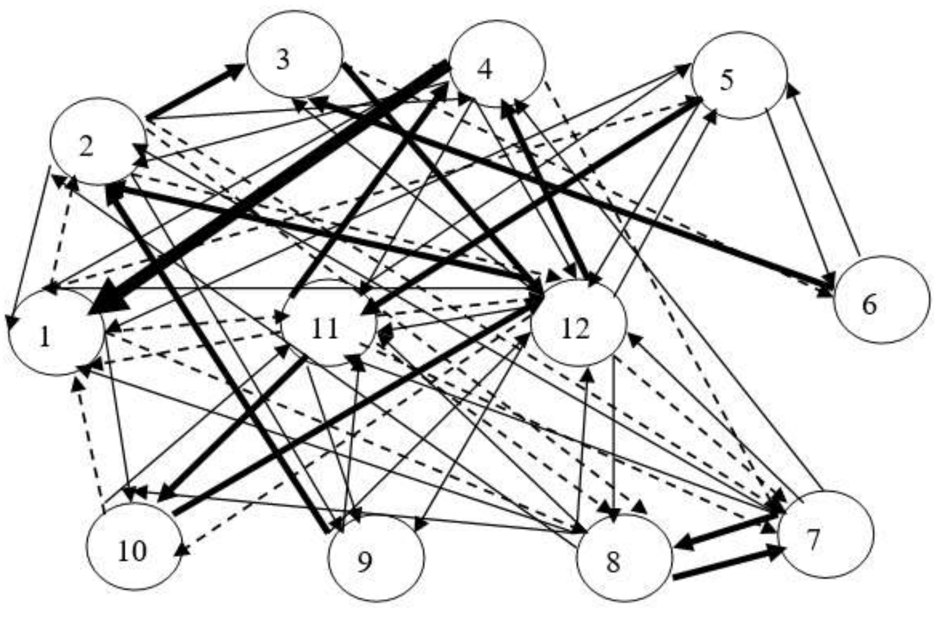

Fig.4.4 Graphical Representation of fourth Expert

The contradiction degree of the experts is presented as follows

E1	E 2	E 3	E 4
0	¼	2/4	¾

The aggregate defuzzified connection matrix M_G obtained from four combined connection matrix is

	O 1	O 2	O 3	O 4	O 5	O 6	O 7	O 8	O 9	O 10	O 11	O 12
O1	0	.994	0	1	1	0	0	1	0	1	1	0
O2	1	0	.899	1	0	0	1	1	1	0	0	1
O3	0	0	0	0	0	1	0	0	0	0	0	.968
O4	.983	1	0	0	0	0	1	0	0	0	1	1
O5	1	0	0	0	0	1	0	0	0	0	.968	1
O6	0	0	.4	0	1	0	0	0	0	0	0	0
O7	0	1	0	1	0	0	0	1	0	0	1	1
O 8	1	1	0	0	0	0	.922	0	0	1	1	1
O 9	0	.976	0	0	0	0	0	0	0	0	1	1
O 10	1	0	0	0	0	0	0	1	0	0	1	.983
O 11	0.987	0	0	.899	1	0	1	1	1	.968	0	1
O 12	1	.986	1	.988	1	0	1	1	1	1	1	0

Let us keep the first factor in ON position

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

C_1 M_G =(0 .994 0 1 1 0 0 1 0 1 1 0)

→(1 1 0 1 1 0 0 1 0 1 1 0)= C_1^1

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

=(0 .994 0 1 1 0 0 1 0 1 1 0)

→(0 1 0 1 1 0 0 1 0 1 1 0)

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

=(1 0 .899 1 0 0 1 1 1 0 0 1)

→(1 0 1 1 0 0 1 1 1 0 0 1)

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

=(0.983 1 0 0 0 0 1 0 0 0 1 1)

→(1 1 0 0 0 0 1 0 0 0 1 1)

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

=(1 0 0 0 0 1 0 0 0 0 .968 1)

→(1 0 0 0 0 1 0 0 0 0 1 1)

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

=(1 1 0 0 0 0 .922 0 0 1 1 1)

→(1 1 0 0 0 0 1 0 0 1 1 1)

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

=(1 0 0 0 0 0 0 1 0 0 1 .983)

→(1 0 0 0 0 0 0 1 0 0 1 1)

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

=(.987 0 0 .899 1 0 1 1 1 .968 0 1)

→(1 0 0 1 1 0 1 1 1 1 0 1)

Therefore C_2= (1 0 0 1 1 0 1 1 1 1 0 1)

C_2 M_G =(4.98 5.96 1 2.988 2 0 2.922 4 1 3 7.968 5.983)

→(1 1 1 1 1 0 1 1 1 1 1 1)= C_2^1

C_2^1 M_G =(1 0 0 0 0 0 0 0 0 0 0 0)

=(0 .994 0 1 1 0 0 1 0 1 1 0)

→(0 1 0 1 1 0 0 1 0 1 1 0)

C_2^1 M_G =(0 1 0 0 0 0 0 0 0 0 0 0)

=(1 0 .899 1 0 0 1 1 1 0 0 1)

→(1 0 1 1 0 0 1 1 1 0 0 1)

C_2^1 M_G =(0 0 1 0 0 0 0 0 0 0 0 0)

=(0 0 0 0 0 1 0 0 0 0 0 .968)

→(0 0 0 0 0 1 0 0 0 0 0 1)

C_2^1 M_G =(0 0 0 1 0 0 0 0 0 0 0 0)

(.983 1 0 0 0 0 1 0 0 0 1 1)

→(1 1 0 0 0 0 1 0 0 0 1 1)

C_2^1 M_G =(0 0 0 0 1 0 0 0 0 0 0 0)

=(1 0 0 0 0 1 0 0 0 0 .968 1)

→(1 0 0 0 0 1 0 0 0 0 1 1)

C_2^1 M_G =(0 0 0 0 0 0 1 0 0 0 0 0)

=(0 1 0 1 0 0 0 1 0 0 1 1)

→(0 1 0 1 0 0 0 1 0 0 1 1)

C_2^1 M_G =(0 0 0 0 0 0 0 1 0 0 0 0)

=(1 1 0 0 0 0 .922 0 0 1 1 1)

→(1 1 0 0 0 0 1 0 0 1 1 1)

C_2^1 M_G =(0 0 0 0 0 0 0 0 1 0 0 0)

=(0 .976 0 0 0 0 0 0 0 0 1 1)

→(0 1 0 0 0 0 0 0 0 0 1 1)

C_2^1 M_G =(0 0 0 0 0 0 0 0 0 1 0 0)

= (1 0 0 0 0 0 0 1 0 0 1 .983)

→(1 0 0 0 0 0 0 1 0 0 1 1)

C_2^1 M_G =(0 0 0 0 0 0 0 0 0 0 1 0)

=(.987 0 0 .899 1 0 1 1 1 .968 0 1)

→(1 0 0 1 1 0 1 1 1 1 0 1)

$C_2^1 M_G$ =(0 0 0 0 0 0 0 0 0 0 0 1)

=(1 .986 1 .988 1 0 1 1 1 1 1 1 0)

→(1 1 1 1 1 0 1 1 1 1 1 0)

Therefore C_3=(1 1 1 1 1 0 1 1 1 1 1 0)

C_3x M_G =(5.97 4.97 .899 3.89 2 2 3.922 5 2 2.968 6.968 8.95)

$C_3^1 M_G$ =(1 0 0 0 0 0 0 0 0 0 0 0)

(1 1 1 1 1 1 1 1 1 1 1 1)= C_3^1

$C_3^1 M_G$ =(1 0 0 0 0 0 0 0 0 0 0 0)

=(0 .994 0 1 1 0 0 1 0 1 1 0)

→(0 1 0 1 1 0 0 1 0 1 1 0)

$C_3^1 M_G$ =(0 1 0 0 0 0 0 0 0 0 0 0)

=(1 0 .899 1 0 0 1 1 1 0 0 1)

→(1 0 1 1 0 0 1 1 1 0 0 1)

$C_3^1 M_G$ =(0 0 1 0 0 0 0 0 0 0 0 0)

=(0 0 0 0 0 1 0 0 0 0 0 0 .968)

→(0 0 0 0 0 1 0 0 0 0 0 1)

$C_3^1 M_G$ =(0 0 0 1 0 0 0 0 0 0 0 0)

=(.983 1 0 0 0 0 1 0 0 0 1 1)

→(1 1 0 0 0 0 1 0 0 0 1 1)

$C_3^1 M_G$ =(0 0 0 0 1 0 0 0 0 0 0 0)

=(1 0 0 0 0 1 0 0 0 0 .968 1)

→(1 0 0 0 0 1 0 0 0 0 1 1)

$C_3^1 M_G$ =(0 0 0 0 0 1 0 0 0 0 0 0)

=(0 0 .4 0 1 0 0 0 0 0 0 0)

→(0 0 0 0 1 0 0 0 0 0 0 0)

$C_3^1 M_G$ =(0 0 0 0 0 0 1 0 0 0 0 0)

=(0 1 0 1 0 0 0 1 0 0 1 1)

→(0 1 0 1 0 0 0 1 0 0 1 1)

$C_3^1 M_G$ =(0 0 0 0 0 0 0 1 0 0 0 0)

=(1 1 0 0 0 0 .922 0 0 1 1 1)

→(1 1 0 0 0 0 1 0 0 1 1 1)

$C_3^1 M_G$ =(1 0 0 0 0 0 0 0 1 0 0 0)

=(0 .976 0 0 0 0 0 0 0 0 1 1)

→(0 1 0 0 0 0 0 0 0 0 1 1)

$C_3^1 M_G$ =(1 0 0 0 0 0 0 0 0 1 0 0)

=(1 0 0 0 0 0 0 1 0 0 1 .983)

→(1 0 0 0 0 0 0 1 0 0 1 1)

$C_3^1 M_G$ =(1 0 0 0 0 0 0 0 0 0 1 0)

=(.987 0 0 .899 1 0 1 1 1 .968 0 1)

→(1 0 0 1 1 0 1 1 1 1 0 1)

C_3^1 M_G =(0 0 0 0 0 0 0 0 0 0 0 1)

=(1 .986 1 .988 1 0 1 1 1 1 1 0)

→(1 1 1 1 1 0 1 1 1 1 1 0) = C_4

Hence C_3=C_4

By repeating in the same fashion the limit points shall be obtained for other ON position of the factors.

The same procedure of induced PCM shall be applied to the conventional aggregate fuzzy connection matrix. The aggregate expert's matrix is conventional in nature as it comprises of only fuzzy values. The same decision making problem can be dealt with PCM procedure as discussed by Nivetha and Florentin. The limit points are determined in both the cases of aggregate combined connection matrix and conventional fuzzy connection matrix. By considering the below aggregate conventional fuzzy connection matrix, the limit points obtained for various cases are presented in Table 4.1

	O 1	**O 2**	**O 3**	**O 4**	**O 5**	**O 6**	**O 7**	**O 8**	**O 9**	**O 10**	**O 11**	**O 12**
O1	0	1	0	1	1	0	0	1	0	1	1	0
O2	1	0	1	1	0	0	1	1	1	0	0	1
O3	0	0	0	0	0	1	0	0	0	0	0	1
O4	1	1	0	0	0	0	1	0	0	0	1	1
O5	1	0	0	0	0	1	0	0	0	0	1	1
O6	0	0	.0	0	1	0	0	0	0	0	0	0
O7	0	1	0	1	0	0	0	1	0	0	1	1
O 8	1	1	0	0	0	0	1	0	0	1	1	1
O 9	0	1	0	0	0	0	0	0	0	0	1	1
O 10	1	0	0	0	0	0	0	1	0	0	1	1
O 11	1	0	0	1	1	0	1	1	1	1	0	1
O 12	1	1	1	1	1	0	1	1	1	1	1	0

Table 4.1 Limit points of Induced PCM & PCM

	Case (a)	Case (b)	Case (c)	Case (d)
On position of the state vector	**Limit point By Induced PCM with aggregate combined connection matrix**	**Limit point By Induced PCM with aggregate Conventional Fuzzy connection matrix**	**Limit point By PCM with aggregate combined connection matrix**	**Limit point By PCM with aggregate conventional Fuzzy connection matrix**
(100000000000)	(1 1 1 1 1 0 1 1 1 1 1 0)	(1 1 1 1 1 0 1 1 1 1 1 0)	(1 1 1 1 1 1 1 1 1 1 1 1)	(1 1 1 1 1 1 1 1 1 1 1 1)
(010000000000)	(1 1 1 1 1 0 1 1 1 1 1 0)	(1 1 1 1 1 0 1 1 1 1 1 0)	(1 1 1 1 1 1 1 1 1 1 1 1)	(1 1 1 1 1 1 1 1 1 1 1 1)
(001000000000)	(1 1 1 1 1 0 1 1 1 1 1 0)	(1 1 1 1 1 0 1 1 1 1 1 0)	(1 1 1 1 1 1 1 1 1 1 1 1)	(1 1 1 1 1 1 1 1 1 1 1 1)
(000100000000)	(1 1 1 1 1 0 1 1 1 1 1 0)	(1 1 1 1 1 0 1 1 1 1 1 0)	(1 1 1 1 1 1 1 1 1 1 1 1)	(1 1 1 1 1 1 1 1 1 1 1 1)
(000010000000)	(1 1 1 1 1 0 1 1 1 1 1 0)	(1 1 1 1 1 0 1 1 1 1 1 0)	(1 1 1 1 1 1 1 1 1 1 1 1)	(1 1 1 1 1 1 1 1 1 1 1 1)
(000001000000)	(1 1 1 1 1 0 1 1 1 1 1 0)	(1 1 1 1 1 0 1 1 1 1 1 0)	(1 1 1 1 1 1 1 1 1 1 1 1)	(1 1 1 1 1 1 1 1 1 1 1 1)
(000000100000)	(1 1 1 1 1 0 1 1 1 1 1 0)	(1 1 1 1 1 0 1 1 1 1 1 0)	(1 1 1 1 1 1 1 1 1 1 1 1)	(1 1 1 1 1 1 1 1 1 1 1 1)
(000000010000)	(1 1 1 1 1 0 1 1 1 1 1 0)	(1 1 1 1 1 0 1 1 1 1 1 0)	(1 1 1 1 1 1 1 1 1 1 1 1)	(1 1 1 1 1 1 1 1 1 1 1 1)
(000000001000)	(1 1 1 1 1 0 1 1 1 1 1 0)	(1 1 1 1 1 0 1 1 1 1 1 0)	(1 1 1 1 1 1 1 1 1 1 1 1)	(1 1 1 1 1 1 1 1 1 1 1 1)
(000000000100)	(1 1 1 1 1 0 1 1 1 1 1 0)	(1 1 1 1 1 0 1 1 1 1 1 0)	(1 1 1 1 1 1 1 1 1 1 1 1)	(1 1 1 1 1 1 1 1 1 1 1 1)
(000000000010)	(1 1 1 1 1 0 1 1 1 1 1 0)	(1 1 1 1 1 0 1 1 1 1 1 0)	(1 1 1 1 1 1 1 1 1 1 1 1)	(1 1 1 1 1 1 1 1 1 1 1 1)
(000000000001)	(1 1 1 1 1 0 1 1 1 1 1 0)	(1 1 1 1 1 0 1 1 1 1 1 0)	(1 1 1 1 1 1 1 1 1 1 1 1)	(1 1 1 1 1 1 1 1 1 1 1 1)

5. Sensitivity Analysis

In induced PCM ,by positioning the first factor O1 in ON state, the resultant limit point obtained is (1 1 1 1 1 0 1 1 1 1 1 0). The limit point states that the factors influenced by the O1 High rate of difficulties in adapting to the new learning system. Similarly the influence of all other factors can be determined. On comparing with Plithogenic Cognitive Maps model, the limit point obtained by keeping the first factor in ON position is (1 1 1 1 1 1 1 1 1 1 1 1).The limit point obtained indicates that the factor O1 has influence on all the factors but the factor that plays a key role is not represented in it. But in induced PCM the flow of limit points is found and the pattern is determined and it is represented in Table 4.2 and Fig.4.5.

Table 4.2. Induced Triggering Pattern

Factors in ON state	**Triggering pattern**
(1 0 0 0 0 0 0 0 0 0 0 0)	$C_1 \rightarrow C_{11} \rightarrow C_{12} \rightarrow C_{12}$
(0 1 0 0 0 0 0 0 0 0 0 0)	$C_2 \rightarrow C_{12} \rightarrow C_{12}$
(0 0 1 0 0 0 0 0 0 0 0 0)	$C_3 \rightarrow C_{12} \rightarrow C_{12}$
(0 0 0 1 0 0 0 0 0 0 0 0)	$C_4 \rightarrow C_{12} \rightarrow C_{12}$
(0 0 0 0 1 0 0 0 0 0 0 0)	$C_5 \rightarrow C_{12} \rightarrow C_{12}$
(0 0 0 0 0 1 0 0 0 0 0 0)	$C_6 \rightarrow C_5 \rightarrow C_{12} \rightarrow C_{12}$
(0 0 0 0 0 0 1 0 0 0 0 0)	$C_7 \rightarrow C_{12} \rightarrow C_{12}$
(0 0 0 0 0 0 0 1 0 0 0 0)	$C_8 \rightarrow C_{12} \rightarrow C_{12}$
(0 0 0 0 0 0 0 0 1 0 0 0)	$C_9 \rightarrow C_{12} \rightarrow C_{12}$
(0 0 0 0 0 0 0 0 0 1 0 0)	$C_{10} \rightarrow C_{12} \rightarrow C_{12}$
(0 0 0 0 0 0 0 0 0 0 1 0)	$C_{11} \rightarrow C_{12} \rightarrow C_{12}$
(0 0 0 0 0 0 0 0 0 0 0 1)	$C_{12} \rightarrow C_{11} \rightarrow C_{12} \rightarrow C_{12}$

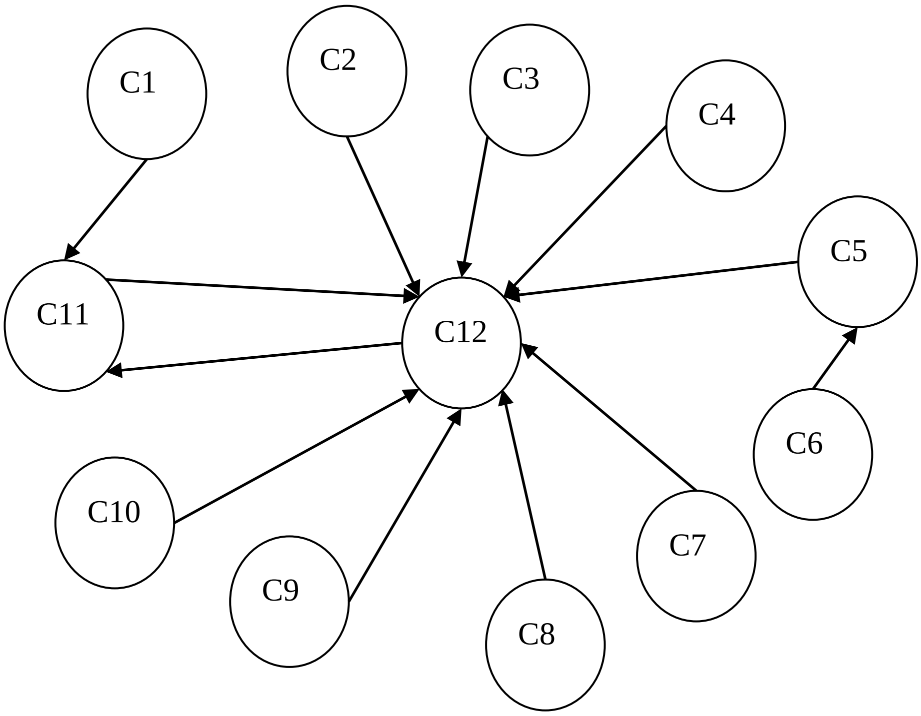

Fig.4.5 Graphical Representation of Induced PCM

Fig.4.5 clearly envisages the factor C12 is the core and intermediate factor that hurdles the online learning system. The limit point in the former case (a) is more reflective than the limit point obtained in case (c). The discussion is also made under PCM with aggregate combined and conventional matrices and the limit points obtained are same and the Table.4.1 is self-explanatory.

5. Conclusion

This paper introduces a new decision making model based on Plithogenic Induced Cognitive Maps. The concept of combined connection matrix and its significance in representing the associational impacts between the factors from expert's outlook is discussed. The validity of the proposed model is discussed in analysing the glitches in the online learning system. The sensitivity analysis vividly explicates the efficiency of the proposed model over the earlier developed models. Induced PCM models will certainly benefit the decision makers to arrive at optimal decisions. The developed model can be discussed by considering the contradiction degree of the factors and linguistic combined connection matrix. This approach can be applied in different decision making scenarios and in various contexts. The proposed method has certain shortcomings, one such is the construction of the combined connection matrix as sometimes it is not always certain to have mixture of values as at many instances the nature of the values decides the nature of the connection matrix; another limitation of the proposed model is the defuzzification methods used to determine the aggregate connection matrix of a single kind. The first limitation can be handled by the right choice of the experts and the second by the appropriate method of defuzzification.

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