



Exploring the Core Attributes of Digitalization Causing High Impact on Learning Trends Of Students Using LIFAM

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Abstract

In the existing educational scenario, the mechanisms of teaching and learning that are conventional have to be enriched unanimously to promote the development of the student community in all dimensions. The present government rings the bell of Digital India, which targets in making the service sectors to be digitally empowered. But in recent days, digitalization has stepped into almost all the fields and education is not an exception to it. The traditional blackboard teaching method was replaced by ICT techniques, but the learning strategies remained customary. To bring a change in the learning mode, the student community has to be provided a platform to learn at their own pace, which can be achieved by imparting the digital way of learning. Incorporation of Digitalization into teaching cum learning domains will pave way for Glean knowledge. Though there are many confrontations in implementation, the degree of the positive effects is high. This paper primarily aims in determining the effects of core factors of digitalization causing major effects on student's learning mode using a novel approach of Linguistic Induced Fuzzy Associative Memories (LIFAM).

Keyword: Associative memories; Digitalization; Fuzzy; learning trends; Linguistic variable

1. Introduction

Digital mode of education has opening gates in the present Indian educational system and the developments towards it are taking place colossally[1,2]. The introduction of ICT has laid a new pattern for teaching but the learning mode remained static [3]. The venture of digitalization has provided wide space for the learners to relax from the conventional methods of learning. In the scenario of digitalization the strict adherence to the classes, submission of written assignments, appearing for examinations, appraisals will be switched to digital mode; learning process will take place at one's own hustle; new ways of learning will come into practice. Thus the absorption of digitalization will result in paradigm shift from conventional learning practices to contemporary trends.[4]

To examine the effects of digitalization on learning trends of student, the concept of Linguistic Induced Fuzzy Associative Memories (LIFAM) is used in this paper, which is the extended form of Induced Fuzzy Associative Memories (IFAM). The concept of Fuzzy Associative Memories was introduced by the researchers to make decisions and interrupt on the impacts of distinct associated factors. The pioneers of the earlier developed models are Kosko [5], Balasangu [6] and so on and it was extended in recent years by many researchers[7,8,9] in this field. The proposed method of LIFAM gets the raw data from the expert's opinion in terms of linguistic variable which reflects the degree of impacts.[10,11]

The paper is organized as follows: section 2 consists of the basic definitions, section 3 encompasses the steps involved in the proposed method, section 4 comprises of the adaptation of the proposed method to the problem considered, section 5 presents the results and discussion and the last section concludes the paper.

2. Preliminaries

Fuzzy Set

A nonempty set A and the universal set X, with a membership function defined as $A: X \rightarrow [0,1]$ is called as fuzzy set.

Fuzzy Associative Memories (FAM)

FAM is a mapping of close inputs to close outputs and it is represented as $S: I^n \rightarrow I^p$, where I^n & I^p are the collection of fuzzy subsets of the domain and range space respectively.

Hexagonal fuzzy number

A depiction of a fuzzy number of the $H = (a1, a2, a3, a4, a5, a6)$ such that all a_i 's are real numbers and $a1 \leq a2 \leq a3 \leq a4 \leq a5 \leq a6$ is called as Hexagonal Fuzzy number with the membership function as

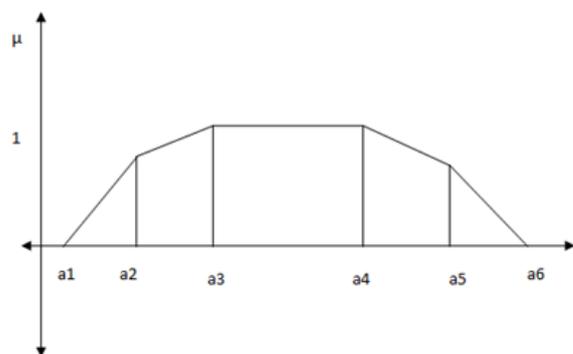


Fig.1.Membership Function of Hexagonal Fuzzy Number

$$\mu(\tilde{A}x) = \begin{cases} \frac{1}{2} \frac{x-a_1}{a_2-a_1} & \text{for } a_1 \leq x \leq a_2 \\ \frac{1}{2} + \frac{1}{2} \frac{x-a_2}{a_3-a_2} & \text{for } a_2 \leq x \leq a_3 \\ 1 & \text{for } a_3 \leq x \leq a_4 \\ 1 - \frac{1}{2} \frac{x-a_4}{a_5-a_4} & \text{for } a_4 \leq x \leq a_5 \\ \frac{1}{2} \frac{a_5-x}{a_6-a_5} & \text{for } a_5 \leq x \leq a_6 \\ 0 & \text{otherwise} \end{cases}$$

	L1	L2	L3	L4	L5	L6
D1	H	H	VH	H	H	M
D2	H	VH	H	M	L	L
D3	VL	L	L	M	M	H
D4	M	H	M	M	H	H
D5	M	L	M	L	L	M
D6	H	H	H	H	H	H
D7	VH	H	H	H	VH	VH

Relational Matrix of FCM

The matrix obtained out of the pictorial representation of the association of the concepts.

Linguistic Variable

A variable which takes linguistic values rather numeric.

3. Proposed Method of LIFAM

The steps involved are as follows:

1. The attributes related to the problem of decision making are taken as the nodes of domain and range space.
2. The connection/relational matrix with linguistic values is obtained from the expert's opinion.
3. The linguistic connection matrix is converted to Hexagonal connection matrix by quantifying the linguistic variables using hexagonal fuzzy numbers.
4. The average Hexagonal relational matrix R is obtained after defuzzification.
5. The vector C1 is kept in ON stage and it is passed to R and the resultant is thresholded by assigning 1 to first two higher values and 0 for others, which is once again passed into R^T. The resultant is again thresholded.
6. The same procedure is repeated for the thresholded vector by considering the occurrence of 1's individually. The resultant vector with maximum number of 1's is taken as C2.
7. The steps are applied continually until the limit point is attained. (i.e.Ci = Cj)

4. Adaptation of LIFAM to the Problem

The following attributes are associated with the effects of Digitalization and they are considered as the nodes of the domain space.

- D1 Learning takes place at one's own pace
- D2 Lack of time constraint
- D3 Enhancement of learning performance
- D4 Immense increase in the comprehension of concepts
- D5 Students are kept engaged
- D6 High choice in Specification
- D7 Bridge the gap between theory and its application

The below attributes are related with the learning trends of students and they are taken as the nodes of range space.

- L1 Increase of interest in learning
- L2 Learning becomes simple and scientific
- L3 Students are relieved from scheduled learning pattern
- L4 Acquisition of knowledge from various sources
- L5 Visualization of theoretical concepts
- L6 Student's creativity is improved

The linguistic opinion of proficient persons presently integrated with the field of education system is presented in the form of relational matrix R

The Hexagonal quantification of linguistic terminologies is as follows

Table.1.Hexagonal quantification of linguistic variablesThe modified linguistic relational matrix is given below

Very Low	(0,0.05,0.1,0.15,0.2,0.25)
Low	(0.15,0.2,0.25,0.3,0.35,0.4)
Medium	(0.3,0.35,0.4,0.45,0.5,0.55)
High	(0.45,0.5,0.55,0.6,0.65,0.7)
Very High	(0.65,0.7,0.75,0.8,0.9,1)

	L1	L2	L3	L4	L5	L6
D	(0.45,0.5,0)	(0.45,0.5,0)	(0.65,0.7,0)	(0.45,0.5,0)	(0.45,0.5,0)	(0.3,0.35,0)
1	.55,0.6,0.6 5,0.7)	.55,0.6,0.6 5,0.7)	.75,0.8,0.9, 1)	.55,0.6,0.6 5,0.7)	.55,0.6,0.6 5,0.7)	.4,0.45,0.5, 0.55)
D	(0.45,0.5,0)	(0.65,0.7,0)	(0.45,0.5,0)	(0.3,0.35,0)	(0.15,0.2,0)	(0.15,0.2,0)
2	.55,0.6,0.6 5,0.7)	.75,0.8,0.9, 1)	.55,0.6,0.6 5,0.7)	.4,0.45,0.5, 0.55)	.25,0.3,0.3 5,0.4)	.25,0.3,0.3 5,0.4)
D	(0.005,0.1,0. 15,0.2,0.25)	(0.15,0.2,0.2 5,0.3,0.35,0. 4)	(0.15,0.2,0.2 5,0.3,0.35,0. 4)	(0.3,0.35,0) 0.55)	(0.3,0.35,0) 0.55)	(0.45,0.5,0) 0.55,0.6,0.6 5,0.7)
D	(0.3,0.35,0)	(0.45,0.5,0)	(0.3,0.35,0)	(0.3,0.35,0)	(0.45,0.5,0)	(0.45,0.5,0)
4	.4,0.45,0.5, 0.55)	.55,0.6,0.6 5,0.7)	.4,0.45,0.5, 0.55)	.4,0.45,0.5, 0.55)	.55,0.6,0.6 5,0.7)	.55,0.6,0.6 5,0.7)
D	(0.3,0.35,0)	(0.15,0.2,0.2)	(0.3,0.35,0)	(0.15,0.2,0.2)	(0.15,0.2,0.2)	(0.3,0.35,0)
5	.4,0.45,0.5, 0.55)	.5,0.3,0.35,0. 4)	.4,0.45,0.5, 0.55)	.5,0.3,0.35,0. 4)	.5,0.3,0.35,0. 4)	.4,0.45,0.5, 0.55)
D	(0.45,0.5,0)	(0.45,0.5,0)	(0.45,0.5,0)	(0.45,0.5,0)	(0.45,0.5,0)	(0.45,0.5,0)
6	.55,0.6,0.6 5,0.7)	.55,0.6,0.6 5,0.7)	.55,0.6,0.6 5,0.7)	.55,0.6,0.6 5,0.7)	.55,0.6,0.6 5,0.7)	.55,0.6,0.6 5,0.7)
D	(0.65,0.7,0)	(0.45,0.5,0)	(0.45,0.5,0)	(0.45,0.5,0)	(0.65,0.7,0)	(0.65,0.7,0)
7	.75,0.8,0.9, 1)	.55,0.6,0.6 5,0.7)	.55,0.6,0.6 5,0.7)	.55,0.6,0.6 5,0.7)	.75,0.8,0.9, 1)	.75,0.8,0.9, 1)

The Average Hexagonal matrix is

	L1	L2	L3	L4	L5	L6
D1	1.2	1.2	1.6	1.2	1.2	0.9
D2	1.2	1.6	1.2	0.9	0.6	0.6
D3	0.3	0.6	0.6	0.9	0.9	1.2
D4	0.9	1.2	0.9	0.9	1.2	1.2
D5	0.9	0.6	0.9	0.6	0.6	0.9
D6	1.2	1.2	1.2	1.2	1.2	1.2
D7	1.6	1.2	1.2	1.2	1.6	1.6

Let C1 = (1000000)

C1*R = (1.2 1.2 1.6 1.2 1.2 0.9) ⇨ (111110) = C1

C1 * R^T = (6.4 5.5 3.3 5.1 3.6 6 6.8) ⇨ (1000001) = C1

C1¹ = (1000000)

C1² = (0000001)

C1²*R = (1.6 1.2 1.2 1.2 1.6 1.6) ⇨ (111111) = C1²

C1² * R^T = (7.3 6.1 4.5 6.3 4.5 7.2 8.4) ⇨ (1000001)

Let C2 = (1000001)

C2*R = (2.8 2.4 2.8 2.4 2.8 2.5) ⇨ (101011) = C2

C2 * R^T = (4.9 3.6 3 4.2 3.3 4.8 6) ⇨ (1000010)

C2¹ = (1000000)

C2² = (0000010)

C2² * R = (1.2 1.2 1.2 1.2 1.2 1.2) ⇨ (111111) = C2²

C2²*R^T = ((7.3 6.1 4.5 6.3 4.5 7.2 8.4) ⇨ (1000001) = C3

$C3^1 = (1000000)$
 $C3^2 = (0000001)$
 $C3^{2*}R = (1.6 \ 1.2 \ 1.2 \ 1.2 \ 1.6 \ 1.6) \hookrightarrow (111111) = C3^2$
 $C3^2 * R^T = (7.3 \ 6.1 \ 4.5 \ 6.3 \ 4.5 \ 7.2 \ 8.4) \hookrightarrow (1000001) = C4$
 $C2 = C4$
 The limit point is $\{(111111), (1000001)\}$
 Let $C1 = (0100000)$
 $C1 * R = (1.2 \ 1.6 \ 1.2 \ 0.9 \ 0.6 \ 0.6) \hookrightarrow (111000) = C1$
 $C1 * R^T = (4 \ 4 \ 1.5 \ 3 \ 2.4 \ 3.6 \ 4) \hookrightarrow (1100011) = C1$
 $C1^1 = (1000000)$
 $C1^2 = (0100000)$
 $C1^3 = (0000010)$
 $C1^4 = (0000001)$
 $C1^1 * R = (1.2 \ 1.2 \ 1.6 \ 1.2 \ 1.2 \ 0.9) \hookrightarrow (111110) = C1^1$
 $C1^1 * R^T = (6.4 \ 5.5 \ 3.3 \ 5.1 \ 3.6 \ 6 \ 6.8) \hookrightarrow (1000001) = C1^1$
 $C1^3 * R = (1.2 \ 1.2 \ 1.2 \ 1.2 \ 1.2 \ 1.2) \hookrightarrow (111111) = C1^3$
 $C1^3 * R^T = ((7.3 \ 6.1 \ 4.5 \ 6.3 \ 4.5 \ 7.2 \ 8.4) \hookrightarrow (1000001) = C1^3$
 $C1^4 * R = (1.6 \ 1.2 \ 1.2 \ 1.2 \ 1.6 \ 1.6) \hookrightarrow (111111) = C1^4$
 $C1^4 * R^T = (7.3 \ 6.1 \ 4.5 \ 6.3 \ 4.5 \ 7.2 \ 8.4) \hookrightarrow (1000001) = C1^4$
 The limit point is $\{(111111), (1000001)\}$
 Let $C1 = (0010000)$
 $C1 * R = (0.3 \ 0.6 \ 0.6 \ 0.9 \ 0.9 \ 1.2) \hookrightarrow (000111) = C1$
 $C1 * R^T = (3.3 \ 2.1 \ 3 \ 3.3 \ 2.1 \ 3.6 \ 4.4) \hookrightarrow (0000011) = C1$
 $C1^1 = (0000010)$
 $C1^2 = (0000001)$
 $C1^1 * R = (1.2 \ 1.2 \ 1.2 \ 1.2 \ 1.2 \ 1.2) \hookrightarrow (111111) = C1^1$
 $C1^1 * R^T = (7.3 \ 6.1 \ 4.5 \ 6.3 \ 4.5 \ 7.2 \ 8.4) \hookrightarrow (1000001) = C1^1$
 $C1^2 * R = (1.6 \ 1.2 \ 1.2 \ 1.2 \ 1.6 \ 1.6) \hookrightarrow (111111) = C1^2$
 $C1^2 * R^T = (7.3 \ 6.1 \ 4.5 \ 6.3 \ 4.5 \ 7.2 \ 8.4) \hookrightarrow (1000001) = C1^2$
 The limit point is $\{(111111), (1000001)\}$
 Let $C1 = (0001000)$
 $C1 * R = (0.9 \ 1.2 \ 0.9 \ 0.9 \ 1.2 \ 1.2) \hookrightarrow (111111) = C1$
 $C1 * R^T = (7.3 \ 6.1 \ 4.5 \ 6.3 \ 4.5 \ 7.2 \ 8.4) \hookrightarrow (1000001) = C1$
 $C1^1 = (1000000)$
 $C1^2 = (0000001)$
 $C1^2 * R = (1.6 \ 1.2 \ 1.2 \ 1.2 \ 1.6 \ 1.6) \hookrightarrow (111111) = C1^2$
 $C1^2 * R^T = (7.3 \ 6.1 \ 4.5 \ 6.3 \ 4.5 \ 7.2 \ 8.4) \hookrightarrow (1000001)$
 Let $C2 = (1000001)$
 $C2 * R = (2.8 \ 2.4 \ 2.8 \ 2.4 \ 2.8 \ 2.5) \hookrightarrow (101011) = C2$
 $C2 * R^T = (4.9 \ 3.6 \ 3 \ 4.2 \ 3.3 \ 4.8 \ 6) \hookrightarrow (1000010)$
 $C2^1 = (1000000)$
 $C2^2 = (0000010)$
 $C2^2 * R = (1.2 \ 1.2 \ 1.2 \ 1.2 \ 1.2 \ 1.2) \hookrightarrow (111111) = C2^2$
 $C2^2 * R^T = ((7.3 \ 6.1 \ 4.5 \ 6.3 \ 4.5 \ 7.2 \ 8.4) \hookrightarrow (1000001) = C3$
 $C3^1 = (1000000)$
 $C3^2 = (0000001)$
 $C3^{2*}R = (1.6 \ 1.2 \ 1.2 \ 1.2 \ 1.6 \ 1.6) \hookrightarrow (111111) = C3^2$
 $C3^2 * R^T = (7.3 \ 6.1 \ 4.5 \ 6.3 \ 4.5 \ 7.2 \ 8.4) \hookrightarrow (1000001) = C4$
 $C2 = C4$
 The limit point is $\{(111111), (1000001)\}$
 Let $C1 = (0000100)$
 $C1 * R = (0.9 \ 0.6 \ 0.9 \ 0.6 \ 0.6 \ 0.9) \hookrightarrow (111111) = C1$
 $C1 * R^T = (7.3 \ 6.1 \ 4.5 \ 6.3 \ 4.5 \ 7.2 \ 8.4) \hookrightarrow (1000001) = C1$
 $C1^1 = (1000000)$
 $C1^2 = (0000001)$
 $C1^2 * R = (1.6 \ 1.2 \ 1.2 \ 1.2 \ 1.6 \ 1.6) \hookrightarrow (111111) = C1^2$
 $C1^2 * R^T = (7.3 \ 6.1 \ 4.5 \ 6.3 \ 4.5 \ 7.2 \ 8.4) \hookrightarrow (1000001)$
 Let $C2 = (1000001)$
 $C2 * R = (2.8 \ 2.4 \ 2.8 \ 2.4 \ 2.8 \ 2.5) \hookrightarrow (101011) = C2$
 $C2 * R^T = (4.9 \ 3.6 \ 3 \ 4.2 \ 3.3 \ 4.8 \ 6) \hookrightarrow (1000010)$
 $C2^1 = (1000000)$
 $C2^2 = (0000010)$
 $C2^2 * R = (1.2 \ 1.2 \ 1.2 \ 1.2 \ 1.2 \ 1.2) \hookrightarrow (111111) = C2^2$
 $C2^2 * R^T = ((7.3 \ 6.1 \ 4.5 \ 6.3 \ 4.5 \ 7.2 \ 8.4) \hookrightarrow (1000001) = C3$
 $C3^1 = (1000000)$
 $C3^2 = (0000001)$
 $C3^{2*}R = (1.6 \ 1.2 \ 1.2 \ 1.2 \ 1.6 \ 1.6) \hookrightarrow (111111) = C3^2$
 $C3^2 * R^T = (7.3 \ 6.1 \ 4.5 \ 6.3 \ 4.5 \ 7.2 \ 8.4) \hookrightarrow (1000001) = C4$
 $C2 = C4$
 The limit point is $\{(111111), (1000001)\}$

Let $C1 = (0000010)$
 $C1 * R = (1.2 \ 1.2 \ 1.2 \ 1.2 \ 1.2 \ 1.2) \hookrightarrow (111111) = C1$
 $C1 * R^T = ((7.3 \ 6.1 \ 4.5 \ 6.3 \ 4.5 \ 7.2 \ 8.4) \hookrightarrow (1000001) = C1$
 From the previous steps
 The limit point is $\{(111111), (1000001)\}$
 Let $C1 = (0000001)$
 From the previous steps
 The limit point is $\{(111111), (1000001)\}$

Table.2. Input vector & Limit Point

Input Vector	Limit Point
(1000000)	(111111), (1000001)
(0100000)	(111111), (1000001)
(0010000)	(111111), (1000001)
(0001000)	(111111), (1000001)
(0000100)	(111111), (1000001)
(0000010)	(111111), (1000001)
(0000001)	(111111), (1000001)

5. Results and Discussion

From the below table, the limit point (111111),(1000001) clearly explicates that the factor D1 & D7 are the core factors of digitalization, which influence the learning trends of the students to high extent. The factors Learning takes place at one's own pace and Bridge the gap between theory and its application are two hub factors which have high degree of impacts on the factors related to student's learning trends considered in the range space. The digitalized education will duly assist the student community to learn at their own space and it will also enable them to comprehend the theoretical aspects and its real time applications.

6. Conclusion

This research work puts forth a new method of LIFAM which considers the realistic opinion of the experts into account for further analysis. This paper discusses about the attributes of effects of digitalization on the learning trends of the students and the association between the factors of domain and range space. The quantification of linguistic variable can be made using the other higher order fuzzy numbers which pave way for extending this work.

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