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An Analytical Estimation on The Factors Affected Students' Education After COVID-19 Pandemic Via Dempster-Shafer Theory of Evidence

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Abstract:

Introduction: Dempster-Shafer Theory (simply D-S Theory) is developed by Arthur P. Dempster and Glenn Shafer. This theory is widely used in many fields. One advantageous aspect of this is the ability to incorporate additional data into D-S Theory. However, it is important to note that the computational process necessitates a significant amount of effort due to the complexities involved with 2^n of sets.

Objectives: This study focuses on combination rule for multiple basic probability assignments in uncertain environment.

Methods: An algorithm has been developed and a python program has also been generated to validate combination rule for multiple basic probability assignments. Tableau software is utilized for illustrating data visualization.

Results: This concept has been implemented by the factors contributing to the decline in students' studies after the COVID-19 pandemic by the way of adopting fuzzy numbers.

Conclusions: Final output is tabulated which are obtained by generated python program. That clearly shows the highest impact factor affected students' studies after COVID-19 pandemic. In future, it is decided to study more number of real-life applications based on fuzzy evidence theory in our Research.

Keywords: D-S Theory; Fuzzy Sets; Fuzzy Numbers; Basic probability assignments, Python program.

1. Introduction

These days, numerous comparisons are required for every circumstance that could arise. At least two data are needed for a comparison, but occasionally we need to compare more than two, in which case some computations are needed to determine which is preferable. The optimum method for computing large amounts of data in this calculation is the dempster combination rule. In 1967, Dempster presented evidence theory to the world, and in 1976, Glenn Shafer [10], one of his students, reinterpreted it. The combination rule was calculated by George J Klir and Bo Yuan [5] using two basic probability assignments and its numerical problem. The book by Kari Senz and Scott Ferson [7] explains a variety of possible combination rules for dempster-shafer frameworks [6 & 8] and includes illustrations of how to execute these rules for discrete and interval-valued data. The belief function is a mathematical framework for describing assessed beliefs in the context of provided data. Uncertainty caused by a lack of evidence can be made explicit using belief functions. The belief function is discussed comprehensively in Bibliographies' [1-4], [11-13].

Dempster's rule of combination is presented in this study for more than two basic probability assignments. We proposed a novel algorithm for calculating efficiency. A python program [9] was developed to solve the proposed method. The success of the suggested approach was validated using numerical examples.

The structure of this research paper is as follows: Gives a brief review of Dempster-Shafer theory in Section II. We presented a new algorithm in Section III for assessing the stimulus evidence. In section IV, we generate a Python program for our proposed method and we utilized a numerical example to demonstrate the applicability of our proposed approach in section V. At last, Section VI provides some concluding remarks.

2. Preliminaries

The two primary topics wrapped by the background knowledge presented in this section are as follows: (a) a brief overview of Dempster-Shafer Theory (D-S Theory) definitions. (b) The definition of Dempster's rule of combination.

The D-S Theory of evidence is based on a finite set of mutually exclusive elements known as the frame of discernment, symbolized by Θ.

Definition 2.1. Basic Probability Assignment [5]

If Θ is a frame of discernment, then a function m: $2^{\Theta} \rightarrow [0,1]$ is called a Basic Probability Assignment whenever

(1) m(∅) = 0

And (2) $\sum_{A\subset\Theta} m(A) = 1.$

Definition 2.2. Belief Measure [5]

A function Bel: $2^{\Theta} \rightarrow [0,1]$ is called a Belief function over Θ,

If Bel(A) = $\sum_{B\subset A} m(B)$

For all proper subsets of B of A.

Furthermore, Bel(Θ) = 1 but Bel (A) = 0 for all A≠Θ.

Definition 2.3. Plausibility Measure [5]

Belief functions and Plausibility functions are mutually dual.

A function Pl: $2^{\Theta} \rightarrow [0,1]$ is called a Plausibility function over Θ,

If Pl(A) = $\sum_{A\cap B\neq\emptyset} m(B)$

For all proper subsets of B of A.

Pl (A) = 1 – Bel ($\bar{A}$)

Since Bel (A) + Bel ($\bar{A}$) ≤ 1.

Definition 2.4. Dempster's Rule of combination [5]

The general way of combining evidence is denoted by the formula

$$m_1 \oplus m_2(A) = \frac{\sum_{A_i \cap B_j = \mathrm{A}} m_1(A_i).m_2(B_j)}{1-K}$$

For all A≠∅ and $m_{1,2}(\emptyset) = 0$, where

$$K = \sum_{A_i \cap B_j = \emptyset} m_1(A_i).m_2(B_j)$$

3. Dempster's Rule of combination for Multiple BPA [8]:

In this section, we propose a method to estimate more than two basic probability assignment (BPA). Through this we can calculate various data at the same time.

Let $Bel_1 \cdots Bel_n$are belief functions over the same frame Θ, with basic probability assignments $m_1 \cdots m_n$ and focal elements $A_1 \cdots A_k$ and $B_1 \cdots B_l$ respectively.

The combination rule for the multiple BPA is

$$m(A) = \frac{\sum_{A_1 \cap A_2 \cap \cdots \cap A_n = A}\left(\prod_{j=1}^{n} m_j(A_j)\right)}{1-k} \quad \cdots(3.1)$$

Where

$$K = \sum_{A_1 \cap A_2 \cap \cdots \cap A_d = \emptyset}\left(\prod_{j=1}^{n} m_j\left(A_j\right)\right) \quad \cdots(3.2)$$

3.1 Algorithm:

An algorithm has been developed to solve the problem with simplicity.

step 1 – START the python program.

step 2 – Create a new file and save your file using Ctrl + s.

step 3 − Define the values of $\boldsymbol{m_j(A_j)}$for j = 1,2, ⋯, n.

step 4 – Using $1 - \sum_{A_1 \cap A_2 \cap \cdots \cap A_j = \emptyset} \prod_{j=1}^{n} m_j\left(A_j\right)$ for finding K value.

Step 5 – Finding combined evidence, put the values in $m(A) = \sum_{A_1 \cap A_2 \cap \cdots \cap A_i = \mathrm{A}} \prod_{j=1}^{n} m_j\left(A_i\right)$.

step 6 – Run the coding using function key F5.

step 7 – Print the output.

step 8 – STOP the program.

4. Numerical Illustration

The quality of education has completely lagged behind during the COVID-19 pandemic. We collecting the data from students. The below factors play an important role in affecting students' studies. That factors are listed below:

- Comprehension of the subject is decreased during Online classes – denoted as C
- Increase in mobile phone use leads to decline in interest in studies – denoted as P

- Difficulty in memorizing concepts – denoted as M
- Decreased writing skills – denoted as W

Example 4.1:

Factors	M1	M2	M3	M4
C	0.038	0.037	0.039	0.038
P	0.040	0.039	0.039	0.040
M	0.037	0.036	0.037	0.038
W	0.038	0.037	0.038	0.039
C, P	0.058	0.057	0.058	0.057
C, M	0.056	0.056	0.057	0.057
C, W	0.057	0.057	0.056	0.056
P, M	0.058	0.058	0.057	0.057
P, W	0.057	0.056	0.058	0.056
M, W	0.056	0.056	0.055	0.055
C, P, M	0.087	0.086	0.088	0.087
C, P, W	0.088	0.087	0.087	0.087
C, M, W	0.086	0.085	0.087	0.086
P, M, W	0.087	0.087	0.086	0.087
C, P, M, W	0.157	0.166	0.158	0.160

Table 4.1

Table 4.1 gives the input getting from experts to find the combination rule for Multiple Basic Probability Assignment, by using the relation (3.1) and the proposed algorithm to solve the computation.

To the calculation, we first compute K value, by using the following

$$K = \sum_{Z_1 \cap Z_2 \cap Z_3 \cap Z_4 = \emptyset} \prod_{j=1}^{4} M_j(Z_j) \quad \cdots (4.1)$$

Where $z_1 = \{C\}, \{P\}, \{M\}, \{W\}$

$Z_2 = \{C, P\}, \{C, M\}, \{C, W\}, \{P, M\}, \{P, W\}, \{M, W\}$

$Z_3 = \{C, P, M\}, \{C, P, W\}, \{C, M, W\}, \{P, M, W\}$

$Z_4 = \{C, P, M, W\}$

Now, find combined evidence for $M_{1,2}$

$$C = \sum_{Z_1 \cap Z_2 \cap Z_3 \cap Z_4 = C} \prod_{j=1}^{4} M_j(Z_j) \quad \cdots (4.2)$$

$$CP = \sum_{Z_1 \cap Z_2 \cap Z_3 \cap Z_4 = CP} \prod_{j=1}^{4} M_j(Z_j) \quad \cdots (4.3)$$

$$CPM = \sum_{Z_1 \cap Z_2 \cap Z_3 \cap Z_4 = CPM} \prod_{j=1}^{4} M_j(Z_j) \qquad \cdots (4.4)$$

$$CPMW = \sum_{Z_1 \cap Z_2 \cap Z_3 \cap Z_4 = CPMW} \prod_{j=1}^{4} M_j(Z_j) \qquad \cdots (4.5)$$

Where $z_1 = \{C\}, \{P\}, \{M\}, \{W\}$

$Z_2 = \{C, P\}, \{C, M\}, \{C, W\}, \{P, M\}, \{P, W\}, \{M, W\}$

$Z_3 = \{C, P, M\}, \{C, P, W\}, \{C, M, W\}, \{P, M, W\}$

$Z_4 = \{C, P, M, W\}$

Similarly, we can calculate P, M, W, CM, CW, PM, PW, MW, CPW, CMW, PMW and $M_{2,3}$, $M_{3,4}$.

4.2. Python program

The equations (4.1), (4.2), (4.3), (4.4) & (4.5) clearly shows that, solving the given problem requires a significant amount of calculating efforts. So, we generated new python code for Dempster-shafer theory, to compute the combined evidence. Using this code, the computations are done without any difficulty.

4.2.1 Sample code

Here, we give a sample python code for Dempster-Shafer theory.

```
M = 1
m1c =float(input('Enter m1c: '))
m1p =float(input('Enter m1p: '))
m1m =float(input('Enter m1m: '))
m1w =float(input('Enter m1w: '))
m1cp=float(input('Enter m1cp:'))
m1cm=float(input('Enter m1cm:'))
m1cw=float(input('Enter m1cw:'))
⋮
print(f'value of pmw is {div(v,K)}')
print(f'value of cpmw is {div(x,K)}')
```

4.2.2 Final Output

```
Enter m1c: .107
Enter m1p: .111
Enter m1m: .105
Enter m1w: .106
Enter m1cp: .064
Enter m1cm: .062
Enter m1cw: .064
Enter m1pm: .065
Enter m1pw: .064
Enter m1mw: .063
Enter m1cpm: .04
Enter m1cpw: .041
Enter m1cmw: .04
Enter m1pmw: .04
Enter m1cpmw: .03
Enter m2c: .109
Enter m2p: .111
Enter m2m: .106
```

Enter m2w: .107

Enter m2cp: .064

Enter m2cm: .064

Enter m2cw: .063

Enter m2pm: .064

Enter m2pw: .064

Enter m2mw: .062

Enter m2cpm: .04

Enter m2cpw: .04

Enter m2cmw: .04

Enter m2pmw: .04

Enter m2cpmw: .029

value of K is 0.637446

value of c is 0.1956401012791672

value of p is 0.20162335319383923

value of m is 0.19143739234382207

value of w is 0.19310027829808332

value of cp is 0.03359657131741356

value of cm is 0.032890629167019646

value of cw is 0.03332203825892704

value of pm is 0.03370481578047396

value of pw is 0.03359657131741356

value of mw is 0.032619233629201536

value of cpm is 0.006212290923466458

value of cpw is 0.0063205353865268595

value of cmw is 0.006212290923466458

value of pmw is 0.006212290923466458

value of cpmw is 0.0013648214907615705

>

4.2.3 Output Table: The final output values are tableted below.

factors	M1,2	M3,4	M	Bel
C	**0.107**	**0.109**	**0.196**	**0.19**
P	**0.111**	**0.111**	**0.201**	**0.201**
M	**0.105**	**0.106**	**0.191**	**0.191**
W	**0.106**	**0.107**	**0.193**	**0.193**
C, P	**0.064**	**0.064**	**0.034**	**0.431**
C, M	**0.062**	**0.064**	**0.033**	**0.420**
C, W	**0.064**	**0.063**	**0.033**	**0.422**
P, M	**0.065**	**0.064**	**0.034**	**0.426**
P, W	**0.064**	**0.064**	**0.034**	**0.428**
M, W	**0.063**	**0.062**	**0.033**	**0.417**
C, P, M	**0.040**	**0.040**	**0.006**	**0.661**
C, P, W	**0.041**	**0.040**	**0.006**	**0.663**
C, M, W	**0.040**	**0.040**	**0.006**	**0.652**
P, M, W	**0.040**	**0.040**	**0.006**	**0.659**
C, P, M, W	**0.030**	**0.029**	**0.001**	**1**

Table 4.2

4.3. Data Visualization:

A clear diagram for the provided computation is illustrated here, by utilizing Tableau software.

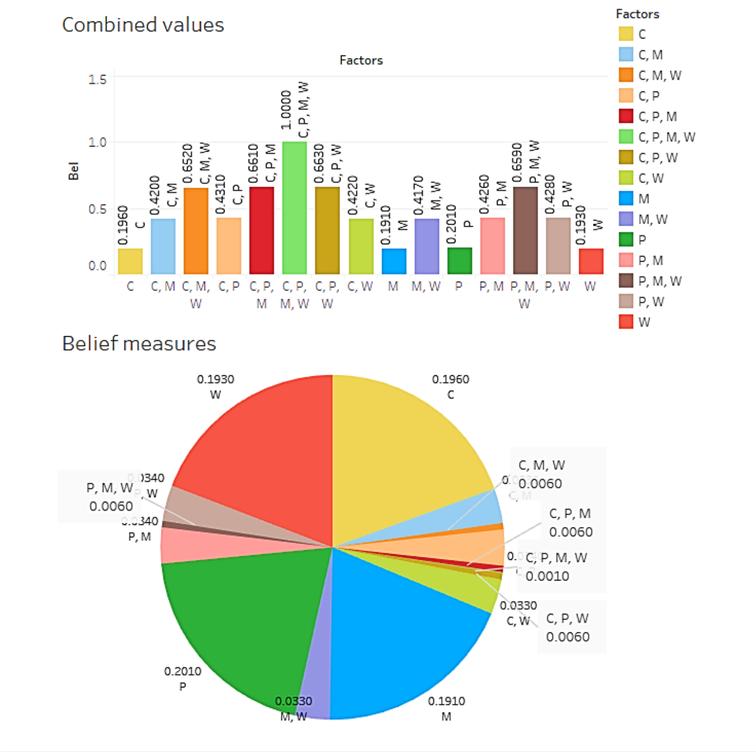

Fig 4.1

5. Conclusion

As we see in the book of "Mathematical Theory of evidence", by Shafer the calculations for two basic probability assignments have been made. But here, in this research work we compared more than two basic probability assignments to find out the high impact factor affecting studies. This concept has been established with the help of an illustration by the factors contributing to the decline in students' studies after the COVID-19 pandemic. An algorithm has been used to solve a proposed method based on given data and a python program has been generated in this research work. Data visualization is done by Tableau software. Finally, based on the results, mobile phone usage has been increased among students, which is one of the factors which affect students' education after the Covid-19 pandemic. The reason is that during and after the pandemic period, students learned through online mode, so that their writing skills and comprehension of the subject declines. And they are distracted by unnecessary advertisements and social media while using mobile phones. Further, it is decided to study more number of real-life applications based on fuzzy evidence theory in our future Research.

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