Infotekmesin
Vol.15, No.01, Januari 2024
p-ISSN: 2087-1627, e-ISSN: 2685-9858
DOI: 10.35970/infotekmesin.v15i1.1979, pp.7-14

Comparison of The Dempster Shafer Method and Bayes' Theorem in The Detection of Inflammatory Bowel Disease

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Info Naskah:
Naskah masuk: 23 Februari 2023
Direvisi: 23 May 2023
Diterima: 27 May 2023

Abstrak

Penelitian ini membahas tentang perbandingan metode dempster shafer dan teorema bayes pada proses deteksi dini penyakit inflamasi usus. Penyakit inflamasi usus atau yang lebih dikenal dengan radang usus adalah penyakit yang menyerang saluran pencernaan berupa iritasi, peradangan kronis, hingga luka pada saluran pencernaan. Tanda awal penyakit inflamasi usus antara lain nyeri perut berlebih, darah keluar pada saat buang air besar, diare akut, berat badan semakin menurun dan kelelahan. Metode dempster shafer adalah metode yang menghasilkan diagnosis yang akurat dari sebuah ketidakpastian yang disebabkan oleh ditambah atau kurangnya informasi tentang gejala sebuah penyakit. Sedangkan teorema bayes menerangkan tentang peluang sebuah kejadian yang didasarkan kepada faktor-faktor yang mungkin berkaitan dengan kejadian tersebut. Penelitian ini bertujuan untuk mengukur tingkat akurasi deteksi penyakit menggunakan metode dempster shafer yang dibandingkan dengan peluang munculnya penyakit tersebut menggunakan teorema bayes. Hasil perhitungan tingkat akurasi menunjukkan bahwa metode Teorema bayes lebih baik dalam memprediksi penyakit inflamasi usus dengan probabilitas kemunculan penyakit terhadap data yang telah diuji sebesar 75.9%.

Keywords:
dempster shafer method;
bayes theorem;
comparison;
inflammatory bowel disease;
detection

Abstract

This study discusses the comparison of the Dempster-Shafer method and Bayes' theorem in the process of early detection of inflammatory bowel disease. Inflammatory bowel disease, better known as intestinal inflammation, attacks the digestive tract in the form of irritation, chronic inflammation, and injuries to the digestive tract. Early signs of inflammatory bowel disease include excess abdominal pain, blood when passing stools, acute diarrhea, weight loss, and fatigue. The Dempster-Shafer method is a method that produces an accurate diagnosis of uncertainty caused by adding or reducing information about the symptoms of a disease. Meanwhile, Bayes' theorem explains the probability of an event based on the factors that may be related to the event. This study aims to measure the accuracy of disease detection using the Dempster-Shafer method compared to the probability of occurrence of the disease using Bayes' theorem. The results of calculating the level of accuracy show that the Bayes Theorem method is better at predicting inflammatory bowel disease with a probability of occurrence of disease in the tested data of 75.9%.

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1. Introduction

Inflammatory Bowel Disease (IBD) is a disease that attacks the human digestive tract better known as intestinal inflammation/inflammation that occurs in the digestive tract [1]. Inflammatory bowel disease is divided into four categories, namely ulcerative colitis, collagenous colitis, lymphocytic colitis, and Crohn's disease [2]. For the ulcerative colitis category, intestinal inflammation occurs in the deepest lining of the large intestine, better known as the colon [3]. For the Crohn's disease category, inflammation can occur in all parts of the digestive system, starting from the mouth to the anus [4]. The category of collagenous colitis is a type of inflammation characterized by the thickening of collagen and it affects the lower part of the lining of the large intestine [5]. The last category, namely lymphocytic colitis, is a type of inflammation characterized by increased white blood cells (lymphocytes) in the large intestine [6].

As technology develops in all fields, the use of technology must also be maximized. One of the uses of technology in the health sector is the development of a branch of artificial intelligence, namely expert systems [7]. Many expert systems have been developed in the medical world to help solve problems that occur in the health world [8]. One of the uses of an expert system is the early detection of diseases that occur in humans or other living things [9]. In this study, an expert system was used to diagnose a disease, namely inflammatory bowel disease. Expert systems are used to provide recommendations for solving problems by expert knowledge which is transferred into a knowledge base in rules that can later produce disease recommendations according to the symptoms experienced by patients [10]. The symptoms of inflammatory bowel disease will be used to recommend a category of inflammatory bowel disease using two methods, namely the Dempster-Shafer method and Bayes' theorem. Both of these methods will be compared for the level of accuracy. The method with the highest level of accuracy or close to expert diagnosis will later be used for the development of an expert system application for the early detection of inflammatory bowel disease.

Several studies that have been carried out include [11] which developed an expert system to detect diseases of the stomach using the Dempster-Shafer method. Some diseases that include stomach disease include stomach ulcers, dyspepsia, and gastroesophageal reflux disease. Many of these diseases are caused by increased stomach acid which eventually causes the stomach wall to not be strong enough to withstand increasingly excessive stomach acid. The results of the research show that the Dempster-Shafer method provides a diagnosis with an accuracy rate of 70% compared to the results of a doctor's diagnosis. Subsequent research by [12] implemented the Dempster Shafer method for the diagnosis of thyroid disease. The expert system developed will detect thyroid disease using the symptoms and complaints experienced by the patient by applying the Dempster Shafer method. The test results show that the method produces a diagnosis of thyroid disease in a patient with a density of 97.6%. These results are used to provide recommendations to doctors in the process of diagnosing a patient's thyroid disease. Subsequent research by [13] applied the Naïve Bayes method to diagnose diseases in cats combined with the certainty factor method. The Naive Bayes method is used to find the probability value of cat disease. The certainty factor method is used to find the value of trust. The test is carried out by comparing the suitability of the results of the system diagnosis with the results of the expert diagnosis. From testing 25 case data, it was found that the accuracy level of the expert system for diagnosing cat diseases using the Android-based Naive Bayes – Certainty Factor method was 80%.

The difference between the research that has been done and this research is that in this study the two methods were compared. The methods being compared are the Dempster-Shafer method and the Bayes theorem. The two methods are compared to diagnose inflammatory bowel disease. After comparing the performance of the two methods and judging from the results of accuracy in the process of detecting inflammatory bowel disease, it is recommended that the method with the highest level of accuracy be implemented into an expert system that will be developed to detect inflammatory bowel disease. In testing the data, 59 test data will be used to see the accuracy of the detection of inflammatory bowel disease using the Dempster-Shafer method and the accuracy of the probability of occurrence of inflammatory bowel disease using the Bayes theorem.

2. Method

There are two methods used for the early detection of inflammatory bowel disease, namely the Dempster-Shafer method and Bayes' theorem. The two methods will later be compared with the results of the diagnosis and compared with the results of the diagnosis from experts. The method with the highest level of accuracy will be recommended to be applied to the development of expert system applications in future research to diagnose inflammatory bowel disease. The research flow is described in the flowchart in Figure 1.

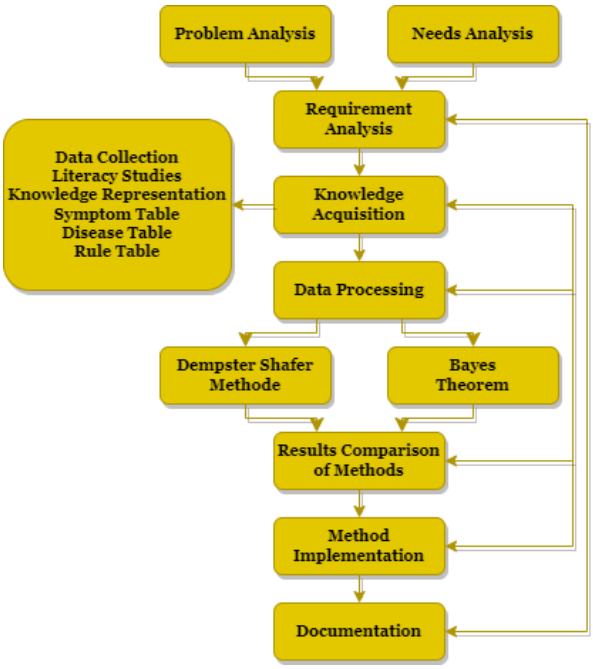

Figure 1. Research Flow

2.1 Dempster-Shafer Method

The first explanation of the Dempster-Shafer method. This method is a method that uses mathematical theory to explore reality based on the belief function and several reasons that can be accepted by common sense for use in the process of combining information to calculate the probability level of an event [14]. This method performs reasoning that aims to find inconsistencies caused by the addition or reduction of new facts that cause the rules to change [15]. It can be concluded that the Dempster-Shafer method provides security for someone to replace the work of an expert in the process of diagnosing an illness by knowing the probability or percentage of the disease occurring [16]. The Dempster-Shafer theory is generally stated in an interval, namely [Belief, Plausibility]/[Bel/Pl]. Belief [Bel] is denoted as a measure of the strength of a symptom/evidence in supporting a hypothesis [12]. If the value of [Bell] = 0, then there is no indication of symptoms/evidence. If the value of [Bel] = 1, then there is an indication of certainty [17]. The formula is as follows:

$$Pl(s) = 1 - Bel(\neg s) \quad (1)$$

The range of Plausibility values is between 0-1. If you are sure, then the value of Bel(¬s) = 1, if you are not sure, then the value of Pl(¬s) = 0 [16]. The level of trust can be reduced by Plausibility. In the Dempster-Shafer theorem, the term frame of discernment is known which is denoted by θ, and the mass function which is denoted by m [11].

Mass Function (m) is the level of confidence in a measure of evidence/symptoms. Use of Dempster's Rule of Combination to address some evidence [18]. This method will conclude that the search for the probability of each disease is determined from each value of the density of symptoms of the disease experienced by the patient [15]. Stages of completing the diagnosis of a disease using the Dempster-Shafer method, namely [14]:

$$M_3Z = \frac{\sum_{x \cap y = z} \; m_1(x).m_2(y)}{1-K} \quad (2)$$

Where is the value of K, namely:

$$K = \sum_{x \cap y = z} \; m_1(x).m_2(y) \quad (3)$$

Information:
m1 (x) : mass function for evidence x
m2 (y) : mass function for evidence y
m3 (z) : mass function for evidence z
K : number of conflicting evidence

2.2 Bayes Theorem

The second method to be compared is the Bayes theorem. This method can overcome uncertainty using the Bayes formula shown by equation 4 [19]. For the Bayes theorem equation with single evidence and double hypothesis it is shown by equation 5 [20], and for the Bayes theorem equation with double evidence and double hypothesis it is shown by equation 6 [21], as follows:

$$p(Y) = \frac{p(X) * p(X)}{p(Y)} \quad (4)$$

$$p(Y) = \frac{p(Y) * p(X_i)}{\sum_{k=1}^{n} \; p(X_k) * p(X_k)} \quad (5)$$

$$p(Y_1, Y_2, \dots, Y_m) = \frac{p(X_1) * \dots * p(X_i) * p(X_i)}{\sum_{k=1}^{n} \; p(X_k) * \dots * p(Y_m|X_k) * p(X_k)} \quad (6)$$

Information:
p(X|Y) : the probability of X and Y occur together
p(Y|X) : the probability of Y and X occurring together
p(Xi|Y) : the probability of hypothesis Xi occurring if evidence Y occurs
p(Y|Xi) : the probability of emergence of evidence Y if hypothesis Xi occurs
p(X) : the probability of X
p(Xi) : the probability of the hypothesis Xi without looking at any evidence
p(Y) : the probability of Y
n : the amount of evidence that may occur

The steps in Bayes' theorem begin with finding the total universe value of the weight of each symptom for each inflammatory bowel disease, then calculating the universe value of p(X) which is then continued by calculating the value of the probability without looking at any evidence that occurs [22]. Then finally look for the value of p(X|Y) and add up the Bayes value [23]. Table 1 shows values in the range of 0 to 1 using Bayes' theorem [24].

Table 1. Bayes Rule [25]

No	Bayes Value	Bayes' Theorem
1	0-0.2	There aren't any
2	0.3-0.4	Possible
3	0.5-0.6	Most likely
4	0.7-0.8	Almost Certain
5	0.9-1	Certain

2.3 Knowledge Base

The knowledge base used in the diagnosis of inflammatory bowel disease is explained in the following tables. The knowledge base itself in an expert system is the core of the knowledge representation that stores the rules and all the data needed from experts [26], [27], [28]. Table 2 describes the disease data which includes inflammatory bowel disease. Table 3 shows the symptoms of each inflammatory bowel disease. Table 4 shows the regulatory data used for the process of diagnosing inflammatory bowel disease.

Table 2. Inflammatory Bowel Disease Data

No	Disease Code	Description
1	I1	Ulcerative Colitis
2	I2	Collagenous Colitis
3	I3	Lymphocytic Colitis
4	I4	Chron's Disease

Table 3. Inflammatory Bowel Disease Symptom Data

No	Symptom Code	Description
1	S1	Stomach Pain
2	S2	Bloated
3	S3	Persistent Diarrhea
4	S4	Decreased Appetite
5	S5	Weight Loss
6	S6	Bloody Bowel Movements
7	S7	Fever
8	S8	Rectal pain
9	S9	Hemorrhoids

Table 4. Rule

	I1	I2	I3	I4
S1	√	√	√	
S2	√		√	√
S3	√	√		√
S4	√		√	
S5	√	√		√
S6	√	√		
S7			√	√
S8		√	√	√
S9		√	√	√

3. Result and Discussion

How to adopt expert knowledge and enter it into a computer device to provide a recommendation for results in the process of diagnosing inflammatory bowel disease, it is necessary to process the expert knowledge base in the form of rules/facts. These rules are later used to produce a diagnosis and conclude the type of inflammatory bowel disease under the existing knowledge base rules. Table 5 shows the formation of rules obtained from expert knowledge.

Table 5. Intestinal Inflammatory Disease Expertise Data

No	Symptom List	Intestinal Inflammatory Disease Data			
		I1	I2	I3	I4
1	S1	0.77	0.82	0.64	
2	S2	0.69		0.82	0.84
3	S3	0.85	0.67		0.81
4	S4	0.73		0.85	
5	S5	0.89	0.93		0.69
6	S6	0.65	0.79		
7	S7			0.76	0.68
8	S8		0.61	0.83	0.91
9	S9		0.91	0.90	0.67

Based on the expert data on inflammatory bowel disease in Table 5 from an expert, a digestive surgeon, a rule base can be made. The following is a list of rule bases that can be formed:

```
Rule1: IF Stomach Pain AND Flatulence AND
Persistent Diarrhea AND Decreased Appetite
AND Weight Loss AND Bloody Chapters THEN
Ulcerative Colitis

Rule2: IF Abdominal Pain AND Persistent
Diarrhea AND Bleeding AND Fever AND Rectal
Pain AND Hemorrhoids THEN Collagenous Colitis

Rule3: IF Abdominal Pain AND Flatulence AND
Decreased Appetite AND Fever AND Rectal Pain
AND Hemorrhoids THEN Lymphocytic Colitis

Rule4: IF Flatulence AND Persistent Diarrhea
AND Weight Loss AND Fever AND Rectal Pain AND
Hemorrhoids THEN Chronic Disease
```

For the implementation of each method, an example is given that a patient experiences the following symptoms as shown in Table 6 is given.

Table 6. Case Examples

Symptoms	Disease Name	Value Belief
Nyeri Perut (S1)	Ulcerative Colitis (I1)	0.77
	Collagenous Colitis (I2)	0.82
	Lymphocytic Colitis (I3)	0.64
Perut Kembung (S2)	Ulcerative Colitis (I1)	0.69
	Lymphocytic Colitis (I3)	0.82
Nafsu Makan Menurun (S4)	Ulcerative Colitis (I1)	0.73
	Lymphocytic Colitis (I3)	0.85
Berat Badan Menurun (S5)	Ulcerative Colitis (I1)	0.89
	Collagenous Colitis (I2)	0.93
	Chron's Disease (I4)	0.69
BAB Berdarah (S6)	Ulcerative Colitis (I1)	0.65
	Collagenous Colitis (I2)	0.79
Demam (S7)	Lymphocytic Colitis (I3)	0.76
	Chron's Disease (I4)	0.68

The following results of the discussion for each method are as follows:

3.1 Analysis of the Application of the Dempster-Shafer Method

The stages of the Dempster-Shafer method are as follows:

a) Tracing forward traces of the rules that have been created:

```
Rule1: IF Stomach Pain=Yes, AND
Flatulence=Yes, AND Decreased
Appetite=Yes, Weight Loss=Yes,
Bleeding=Yes AND Fever=Yes THEN Ulcerative
Colitis.

Rule2: IF Stomach Pain=Yes AND Weight
Loss=Yes AND Bleeding Chapters=Yes THEN
Collagenous Colitis

Rule3: IF Stomach Pain=Yes, AND
Flatulence=Yes, AND Decreased
Appetite=Yes, AND Fever=Yes THEN
Lymphocytic Colitis

Rule4: IF Flatulence=Yes AND Weight
Loss=Yes AND Fever=Yes THEN Chronic
Disease
```

Conclusion: Based on advanced tracing of the patient's symptoms matched with the rule that has been made, inflammatory bowel disease narrows to four diseases, namely

ulcerative colitis, collagenous colitis, lymphocytic colitis and chronic disease.

b) Carry out the calculation process using equation (1), equation (2), and equation (3) for each symptom, as follows:

1) Determine the confidence level of M_1 and M_2 to produce M_3

Symptom S_1: Stomach Pain

$M_1\{S_1\} = \frac{0.77+0.82+0.64}{3} = 0.743$

$M_1\{\theta\} = 1 - 0.743 = 0.257$

Symptom S_2: Bloated

$M_2\{S_2\} = \frac{0.69+0.82}{2} = 0.755$

$M_2\{\theta\} = 1 - 0.755 = 0.245$

Table 6. New Density Values for M_3

	$M_2\{I_1\}$0.755	**$M_2\{\theta\}$0.245**
$M_1\{I_1\}$0.743	$\{I_1\}$0.561	$\{I_1\}$0.182
$M_1\{\theta\}$0.257	$\{I_1\}$0.194	$\{\theta\}$0.063

Calculating the confidence level of M_3:

Belief Value $M_3\{I_1\} = \frac{0.561+0.182+0.194}{(1-0)} = 0.937$

Plausibility Value $M_3\{\theta\} = \frac{0.063}{(1-0)} = 0.063$

2) Determine the confidence level of M_3 and M_4 to produce M_5

Symptom S_4: Decreased Appetite

$M_4\{S_4\} = \frac{0.73+0.85}{2} = 0.79$

$M_4\{\theta\} = 1 - 0.79 = 0.21$

Table 7. New Density Values for M_5

	$M_4\{I_1, I_3\}$0.79	**$M_2\{\theta\}$0.21**
$M_3\{I_1\}$0.312	$\{I_1\}$0.247	$\{I_1, I_3\}$0.066
$M_3\{I_1, I_2, I_3\}$0.063	$\{I_1, I_3\}$0.05	$\{I_1, I_2, I_3\}$0.013
$M_3\{\theta\}$0.625	$\{I_1, I_3\}$0.494	$\{\theta\}$0.131

Calculating the confidence level of M_5:

Belief Value $M_5\{I_1, I_3\} = \frac{0.247+0.066}{(1-0)} = 0.313$

Belief Value $M_5\{I_1, I_3\} = \frac{0.05+0.013}{(1-0)} = 0.018$

Belief Value $M_5\{I_1, I_2, I_3\} = \frac{0.494}{(1-0)} = 0.494$

Plausibility Value $M_5\{\theta\} = \frac{0.131}{(1-0)} = 0.131$

3) Determine the confidence level of M_5 and M_6 to produce M_7

Symptom S5: Weight Loss

$M_6\{I_1, I_2, I_4\} = \frac{0.89+0.93+0.69}{3} = 0.837$

$M_6\{\theta\} = 1 - 0.837 = 0.163$

Table 8. New Density Values for M_7

	$M_6\{I_1, I_2, I_4\}$0.837	**$M_6\{\theta\}$0.163**
$M_5\{I_1, I_3\}$0.313	$M_6\{I_1, I_2, I_4\}$0.262	$M_5\{I_1, I_3\}$0.021
$M_5\{I_1, I_3\}$0.018	$M_6\{I_1, I_2, I_4\}$0.015	$M_5\{I_1, I_3\}$0.003
$M_5\{I_1, I_2, I_3\}$0.494	$M_6\{I_1, I_2, I_4\}$0.414	$M_5\{I_1, I_2, I_3\}$0.081
$M_5\{\theta\}$0.131	$M_6\{I_1, I_2, I_4\}$0.11	$M_5\{\theta\}$0.021

Calculating the confidence level of M_7:

Belief Value $M_7\{I_1, I_2, I_4\} = \frac{0.262+0.021}{(1-0)} = 0.283$

Belief Value $M_7\{I_1, I_3\} = \frac{0.015+0.003}{(1-0)} = 0.018$

Belief Value $M_7\{I_1, I_3\} = \frac{0.414+0.081}{(1-0)} = 0.495$

Belief Value $M_7\{I_1, I_2, I_3\} = \frac{0.11}{(1-0)} = 0.11$

Plausibility Value $M_7\{\theta\} = \frac{0.021}{(1-0)} = 0.021$

4) Determine the confidence level of M_7 and M_8 to produce M_9

Symptom S6: Bloody Bowel Movements

$M_8\{I_1, I_2\} = \frac{0.65+0.79}{2} = 0.72$

$M_8\{\theta\} = 1 - 0.72 = 0.28$

Table 9. New Density Values for M_9

	$M_8\{I_1, I_2\}$0.72	**$M_8\{\theta\}$0.28**
$M_7\{I_1, I_2, I_4\}$0.283	$M_8\{I_1, I_2\}$0.204	$M_7\{I_1, I_2, I_4\}$0.079
$M_7\{I_1, I_3\}$0.018	$M_8\{I_1, I_2\}$0.013	$M_7\{I_1, I_3\}$0.005
$M_7\{I_1, I_3\}$0.495	$M_8\{I_1, I_2\}$0.356	$M_7\{I_1, I_3\}$0.139
$M_7\{I_1, I_2, I_3\}$0.11	$M_8\{I_1, I_2\}$0.079	$M_7\{I_1, I_2, I_3\}$0.031
$M_7\{\theta\}$0.021	$M_8\{I_1, I_2\}$0.015	$M_7\{\theta\}$0.006

Calculating the confidence level of M_9:

Belief Value $M_9\{I_1, I_2\} = \frac{0.204+0.079}{(1-0)} = 0.283$

Belief Value $M_9\{I_1, I_2, I_4\} = \frac{0.013+0.005}{(1-0)} = 0.018$

Belief Value $M_9\{I_1, I_3\} = \frac{0.356+0.139}{(1-0)} = 0.495$

Belief Value $M_9\{I_1, I_3\} = \frac{0.079+0.031}{(1-0)} = 0.11$

Belief Value $M_9\{I_1, I_2, I_3\} = \frac{0.015}{(1-0)} = 0.015$

Plausibility Value $M_9\{\theta\} = \frac{0.006}{(1-0)} = 0.006$

5) Determine the confidence level of M_9 and M_{10} to produce M_{11}

Symptom S7: Fever

$M_{10}\{I_3, I_4\} = \frac{0.76+0.68}{2} = 0.72$

$M_{10}\{\theta\} = 1 - 0.72 = 0.28$

Table 10. New Density Values for M_{11}

	$M_{10}\{I_3, I_4\}$0.72	**$M_{10}\{\theta\}$0.28**
$M_9\{I_1, I_2\}$0.283	$M_{10}\{I_3, I_4\}$0.204	$M_9\{I_1, I_2\}$0.079
$M_9\{I_1, I_2, I_4\}$0.018	$M_{10}\{I_3, I_4\}$0.013	$M_9\{I_1, I_2, I_4\}$0.005
$M_9\{I_1, I_3\}$0.495	$M_{10}\{I_3, I_4\}$0.356	$M_9\{I_1, I_3\}$0.139
$M_9\{I_1, I_3\}$0.11	$M_{10}\{I_3, I_4\}$0.079	$M_9\{I_1, I_3\}$0.031
$M_9\{I_1, I_2, I_3\}$0.015	$M_{10}\{I_3, I_4\}$0.011	$M_9\{I_1, I_2, I_3\}$0.004
$M_9\{\theta\}$0.006	$M_{10}\{I_3, I_4\}$0.004	$M_9\{\theta\}$0.002

Calculating the confidence level of M_{11}:

Belief Value $M_{11}\{I_3, I_4\} = \frac{0.204+0.079}{(1-0)} = 0.283$

Belief Value $M_{11}\{I_1, I_2\} = \frac{0.013+0.005}{(1-0)} = 0.018$

Belief Value $M_{11}\{I_1, I_2, I_4\} = \frac{0.356+0.139}{(1-0)} = 0.495$

Belief Value $M_{11}\{I_1, I_3\} = \frac{0.079+0.031}{(1-0)} = 0.11$

Belief Value $M_{11}\{I_1, I_3\} = \frac{0.011+0.004}{(1-0)} = 0.015$

Belief Value $M_{11}\{I_1, I_2, I_3\} = \frac{0.004}{(1-0)} = 0.004$

Plausibility Value $M_{11}\{\theta\} = \frac{0.002}{(1-0)} = 0.002$

c) Conclusion Drawing

The calculation results show that the confidence value of inflammatory bowel disease in the Ulcerative Colitis category from the symptoms of abdominal pain (S1), flatulence (S2), decreased appetite (S4), decreased body weight (S5), and bloody bowel movements (S6), and fever (S7) that is equal to 73.1%. Confidence in inflammatory bowel disease category Collagenous Colitis from symptoms of abdominal pain (S1), weight loss (S5), and bloody bowel movements (S6) of 38.1% Confidence in inflammatory bowel disease category Lymphocytic Colitis from symptoms of abdominal pain (S1), flatulence (S2), and decreased appetite (S4), and fever (S7) of 17.5%. The belief in inflammatory bowel disease in the Chron's Disease category from symptoms of flatulence (S2), decreased body weight (S5), and fever (S7) was 13.6%.

3.2 Analysis of Application of Bayes Theorem

The symptoms experienced by patients who will be solved using Bayes' Theorem are the same as case studies that are solved using the Dempster-Shafer method. These symptoms include:

Abdominal Pain(S_1): 0.7	$P(Y\|X_1)$
Flatulence(S_2): 0.6	$P(Y\|X_2)$
Decreased Appetite(S_4): 0.8	$P(Y\|X_3)$
Weight Loss (S_5): 0.6	$P(Y\|X_4)$
Bloody Bowel Movements(S_6): 0.5	$P(Y\|X_5)$
Fever (S_7): 0.8	$P(Y\|X_6)$

Then look for the universal value by adding up the hypotheses above:

$$\sum_{k=1}^{6} \quad S_1 + S_2 + S_4 + S_5 + S_6 + S_7$$
$$= 0.7 + 0.6 + 0.8 + 0.6 + 0.5 + 0.8$$
$$= 4$$

After the sum above is known, then use equation (4) to calculate the universe value as follows:

$$P(X_1) = \frac{X_1}{\sum_{k=1}^{6}} = \frac{0.7}{4} = 0.175$$
$$P(X_2) = \frac{X_2}{\sum_{k=1}^{6}} = \frac{0.6}{4} = 0.15$$
$$P(X_3) = \frac{X_3}{\sum_{k=1}^{6}} = \frac{0.8}{4} = 0.2$$
$$P(X_4) = \frac{X_4}{\sum_{k=1}^{6}} = \frac{0.6}{4} = 0.15$$
$$P(X_5) = \frac{X_5}{\sum_{k=1}^{6}} = \frac{0.5}{4} = 0.125$$
$$P(X_6) = \frac{X_6}{\sum_{k=1}^{6}} = \frac{0.8}{4} = 0.2$$

After the value of P(Hi) is known, the probability of the hypothesis H regardless of any evidence uses equation (5) and looks for the value of P(Hi|E) or the probability of the hypothesis Hi being true if evidence E is given using equation (6):

$$P(Y) = \frac{p(Y)*p(X_i)}{\sum_{k=1}^{n} \quad p(X_k)*p(X_k)}$$

$$\sum_{k=1}^{6} \quad = p(X_k) * p(X_k)$$
$$= 0.7 * 0.175 + 0.6 * 0.15 + 0.8 * 0.2 + 0.6 * 0.15 + 0.5 * 0.125 + 0.8 * 0.2$$
$$= 0.1225 + 0.09 + 0.16 + 0.09 + 0.0625 + 0.16$$
$$= 0.685$$

$$P(X_1|Y) = \frac{0.7*0.175}{0.685} = 0.181$$
$$P(X_2|Y) = \frac{0.6*0.09}{0.685} = 0.079$$
$$P(X_3|Y) = \frac{0.8*0.16}{0.685} = 0.187$$
$$P(X_4|Y) = \frac{0.6*0.09}{0.685} = 0.079$$
$$P(X_5|Y) = \frac{0.5*0.0625}{0.685} = 0.046$$
$$P(X_6|Y) = \frac{0.8*0.16}{0.685} = 0.187$$

After all P(Hi|E) values are known, then add up all the bayes values as follows:

$$\sum_{k=1}^{6} \quad NB1 + NB2 + NB4 + NB5 + NB7 + NB8$$
$$= 0.181 + 0.079 + 0.187 + 0.079 + 0.046 + 0.187$$
$$= 0.759$$

To find the accuracy value of the calculation results using the Bayes theorem are as follows:

$$Level\ of\ Accuracy = 0.759 * 100\% = 75.9\%$$

Based on calculations using the Bayes Theorem method, the probability of inflammatory bowel disease Ulcerative Colitis with symptoms experienced by patients such as abdominal pain, flatulence, decreased appetite, decreased body weight, bloody bowel movements, and fever is 75.9%.

The probability level of each disease after being calculated using equations (4), equation (5), and equation (6) according to the previous calculation is Collagenous Colitis from symptoms of abdominal pain (S1), decreased body weight (S5), and loose stools bleeding (S6) of 42.7%. Belief in inflammatory bowel disease in the Lymphocytic Colitis category from the symptoms of abdominal pain (S1), flatulence (S2), decreased appetite (S4), and fever (S7) was 21.9%. Belief in inflammatory bowel disease in the Chron's Disease category from symptoms of flatulence (S2), decreased body weight (S5), and fever (S7) was 20.4%.

3.3 Comparison Test Results of the Two Methods

After performing calculations using the Dempster-Shafer method and Bayes' theorem, the most appropriate and best method will be determined in the process of diagnosing

inflammatory bowel disease. Based on the calculation results obtained, it can be concluded as follows:

a) The calculation process using the Dempster-Shafer method, obtained probability values for inflammatory bowel disease in the Ulcerative Colitis category with a percentage of 73.1%, Collagenous Colitis category at 38.1%, Lymphocytic Colitis category at 17.51%, and Chron's Disease category with 13.61%. While the calculation process using Bayes' theorem obtained a probability value of 75.9% for inflammatory bowel disease in the ulcerative colitis category, for the Collagenous Colitis category by 42.7%, for the Lymphocytic Colitis category by 21.9%, and for the Chron's Disease category by 20.4%. From the comparison of the results of these calculations, the greatest probability is obtained for inflammatory bowel disease in the Ulcerative Colitis category from the symptoms experienced by the patient using both the Dempster-Shafer method and Bayes' theorem. From these results, it can be concluded that the probability of the emergence of inflammatory bowel disease in the Ulcerative Colitis category is 75.9% using the Bayes Theorem method.

b) From the calculation process using the Dempster-Shafer method and Bayes' theorem for data with more than 2 pieces of evidence, it is necessary to repeat the processing and calculation of combined data several times.

c) In the case of a diagnosis of inflammatory bowel disease, according to Bayes' Theorem, if more symptoms refer to a disease, the probability value of a certain category of disease will be higher, in contrast to the Dempster Shafer method, where more symptoms are selected, the probability value will be smaller. Also, even the probability value of one symptom can be higher than the probability value of more than one symptom.

d) In the Dempster-Shafer method, the probability value obtained is smaller than the probability value of Bayes' Theorem. With these results, to diagnose intestinal inflammatory disease, the most appropriate and good method is to use Bayes' theorem. This is to the science of expertise that one disease cannot be determined by only one symptom, in other words the probability value is low and the more symptoms one suffers, the more likely it is to be diagnosed with this type of disease with a high probability value.

e) Comparison of the prediction results of inflammatory bowel disease for each disease category with codes I1, I2, I3, and I4, for a patient experiencing symptoms S1, S2, S4, S5, S6, and S7, shown in Figure 2 below:

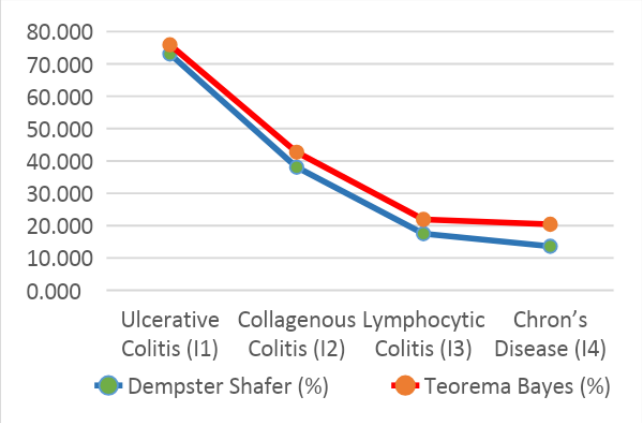

Figure 2. Comparison of The Results of The Dempster-Shafer Method and Bayes' Theorem

The test results on 59 data obtained from observations at the hospital without mentioning the patient's identity are shown in the graph below. The test results showed that the test using the Dempster Shafer method was more accurate than the probability of occurrence of inflammatory bowel disease using Bayes' theorem in 9 patients out of 59 patients with codes PC3, PC4, PC15, PC21, PC26, PC29, PC34, PC46, and PC50. Whereas for the other 50 patients including patients with code PC11, which were used as examples of calculations, the test results showed that the probability of occurrence of inflammatory bowel disease based on the symptoms identified and experienced by the patients had better accuracy than testing using the Dempster Shafer method.

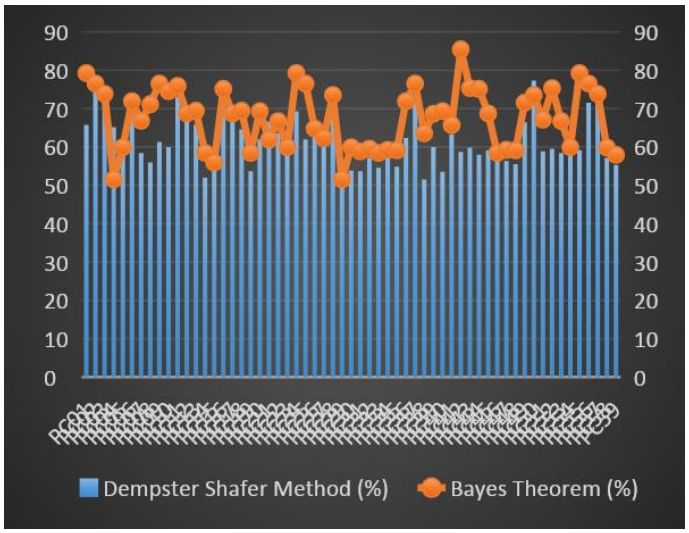

Figure 3. Comparison of The Results of The Dempster-Shafer Method and Bayes' Theorem Against 59 Test Data

4. Conclusion

Based on the results of the discussion regarding the comparison of the Dempster-Shafer method and Bayes' theorem in the process of diagnosing inflammatory bowel disease that has been described, several conclusions can be obtained are based on the results of the calculations that have been done, it can be seen that the diagnosis using the Bayes theorem is the method that has the highest probability value from the calculation using the Dempster Shafer method. With

the results of these calculations, later the implementation of an expert system for diagnosing inflammatory bowel disease can be developed by implementing the Bayes Theorem method.

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