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IMPLEMENTATION OF FORWARD INFERENCE REASONING IMPLEMENTING THE DEMPSTER-SHAFER METHOD FOR DIAGNOSIS OF LUNG DISEASE SYMPTOMS

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Abstract

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Artificial intelligence is an effort to transfer intelligence that is added to a system that can be regulated in a scientific context or can be called artificial intelligence so that machines (computers) can do work as humans can do. Lung disease is a condition in which the lungs cannot function normally. Some of the most common include asthma, chronic obstructive pulmonary disease (COPD), pneumonia, tuberculosis, and lung cancer. The Dempster-Shafer method was first introduced by Dempster, who experimented with uncertainty models with a range of probabilities rather than a single probability. Application of the Dempster-Shafer method to diagnose lung disease, it can be concluded that inference techniques are easy to use in designing expert systems to get a conclusion but, it has weaknesses in finding these conclusions if the system has a large enough knowledge base and this will be very much use time and hinder the consultation process.

Keywords: Dempster-Shafer, Lung Disease, Expert System

1. Introduction

Artificial intelligence is intelligence that is added to a system that can be regulated in a scientific context or it can be called artificial intelligence (English: Artificial Intelligence) or simply AI, defined as the intelligence of scientific entities. Andreas Kaplan and Michael Haenlein define artificial intelligence as “the ability of a system to correctly interpret external data, to learn from it, and use that learning to achieve specific goals and tasks through flexible adaptation”. Such a system is generally considered a computer. Intelligence is created and incorporated into a machine (computer) in order to do work as humans can. Several kinds of fields that use artificial intelligence include expert systems, computer games, fuzzy logic, artificial neural networks and robotics [1]

AI automates repeated learning and discovery through data. But AI is different from hardware-driven robotic automation. Instead of automating manual tasks, AI performs frequent, high-volume, computerized tasks reliably and without fatigue. For this type of automation, human investigation is still important to organize the system and ask the right questions [2].

AI adds intelligence to existing products. In most cases, AI is not sold as an individual application. However, the products you are already using will be enhanced with AI capabilities, much like Siri was added as a feature on a new generation of Apple products. Automation, chat platforms, bots and smart machines can be combined with large amounts of data to enhance many technologies at home and in the workplace, from security intelligence to investment analysis.

Lung disease is a condition in which the lungs cannot function normally. Some of the most common include asthma, chronic obstructive pulmonary disease (COPD), pneumonia, tuberculosis, and lung cancer.

The disease can be of genetic origin, smoking habits, air pollution, and exposure to chemicals in the workplace. These diseases generally show symptoms, namely difficulty breathing, chronic coughing, wheezing, and chest pain. Severe conditions can cause the patient to cough up blood, chronic infections that do not resolve with treatment, and respiratory failure [3], [4].

Lung disease is the most common health disorder in the world, affecting patients of all ages - men, women, children, the elderly, smokers and nonsmokers. According to the World Health Organization (WHO), sufferers of ASA worldwide reach 235 million people and about three million people die of COPD. In addition, lung cancer is the leading cause of cancer death, both in men and women. This means that one in four cancer deaths is lung cancer. Lung disease is also the leading cause of death in infants under one year of age [5]

The Dempster-Shafer method was first introduced by Dempster, who experimented with uncertainty models with a range of probabilities rather than a single probability. Then in 1976 Shafer published Dempster's theory in a book entitled Mathematical Theory Of Evident. Dempster-Shafer Theory Of Evidence, shows a way to give weight to belief according to the facts gathered. In this theory can distinguish uncertainty and ignorance. Dempster-Shafer theory is a representation, combination and propogation of uncertainty, where this theory has several characteristics that are instutitively in accordance with the way of thinking of an expert, but a strong mathematical basis [6]. In general, the Dempster-Shafer theory is written in an interval: [Belief, Plausibility].

Believe is a measure of confidence in evidence / symptoms. If it is 0, it indicates that there is no certainty, and if it is 1 it indicates certainty. The believe data is obtained from expert input. Plausibility is a measure of distrust of evidence / symptoms. If it is 1, it indicates that there is no certainty, and if it is 0, it indicates certainty. Palusability data is obtained from 1 - believe [7].

2. METHOD

2.1. *Research Method*

In writing this study, the authors did several things to obtain the necessary data, including [8]:

1. Data collection methods
   Some of the methods used by the author are:
   a. Literature search
      To get a valid theoretical result to be used as a basis, the author searches for several reference books from libraries and electronic media (internet) about expert systems and the Dempster-Shafer method and computer books.
   b. Interview
      Conducting direct consultations or questions and answers with people who know more about the expert system and the Dempster-Shafer method
2. Needs Analysis
   a. The needs analysis used is the Dempster-Shafer method, which is carried out to determine the desired input and output.
   b. System analysis and design
      System design is a step taken to create a program design based on the desired input and output.
   c. System testing
      After making the system design, the next step is to implement the design results into the program
   d. Writing research reports
      The author of this research report is the final result of the research that has been done.

2.2. Expert System

Expert systems are computer-based systems that use knowledge, facts and reasoning techniques to solve problems that usually only an expert in the field can solve [9], [10]. Basically an expert system is applied to support problem solving activities. Some of the solving activities referred to include: decision making, knowledge fusing, designing, planning, forecasting, regulating, controlling, diagnosis (diagnosing), formulation (prescribing), explanation (explaining), giving advice (advising) and training (tutoring). In addition, an expert system can also function as a clever assistant to an expert [2]. In its preparation, an expert system combines inference rules with a specific knowledge base provided by one or more experts in a particular field. The combination of these two things is stored in the computer, which is then used in decision making for solving certain problems [2], [11].

2.3. Knowledge Base

The knowledge base contains knowledge for understanding, formulation and problem solving. This expert system component is composed of two basic elements, namely facts and rules. Facts are information about objects in a certain problem area, while rules are information about how to get new facts from known facts [2].

In case studies of knowledge-based systems there are several characteristics that are built to assist us in shaping a series of architectural principles. These principles include:

a. Knowledge is the key to the strength of an expert system.
b. Knowledge is often uncertain and incomplete.
c. Often poor knowledge of specifications.
d. Amateurs become masters gradually.
e. Expert systems must be flexible.
f. Expert systems must be transparent.

The history of research in the field of artificial intelligence has shown over and over again that knowledge is the key to any intelligent system.

2.4. Knowledge Representation

Knowledge representation is a technique to represent the knowledge base obtained in a certain schema / diagram so that it can be seen the relationship / relationship between one data and another. This technique helps the knowledge engineer in understanding the structure of knowledge that will be made by the expert system [11].

The representation language must be able to make a programmer able to express the knowledge needed to get a problem solution, can be translated into a programming language and can be stored. It must be designed so that the facts and other knowledge contained in it can be used for reasoning. Knowledge can be represented in simple or complex forms, depending on the problem.

2.5. The Dempster-Shafer theory

There are various kinds of reasoning with a complete and very consistent model, but in fact there are many problems that cannot be resolved completely and consistently. This inconsistency is the result of the addition of new facts. Such reasoning is called non-monotonic reasoning. To overcome this inconsistency, reasoning can be used with the Dempster-Shafer theory. [6], [7] In general, the Dempster-Shafer theory is written in an interval:

[*Belief,Plausibility*]..................………….. [1]

1. Belief (Bel) is a measure of the strength of evidence in support of a set of propositions. If it is 0, it indicates that there is no evidence, and if it is 1 it indicates certainty.
2. Plausibility (Pl) is denoted as:
   Pl(s) = 1 – Bel (-s)…..………...…………. [2]

Plausibility is also 0 to 1. If you are sure of -s, then you can say that Bel (-s) = 1, and Pl (-s) = 0. In the Dempster-Shafer theory, there is a frame of discrement denoted by θ. This frame is a universe of discussion from a set of hypotheses.Its purpose is to relate the confidence measures of the elements θ. Not all evidence directly supports every element. For that we need a probability density function (m). The value m defines not only the elements θ, but also all its subsets. So if θ contains n elements, then the subset of θ is 2n. The

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sum of all m in the subset θ equals 1. If there is no information available to select a hypothesis, then the value: m {θ} = 1.0. If it is known that X is a subset of θ, where m1 is a function of density, and Y is also a subset of θ with m2 as a function of density, then a combination function of m1 and m2 as m3 can be formed, namely:

$$m_3(Z) = \frac{\sum_{x \cap y = z} m_1(x) m_2(y)}{1 - \sum_{x \cap y = \theta} m_1(x) m_2(y)} \quad \text{...[3]}$$

Misalkan :
With:

G = Nutrition;
L = Environment;
I = Infection;
K = Poisoning;

Its purpose is to relate the confidence measure to 0 elements. Not all evidence directly supports every element. For example, infection may only be supportive (G, L, K). For that we need a probability density function (m). The value m defines not only the elements of 0, but also all its subsets. So if 0 contains n elements, then the subsets of 0 all add up to 2. We must show that the sum of all m in subset 0 equals 1. Supposing there is no information to select the four hypotheses, then the value M (0) = 1,0 If then it is known that Trauma is a symptom of poisoning, infection, and the environment with m = 0.8, then: M (G,L,K) = 0,8

3. RESULTS AND DISCUSSION

3.1. Rule Basis Design

In data design, it will be explained how the data contained in the system is in accordance with its function as input data or system output data.

Table 1. Bronchitis, clinical symptoms

Symptoms	Weight Value
a. Dry cough	0.2
b. Cough up with phlegm after 2-3 days	0.3
c. The sound is there lenders	0.2
d. Thick, yellow phlegm	0.1
e. Shortness of breath complaining of retrostenal pain	0.1
f. Wheezing	0.1

Table 2. Rare Episodic Asthma, Clinical symptoms

Symptoms	Weight Value
a. Hard to breathe	0.2
b. Wheezing for 3-4 days	0.3
c. Cough for 10-14 days	0.2
d. Excessive mucus production	0.1
e. There are at the age of 3-6 years	0.1
f. Attacks 3-4x a year	0.05
g. Symptoms appear at night	0.05

Table 3. Frequent Episodic Asthma, Clinical symptoms

Symptoms	Weight Value
a. Hard to breathe	0.1
b. Cough	0.3
c. Excessive mucus production	0.1
d. Symptoms appear at night	0.1

e. Occurs at age <3 years, and 8-13 years	0.2
f. Attacks 3-4x a year	0.2

Table 4. Chronic / Persistent Asthma Clinical symptoms:

Symptoms	Weight Value
a. Occurs at the age of 6 months or <3 years	0.2
b. Symptoms appear at night	0.3
c. Growth disorders	0.2
d. Hard to breathe	0.1
e. Wheezing every day	0.1
f. Cough	0.05
g. Excessive mucus production	0.05

Table 5. Severe and Recurrent Episodic Asthma Clinical symptoms

Symptoms	Weight Value
a. Hard to breathe	0.3
b. Wheezing	0.1
c. Cough	0.1
d. Excessive mucus production	0.2
e. ARI (upper respiratory tract infection)	0.2
f. In young children and before school	0.1

Table 6. Persistent Asthma in Infants Clinical symptoms

Symptoms	Weight Value
a. Hard to breathe	0.3
b. Wheezing with takhipnu for a few days or a few weeks	0.3
c. Cough	0.2
d. Excessive mucus production	0.1
e. 3-12 months old	0.1

Table 7. Hypersecretory Asthma Clinical symptoms

Symptoms	Weight Value
a. Hard to breathe	0.1
b. Cough	0.3
c. Excessive mucus production	0.2
d. The sound of crackling breath	0.3
e. There are small children and at the age of starting school	0.1

Table 8. Asthma due to physical load Clinical symptoms

Symptoms	Weight Value
a. Hard to breathe	0.1
b. Wheezing	0.3
c. Cough	0.2
d. Excessive mucus production	0.3
e. After doing physical activity	0.1

Table 9. Asthma with allergens Clinical symptoms

Symptoms	Weight Value
a. Hard to breathe	0.1
b. Delirious	0.2

c. A hard, dry night cough	0.2
d. Cough occurs at 1-4 in the morning	0.3
e. At the age of 2-6 years	0.3

Table 10. Night Cough Clinical symptoms

Symptoms	Weight Value
a. Hard to breathe	0.1
b. Delirious	0.3
c. Cough	0.2
d. Excessive mucus production	0.3
e. Asthma at 1-4 in the morning	0.1

Table 11. Bad Asthma in the Morning. Clinical symptoms

Symptoms	Weight Value
a. Occurs in young children and babies	0.05
b. The temperature suddenly rises to 39-40 C	0.2
c. Accompanied by high febrile seizures	0.2
d. Restless child	0.2
e. Breathing fast and shallow	0.05
f. Nasal lobe breathing	0.1
g. Cyanosis around the nose and mouth	1
h. Accompanied by vomiting and diarrhea	1

Table 12. Bronchopneumonia Clinical symptoms

Symptoms	Weight Value
a. Body shivering	0.05
b. The baby has seizures	0.1
c. The temperature rises to 39-400 C	0.2
d. Hard to breathe	0.2
e. Nasal lobe breathing	0.2
f. Cyanosis around the nose and mouth	0.05
g. Chest pain	0.1
h. Cough at first dry and with phlegm	0.05
i. The child prefers to lie on the affected chest	0.05

Table 13. Lobar Pneumonia Clinical symptoms

Symptoms	Weight Value
a. ARI	0.05
b. Cough and cold	0.2
c. Hard to breathe	0.2
d. Shallow and rapid breathing	0.2
e. Restless child	0.05
f. Cyanotic	0.1
g. Nasal lobe breathing	1
h. Delirious	1

Table 14. Acute Bronchiolitis Clinical symptoms

Symptoms	Weight Value
a. Asthma,	0.3
b. Bronchitis,	0.3

c. Bronchopneumonia	0.4

Table 15. Atelectasis Clinical symptoms

Symptoms	Weight Value
a. Occurs 24 hours after surgery	0.05
b. Dyspnu (shortness of breath)	0.3
c. Cyanosis (bluish)	0.2
d. Tachycardia (rapid pulse)	0.1
e. Chest pain	0.1
f. Restless	0.05
g. Increase in body temperature	0.2

Table 16 Massive atelectasis Clinical symptoms

Symptoms	Weight Value
a. Dispnu expirator	0,5
b. Crackles are wet and crisp	0,5

Table 17. Obstructive emphysema Clinical symptoms

Symptoms	Weight Value
a. Crepitation (air in the skin) is emphysematic	1

Table 18. Emphysema Bulosa Clinical symptoms:

Symptoms	Weight Value
a. Pain in the affected side of the thorax	0.1
b. Dispnu	0.2
c. Cough	0.1
d. Sneezing	0.3
e. Due to strenuous physical training	0.3

Table 19. Pneumothorax Clinical symptoms

Symptoms	Weight Value
a. Hard to breathe	0.3
b. Delirious	0.2
c. Cough	0.1
d. The sound of a lender	0.3
e. After doing excessive physical activity	0.1

Table 20. Empyema Torasis Clinical symptoms

Symptoms	Weight Value
a. The temperature was suddenly high	0.1
b. Tachycardia	0.3
c. Dyspnea	0.2
d. Cyanosis	0.05
e. Coughs	0.1
f. Looks very sick	0.05
g. Remittance fever	0.2

From the disease and symptom data above, it can be represented as the rule below. This knowledge representation is used to determine the search process or determine the conclusions of the diagnosis. The following is the discussion

1
. Rule 1 Bronchitis And cough with phlegm
If the cough is dry after 2-3 days

And the voice is lenders
And thick, yellow phlegm
And shortness of breath
And retrostenal pain
And wheezing
Then Bronchitis

2. Rule 2: Asthma Episodic Disease Rare
If coughing up thick and yellow sputum
And shortness of breath
And wheezing
And attacks 3-4 times a year
And symptoms at night
And ages 3-6 years
Then Asma Episodik Jaran

3. Rule 3 Frequent Episodic Asthma
If coughing up thick and yellow sputum
And shortness of breath
And wheezing
And attacks 3-4 times a year
And symptoms at night
And hay fever
And <3 years old
And ages 8-13 years
Then Asma Episodik Often

4. Rule 4 Chronic / Persistent Asthma
If coughing up thick and yellow sputum
And shortness of breath
And wheezing
And symptoms at night
And growth disorders
Then Chronic / Persistent Asthma

5. Rule 5, Severe & Recurring Episodic Asthma
If coughing up thick and yellow sputum
And shortness of breath
And wheezing
And ages 3-6 years
And ISPA (Upper Respiratory Tract Infection)
Then Episodic Asthma Severe & Recurring

6. Rule 6 Persistent Asthma in Infants
If coughing up thick and yellow sputum
And shortness of breath
And wheezing
And <3 years old
Then Persistent Asthma in Babies

7. Rule 7 Hypersecretory asthma
If coughing up thick and yellow sputum
And shortness of breath
And wheezing
And the sound of crackling breath
And ages 3-6 years
Then Asthma Hypersecretion

8. Rule 8 Asthma due to Physical Burden
If coughing up thick and yellow sputum
And shortness of breath
And wheezing
And it hurts when doing physical activity
Then Asma due to Physical Load

9. Rule 9 Asthma with Allergens
If the cough is dry
And thick, yellow phlegm
And shortness of breath
And wheezing
And ages 3-6 years
And after being exposed to allergens
And cough at night at 1-4 am
Then Asthma with Allergens

10. Rule 10 for Night Cough
If coughing up thick and yellow sputum
And shortness of breath
And wheezing
And asthma at 1-4 am
Then Cough tonight

11. Rule 11 for Bad Asthma in the Morning

If age <3 years
And breathing shallow and fast
And the child becomes restless And cyanotic (bluish) And the body temperature rises
And seizures with fever
And vomiting accompanied by diarrhea
Then Bad Asthma in the Morning

12. Rule 12 Bronchopneumonia disease
If cough with phlegm after 2-3 days
And shortness of breath
And cyanotic
And breathe out the nostrils
And pain in the chest
And body temperature rises
And seizures with fever
And the body is shivering
Then Bronchopneumonia

13. Rule 13, Lobaris pneumonia
If cough with phlegm after 2-3 days
And shortness of breath
And wheezing
And ISPA (Upper Respiratory Infection)
And shallow and fast breathing
And the child becomes restless
And cyanotic
And breathe out the nostrils
Then Pneumonia Lobaris

14. Rule 14 Acute Bronchiolitis
If accompanied by other diseases, asthma, bronchitis
Then Acute Bronchiolitis

15. Rule 15: Atelectasis
If shortness of breath
And tachycardia (rapid pulse) And the child becomes restless And cyanotic (bluish) And pain in the chest
And occurs 24 hours after surgery
And body temperature rises
Then Atelectasis

16. Rule 16: Massive Atelectasis
If shortness of breath And the crackle is wet & crispy
Then Massive Atelectasis

17. Rule 17 Obstructive Emphysema disease
If crepitus is in the skin area (as if there is air under the skin)
Then Obstructive Emphysema

18. Rule 18 for Emphysema Bulosa
If the cough is dry
And shortness of breath
And it hurts when doing physical activity
And pain in the chest
Then Emphysema Bulosa

19. Rule 19 Pneomothorax disease
If coughing up thick and yellow sputum
And shortness of breath
And wheezing
And it hurts when doing physical activity
Then Emphysema Bulosa

20. Rule 20 for Emphysema Torasis
If the cough is dry
And shortness of breath
And tachycardia (rapid pulse) And looks very sick
And cyanotic
And body temperature rises
And the body is shivering
Then Emphysema Turosis

3.2. Application of Dempster-Shafer in the Diagnosis of Lung Disease

In the example below, we will look for certainty of lung disease using the rules in table 21. Below:

Table 21. Example of Rule for Lung Disorders with Certainty Factors

NO.	Sympoms	Weight
1	Hard to breathe	0,1
2	Body shivering	0,1
3	Body temperature rises	0,05
4	Cyanotic	0,1
5	tachycardia (rapid pulse) And looks very sick	0,05

Then:
To calculate the WEIGHT value of selected lung diseases using Symptom-1 and Symptom-2
WEIGHT (SYMPTOM-1, SYMPTOM-2) = WEIGHT (SYMPTOM-1) + WEIGHT (SYMPTOM-2) - [(WEIGHT (SYMPTOM-1) x WEIGHT (SYMPTOM-2)]

= 0.1 + 0.1 - (0.1) (0.1)

= 0.19

Then combine it with R? next, which in this example is SYMPTOM-3
WEIGHT (SYMPTOM-1, SYMPTOM-2, SYMPTOM-3) = WEIGHT (SYMPTOM-1, SYMPTOM-2) + WEIGHT (SYMPTOM-3) - ((WEIGHT (SYMPTOM-1, SYMPTOM-2) x WEIGHT (SYMPTOM- 3)]

= 0.19 + 0.05 - (0.19) (0.05)

= 0.24 - 0.0095

= 0.2305 (23%)

That is, the combination of SYMPTOM-1, SYMPTOM-2, and SYMPTOM-3 will produce 23% chance that the conclusion of Emphysema Turosis lung disease will occur.

The page below is used to start a disease consultation, while the pictures from this page can be seen in figures 1 and 2 below:

Figure 1. Consultation Form Step-1

Figure 2. Step-2 Consultation Form

After successfully logging in, it will immediately go to the main system administrator page, which can be seen as shown in Figure 3 below:

Figure 3. System Administrator Main Page

The Disease page is used to enter Disease data and Symptom, while the image looks like in Figures 5 and 6 below:

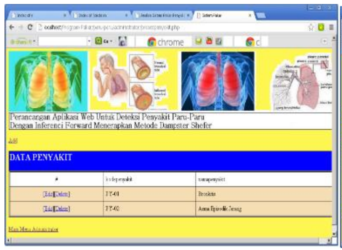

Figure 5. Disease List page

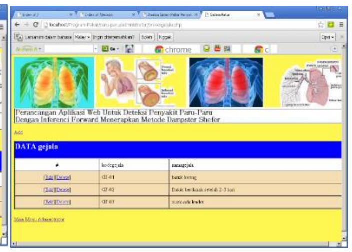

Figure 6. Symptom List page

4. CONCLUSIONS

After designing and applying the software, it can be concluded that the inference technique is easy to use in designing expert systems to get a conclusion but, it has weaknesses in finding these conclusions, namely it is very slow in its search, especially if the system has a large enough knowledge base and this. would be time consuming and hinder the consultation process..

Reference

[1] R. Ambarita, "Sistem Pakar Diagnosa Kerusakan Mainboard Komputer," IJIS - Indones. J. Inf. Syst., vol. 2, no. 1, 2017, doi: 10.36549/ijis.v2i1.20.
[2] S. Kusrini, "Sistem Pakar Teori dan Aplikasi," Penerbit Andi Yogyakarta, 2006.
[3] A. Napanggala, "Penyakit Paru Obstruktif Kronis (PPOK) dengan Efusi Pleura dan Hipertensi Tingkat I Chronic Pulmonary Obstructive Disorder (COPD) with Pleural Effusion and Hypertension Grade I," Medula Unila, vol. 4, pp. 1–6, 2015.
[4] M. A. H. Ramadhan and B. Hartono, "Kejadian Penyakit Paru Obstruktif Kronik (PPOK) Pada Pengendara Ojek Online di Kota Bogor dan Kota Depok Tahun 2018 (Studi Kasus Pencemaran Udara)," J. Nas. Kesehat. Lingkung. Glob., vol. 1, no. 1, Feb. 2020, doi: 10.7454/JUKL.V1I1.3779.
[5] R. Yudhawati and Y. D. Prasetiyo, "Imunopatogenesis Penyakit Paru Obstruktif Kronik," J. Respirasi, vol. 4, no. 1, p. 19, 2019, doi: 10.20473/jr.v4-i.1.2018.19-25.
[6] D. T. Yuwono, A. Fadlil, and S. Sunardi, "Implementasi Metode Dempster Shafer Pada Sistem Pakar Diagnosa Gangguan Kepribadian," J. Sist. Inf. Bisnis, vol. 9, no. 1, p. 25, 2019, doi: 10.21456/vol9iss1pp25-31.
[7] M. Widyaningsih, R. Gunadi, J. T. Informatika, and K. Tengah, "Dempster shafer untuk sistem diagnosa gejala penyakit kulit pada kucing," vol. 7, no. 114, 2017.
[8] Sugiyono, Metode Penelitian Kuantitatif, Kualitatif dan R&D. Bandung: PT Alfabet, 2016.
[9] A. H. Aji, M. T. Furqon, and A. W. Widodo, "Sistem Pakar Diagnosa Penyakit Ibu Hamil Menggunakan Metode Certainty Factor (CF) | Jurnal Pengembangan Teknologi Informasi dan Ilmu Komputer," 2017. http://j-ptiik.ub.ac.id/index.php/j-ptiik/article/view/1556 (accessed Dec. 03, 2019).
[10] H. Indriyawati, A. Sugiharto, and B. Surarso, "Sistem Pakar Diagnosa Penyakit Telinga Hidung Tenggorok (Tht) Dengan Menggunakan Metode Inferensi Berbasis Short Message Service (Sms)," J. Sist. Inf. Bisnis, vol. 3, no. 1, pp. 1–6, 2013, doi: 10.21456/vol3iss1pp01-06.
[11] M. Arhami, "Konsep dasar sistem pakar," Yogyakarta Andi, vol. 206, 2005.
[12] F. N. Salisah, L. Lidya, and S. Defit, "Sistem Pakar Penentuan Bakat Anak Dengan Menggunakan Metode Forward Chaining," J. Ilm. Rekayasa dan Manaj. Sist. Inf., 2015.
[13] A. A. dkk Muslim, "Sistem Pakar Diagnosa Hama Dan Penyakit Cabai Berbasis Teorema Bayes," Jutisi, 2015.