Implementation of Fuzzy Logic Method and Certainty Factor for Diagnosis Expert System of Chronic Kidney Disease

Anggil Agusta [1*], Florentina Yuni Arini [1], Riza Arifudin [1]

[1]Department Of Computer Science, Faculty of Mathematics and Natural Sciences, Universitas Negeri Semarang, Semarang, Indonesia
*Corresponding author: anggilagusta@gmail.com

ARTICLE INFO

Article history
Received 6 February 2020
Revised 10 March 2020
Accepted 2 April 2020

Keywords
Expert System
Fuzzy Logic
Certain Factor
CKD

ABSTRACT

Problem analysis from the development of technology that was originally conducted manually, it can now conduct systematically using computerization. An expert system can solve one problem analysis in diagnosing a disease like chronic kidney disease. Fuzzy logic and certainty factor are expert system methods that are often used. The data used in this research was Chronic Kidney Disease, which was obtained from the UCI dataset. The system was developed using the Laravel PHP framework programming language and MySQL database. The system's development used the waterfall method, which was analyzing user needs to the system, conducting design of the system, coding, and testing the system if it achieves what was expected. The combination of fuzzy logic and certainty factor methods worked with several stages, namely fuzzification (CF_{user}), rule base formation for CF, calculating CF_{expert}, Calculating CF values, the combination of CF values, Finding $CF_{maximum}$. The accuracy level of the system generated from 400 data was obtained 92.25% accuracy for the fuzzy logic method, 97.25% accuracy for the certainty factor, 99% accuracy method for the combination of fuzzy logic and certainty factor methods. While the kappa value for the fuzzy logic method, certainty factor, and the combination of the two methods were respectively 0.84, 0.94, 0.98.

This is an open access article under the CC–BY-SA license.

1 Introduction

Expert system is a branch of intelligence that is quite old because it began to be developed in the middle of the 1960s, well known as the knowledge base expert system (Rochana, Andriani, & Utami, 2011). The existence of an expert system can make users interact with computers to solve certain problems because an expert system can provide a knowledge base like a human expert. Besides as information for the community, especially for sufferers of certain diseases, to find out the initial diagnosis, it can also be a tool for doctors to make decisions (Bria & Takung, 2015).

The method for expert systems that have high accuracy is the certainty factor. Certainty factors stated trust in an event based on evidence or judgment from an expert. Certainty factor uses the value to assume an expert's degree of confidence in data. There are concepts of beliefs and uncertainties that are then formulated in the basic formula (Indriani & Amaliah, 2014). The method which has high accuracy and is often used in expert systems other than the certainty factor is the fuzzy logic method.

Fuzzy logic is a logic that has a grey value between right or wrong. Fuzzy logic theory determines a value that can be true or false value together, but how much the existence and error depended on the weight of its own membership (Krisnawan, Putra, & Bayupati, 2014). Fuzzy logic combines a variety of thinking ways that allow complex system modeling based on human knowledge and experience (Widaningrum, 2015).

One of the most important organs of the human body is the kidneys. The kidneys are a pair of peanut-shaped organs that are located on the lower back. Kidney disease can be a chronic disease that

has become a major health problem in the world community. When this condition occurs, toxic levels and harmful fluids will accumulate in the human body. Chronic kidney disease is increasing every year. This is influenced by growth factors, increased aging, obesity, and unhealthy lifestyles (Putri, Mongan, & Memah, 2016). For finding out if the patient has chronic kidney disease, it can be conducted by laboratory tests of urine and blood samples. Then the data will be processed to diagnose whether the patient has chronic kidney disease or not.

A research conducted by Jumiyati, Pramono, and Hasanuddin (2015), regarding the expert system for diagnosing pulmonary TB disease in children with fuzzy logic methods. This study uses fuzzy inference with the system results that can provide a diagnosis in accordance with the rules applied to the system where the rules come from expert knowledge so that the system can make a diagnosis almost the same as the diagnosis made by an expert. The next study was conducted by Indriani, Rachmawati, and Fitriana (2018), about the certainty factor method in the Childhood Diagnosis Expert System, stating that the certainty factor method produced a system accuracy of 96%.

The aims of this study are (1) to find out the implementation of the fuzzy logic method and certainty factor in the expert system for diagnosis of chronic kidney disease, (2) to know the development of expert systems for diagnosing chronic kidney disease using the fuzzy logic method and certainty factor, (3) to know the analysis of accuracy results between fuzzy logic method and certainty factor method.

2 Methods

2.1 Expert System

Expert system consists of knowledge of expertise, transfer of expertise, inference, rules, and ability to explain. According to Muslim, Kurniawati, & Sugiharti (2015), the expert system was made not to replace a human expert, but the expert system can present the knowledge from an expert to the system so that it can be used by many people. The expert system can be a diagnosis system of a disease that can help users diagnose a disease. Those users can be the patients who want to know information about the diagnosis of the disease suffered and an expert or doctor in helping to diagnose the disease.

2.2 Fuzzy Logic

Fuzzy logic is a method often used in expert systems. Fuzzy logic is included in the component of soft computing. Prof. Lotfi A. Zadeh first introduced fuzzy logic in 1965 (Pamuji, 2017). Fuzzy logic used the grey area as the membership degree. The role of membership degree determines the existence of elements in a set of very important in fuzzy theory (Kusumadewi & Purnomo, 2010). The membership degree is a curve that shows the mapping of data input points into its membership value, which has an interval between 0 and 1 (Pamuji, 2016). There are several operations specifically defined to combine and modify fuzzy sets. The value of membership resulting from two set operations is often known as fire strength or α-predicate.

2.3 Fuzzy Inference System

Fuzzy Inference System (FIS) is a computational framework based on fuzzy set theory, fuzzy rules, and fuzzy reasoning (Arifin, Muslim, & Sugiman, 2015) The fuzzy inference system accepts input in the form of a firm or crisp set. The crisp set's input is sent to the knowledge base that contains n fuzzy rules in the IF-THEN form. Then look for membership value or commonly called Fire Strength. Fire Strength or membership value will be searched for in each rule. If the number of rules is more than one, then parts of all rules will be collected. Furthermore, the aggregation results will be defuzzied to get crisp values as system output (Hikmawati, Arifudin, & Alamsyah, 2017).

The FIS approach is broadly implemented in three stages including:

1. *Fuzzification* (Blurring stage), which is a mapping from a firm or crisp input to a fuzzy set.
2. *Inference* (Inference stage), which is the generating of rules when in a blurred set.
3. *Defuzzification* (Affirmation stage), which is the transformation of the output from the vague value to a firm or crisp value.

2.4 Certainty Factor

Certainty factor is a method to prove whether a fact is certain or uncertain in the form of a matrix and is usually used in expert systems. This method is very suitable for expert systems that diagnose things or uncertain facts (Wulandari & Yuliandri, 2014) The basic formula of Certainty Factor can be seen in Equation 1.

$$CF [H . E] = MB [H , E] – MD [H , E] \quad (1)$$

Description:
CF = Certainty Factor in the H hypothesis that is influenced by fact E.
MB = Measure of Belief is the size, or increasing value of the hypothesis H belief is influenced by the fact E.
MD = Measure of Disbelief is the size, or increasing value of the hypothesis H distrust is influenced by the fact E.
E = Evidence (events or facts).
H = Hypothesis (supposition).

2.5 Related Works

This study was developed from several references that have relevance to the methods and objects of research. The use of reference is intended to provide limits to methods and systems that will be further developed. The following is a description of some references.

This previous research conducted by Azka, Farmadi, and Kartini (2017), regarding the expert system of early diagnosis of kidney disease using the fuzzy logic method for determining certainty factor, explains that the combination of fuzzy logic and certainty factor can be used well for expert systems in diagnosing kidney disease. The accuracy of the system using the method was obtained 100%, but there are several systems diagnoses whose results were two types of diseases, and one of them was in accordance with the diagnosis results from experts. The research conducted by Muslim (Muslim *et al*., 2015) in his research was an expert diagnostic system for chronic kidney disease based on Mamdani fuzzy inference system. In his research using the fuzzy logic Mamdani method for the diagnosis of CKD. The accuracy of the method used was obtained at 98.86%.

Abdullah (2014), in his research, used the Fuzzy Inference System and linear regression for health quality modeling related that Fuzzy Inference System and linear regression can be used in expert systems for their research. The research conducted by Jumiyati *et al*. (2015) about the expert system of pulmonary TB disease diagnosis in children with fuzzy logic methods. In this study, using fuzzy inference with the results of the system can provide a diagnosis in accordance with the rules applied to the system where the rules come from expert knowledge so that the system can make a diagnosis almost the same as the diagnosis made by an expert.

Another study was conducted by Sanaei, Kazemi, and Ahmadi (2015) about the implementation of fuzzy logic for the diagnosis of shingles. In his research produced an expert system that obtained 97% accuracy according to expert results from 200 total data. Research of Poly and Boudet (2017) discussed fuzzy expert systems architecture for processing data and processing. In many decision-making scenarios, fuzzy expert systems had been useful to infer more conceptual knowledge from data. With the emergence and growing development of cloud-based system architecture, it is necessary to improve the fuzzy expert system to support higher-level operators, large rule bases, and abundant input flows.

Another study conducted by Wulandari et al. (2014) about diagnosing nutritional disorders using the certainty factor method explained the implementation of certainty in expert systems for diagnosing diseases. The study concluded that the certainty factor method could be used to diagnose nutritional diseases with 90% accuracy with expert results. The next study was conducted by Indriani *et al*. (2018) about the certainty factor method in the Childhood Diagnosis Expert System, stating that the certainty factor method produced a system accuracy of 96%. Aji, Furqon conducted another study, & Widodo (2018) regarding the expert system for diagnosing disease in pregnant women using the certainty

factor method. In his research produced expert systems that have been tested with the black box method and the results of accuracy of 100% of the 13 data samples.

3 Results and Discussion

The implementation of this study used the Chronic Kidney Disease (CKD) datasets obtained from the UCI repository of machine learning. CKD consists of 25 attributes, including binary class attributes, which are divided into ckd and not_ckd. The system was developed using the Laravel PHP framework programming language and MySQL database. The development of the system used the waterfall method. The first stage was needs analysis, analyzing what the user could use from the system. The next stage was designed by designing DFD and database table structure. The next stage was implementation, starting to code by realizing the needs analysis and system design results. The last stage was testing, by testing the functional system whether it was expected or not. Functional system testing can be seen in Table 1.

Table 1. Functional system testing

No	Tested Requirement	The Testing
1	Menu of Input Data	View, process, download, change, delete and add input data.
2	Menu of Import Data	View, process, download and change import data.
3	Setting	View, and change symptom data.
4	Accuracy of Input Data	Process and see the accuracy of input data.
5	Accuracy of Import Data	Process and see the accuracy of import data.

The limits of the patient's normal condition for the diagnosis of CKD in a disease book in volume II edition V by (Sudoyo, Setiyohadi, Alwi, Simadibrata, & Setiati, 2009) can be seen in Table 2.

Table 2. The limits of the patient's normal condition for the diagnosis of CKD

No	Variable	*Not* CKD condition	CKD condition
1	Age	<=65 years	>65 years
2	Blood pressure	80 mm/Hg	>80 mm/Hg
3	Spesific Gravity	1,010-1,030	<1,010
4	Albumin	0	>0
5	Sugar	0	>0
6	Red blood cell	normal	abnormal
7	Puss cell	normal	abnormal
8	Puss cell Clumps	not present	present
9	Bacteria	not present	present
10	Blood glucose random	<=110 mgs/dl	>110 mgs/dl
11	Blood urea	<=40 mgs/dl	>40 mgs/dl
12	Serum creatinine	0,5-1,5 mgs/dl	>1,5 mgs/dl
13	Sodium	135-155 mEq/L	<135 mEq/L
14	Potasium	3,5-5 mEq/L	>5 mEq/L
15	Hemoglobin	10-16 gms	<10 gms
16	Packed cell volume	30-48 cells/cumm	<30 cells/cumm
17	White blood cell count	4000-10000 cells/cumm	>10000 cells/cumm
18	Red blood cell count	4,7-6,1 millions/cmm	<4,7 millions/cmm

19	Hypertension	no	yes
20	Diabetes Mellitus	no	yes
21	Coronary artery disease	no	yes
22	Appetite	good	poor
23	Pedal edema	no	yes
24	Anemia	no	yes

The symptom weight value was also used to weigh the value of the certainty factor method to obtain expert CF values and determine the category of symptoms, whether it was in the main symptom or supporting symptom in the diagnosis of chronic kidney. The following is the symptom weight value that has been sorted from the highest value or is very influential on CKD until the lowest symptoms or little effect on CKD can be seen in Table 3.

Table 3. Used weight value

No	Name	CF CKD	CF *Not* CKD
1	Serum creatinine	0.8	-0.8
2	Puss cell	0.8	-0.2
3	Blood urea	0.8	-0.2
4	Hemoglobin	0.8	-0.2
5	Albumin	0.8	0
6	Hypertension	0.8	0
7	Pedal edema	0.8	0
8	Anemia	0.8	0
9	Spesific Gravity	0.6	-0.2
10	Red blood cell	0.6	-0.2
11	Potasium	0.6	-0.2
12	Coronary artery disease	0.6	0
13	Appetite	0.6	0
14	Blood pressure	0.5	-0.2
15	Red blood cell count	0.4	-0.4
16	Bacteria	0.4	-0.2
17	Diabetes Mellitus	0.4	0
18	Puss cell Clumps	0.2	-0.2
19	Sodium	0.2	-0.2
20	Packed cell volume	0.2	-0.2
21	White blood cell count	0.2	-0.2
22	Age	0.2	0
23	Sugar	0.2	0
24	Blood glucose random	0.2	0

The fuzzy logic method worked with four stages, namely fuzzification, fuzzy inference, defuzzification, and determining the results of the diagnosis based on the results of defuzzification. The implementation of the certainty factor method for the CKD diagnosis had several stages, namely formatting of the CKD rule base, calculating the CF value, the combination of each CF

value, and obtaining the maximum value from the CF combination result. Maximum CF can be used to determine the diagnosis of CKD. Whereas the combination of fuzzy logic and certainty factor has the first stage is the CF user fuzzification process, the formation of rule base CKD, calculating expert CF values based on CKD rule base, the combination of methods to combine expert CF and CF user, the combination of each CF value and maximum CF score, the last step is to find the results of a CKD diagnosis based on the maximum CF values that have been obtained.

After the data was processed through several methods, it obtained the value results of the method used. Next, it was processing the results of the score into a diagnosis of whether or not CKD.

1. Diagnosis Results of Fuzzy Logic

Diagnosis of CKD use the results of the fuzzy logic method rules or rules used are:

a. If Z <= 50% then the diagnosis result = notCKD,
b. If Z > 50% then the diagnosis result = CKD.

Example taken from data, Z = 66% So the diagnosis of chronic kidney disease using fuzzy logic is CKD.

2. Diagnosis Results of Certainty Factor

Diagnosis of CKD using the results of the certainty factor method the rules or rules used are:

a. If CFmaksimal <= 0% then the diagnosis result = notCKD,
b. If CFmaksimal > 0% then the diagnosis result = CKD.

An example is taken from data, CFmaksimal = 100% So the diagnosis of chronic kidney disease using certainty factor is CKD.

3. Diagnosis Results in Combination of Fuzzy Logic and Certainty Factor

Diagnosis of CKD using a combination of fuzzy logic methods and certainty factor the rules or rules used are:

a. If CFmaksimal <= 0% then the diagnosis result = notCKD,
b. If CFmaksimal > 0% then the diagnosis result = CKD.

An example is taken from data, CFmaksimal = 100% So, the results of the diagnosis of chronic kidney disease using a combination of fuzzy logic methods and certainty factor is CKD.

The accuracy calculation phase was conducted using two methods, namely, using confusion matrix and kappa statistics. A confusing matrix is a useful tool for analyzing how well to calculate accuracy by recognizing tuples from different classes. TP and TN provide information when data is correct or appropriate, while FP and FN notify when data is incorrect or inappropriate. Kappa statistic is a measure that states the consistency of measurements made by two assessors (rater) or consistency between two measurement methods or can also measure consistency between two measurement tools. Calculation of accuracy was carried out for three methods used for the diagnosis of chronic kidney disease. A comparison of the results of the accuracy of each method used in the CKD diagnosis expert system can be seen in Table 4.

Table 4. The accuracy results of expert system CKD diagnosis system method

No	Methods	*Confusion Matrix*	*Kappa Statistic*	Description
1	*Fuzzy Logic*	92.3%	0.84	*Almost Perfect*
2	*Certainty Factor*	97.3%	0.94	*Almost Perfect*
3	*Fuzzy Logic* and *Certainty Factor* Combination	99%	0.98	*Almost Perfect*

The fuzzy logic method obtained 92.3% accuracy and a kappa value obtained of 0.84, the certainty factor method obtained 97.3% accuracy and a kappa value of 0.94, while for the combination of fuzzy logic and certainty factors obtained 99% accuracy and the kappa value obtained to 0.98.

4 Conclusion

The accuracy of each method in the CKD diagnosis expert system was measured using the confusion matrix and kappa statistics. The amount of data used was 400 data divided into 250 diagnosis data of

CKD and 150 diagnosis data of notCKD. By using confusion matrix in fuzzy logic method was obtained of 92.3% accuracy, for the certainty factor method was obtained of 97.3% accuracy, while the combination of fuzzy logic and certainty factor methods was obtained of 99% accuracy. The comparison using the kappa statistic obtained the kappa value as follows. The kappa value for fuzzy logic was 0.84, certainty factor was 0.94, while for the combination of fuzzy logic and certainty factor methods was 0.98. Based on the kappa value of the three methods for the method accuracy in the expert system, the diagnosis was almost perfect.

References

Abdullah, L. (2014). Modeling of Health Related Quality of Life Using an Integrated Fuzzy Inference System and Linear Regression. *Elsevier Procedia Computer Science*, 99-105. doi:10.1016/j.procs.2014.11.039

Aji, A. H., Furqon, M. T., & Widodo, A. W. (2018). Sistem Pakar Diagnosa Penyakit Ibu Hamil Menggunakan Metode Certainty Factor (CF) [Expert System for Diagnosing Diseases of Pregnant Women Using the Certainty Factor (CF) Method]. *Jurnal Pengembangan Teknologi Informasi dan Ilmu Komputer*, 2(5), 2127-2134. Retrieved from http://j-ptiik.ub.ac.id/index.php/j-ptiik/article/view/1556

Arifin, S., Muslim, M. A., & Sugiman. (2015). Implementasi Logika Fuzzy Mamdani untuk Mendeteksi Kerentanan Daerah Banjir di Semarang Utara [Implementation of Fuzzy Mamdani Logic to Detect Vulnerability of Flood Areas in North Semarang]. *Scientific Journal of Informatics*, 2(2), 179-192. doi:10.15294/sji.v2i2.5086

Azka, N., Farmadi, A., & Kartini, D. (2017). Sistem Pakar Diagnosa Awal Penyakit Ginjal dengan Metode Fuzzy Logic untuk Penentuan Certainty Factor [Expert System for Early Diagnosis of Kidney Disease with Fuzzy Logic Method for Determining Certainty Factors]. *Jurnal Elektronik Nasional Teknologi dan Ilmu Komputer (JENTIK)*, 77–91.

Bria, Y. P., & Takung, E. A. S. (2015, March). Pengembangan Sistem Pakar Diagnosis Penyakit Tuberculosis dan Demam Berdarah Berbasis Web Menggunakan Metode Certainty Factor [Development of Web-Based Expert System for Diagnosis of Tuberculosis and Dengue Fever Using the Certainty Factor Method]. In *Seminar Nasional Teknologi Informasi dan Komunikasi 2015 (SENTIKA 2015)*, 271-276.

Hikmawati, Z. S., Arifudin, R., & Alamsyah. (2017). Prediction the Number of Dengue Hemorrhagic Fever Patients Using Fuzzy Tsukamoto Method at Public Health Service of Purbalingga. *Scientific Journal of Informatics*, 4(2), 115-124. doi:10.15294/sji.v4i2.10342

Indriani, A. F., Rachmawati, E. Y., & Fitriana, J. D. (2018). Pemanfaatan Metode Certainty Factor dalam Sistem Pakar Diagnosa Penyakit pada Anak [Utilization of the Certainty Factor Method in the Expert System for Diagnosing Diseases in Children]. *Techno.com*, 17(1), 12-22. doi:10.33633/tc.v17i1.1576

Indriani, A., & Amaliah, Y. (2014, January). Implementasi Sistem Pakar untuk Mendiagnosa Penyakit Kandungan Menggunakan Metode Certainty Factor [Implementation of Expert System to Diagnose Gynecological Diseases Using the Certainty Factor Method]. In *Seminar Nasional Teknologi Informasi dan Multimedia 2014 STMIK AMIKOM Yogyakarta*, 15-20. Retrieved from https://ojs.amikom.ac.id/index.php/semnasteknomedia/article/view/1065/0

Jumiyati, M., Pramono, B., & Hasnuddin, L. O. (2015). Aplikasi Sistem Pakar Diagnosis Penyakit TB Paru Pada Anak dengan Metode Logika Fuzzy Berbasis Android [Application of Expert System for Diagnosis of Pulmonary TB in Children with the Android-Based Fuzzy Logic Method]. *semanTIK*, 1(1), 25-32. Retrieved from http://ojs.uho.ac.id/index.php/semantik/article/view/414

Krisnawan, I. P. B., Putra, I. K. G. D., & Bayupati, I. P. A. (2014). Sistem Pakar Diagnosa Penyakit Kulit dan Kelamin dengan Metode Certainty Factor dan Fuzzy Logic [Expert System for

Diagnosing Skin and Genital Diseases using Certainty Factor and Fuzzy Logic Methods]. *MERPATI,* 2(3), 351-360. Retrieved from https://ojs.unud.ac.id/index.php/merpati/article/view/17906

Kusumadewi, S., & Purnomo, H. (2010). *Aplikasi Logika Fuzzy untuk Pendukung Keputusan [Fuzzy Logic Application for Decision Support](2nd ed.)*. Yogyakarta: Graha Ilmu.

Muslim, M. A., Kurniawati, I., & Sugiharti, E. (2015). Expert System Diagnosis Chronic Kidney Disease Based on Mamdani Fuzzy Inference System. *Journal of Theoretical and Applied Information Technology*. 78(1), 70-75. Retrieved from http://lib.unnes.ac.id/id/eprint/33052

Pamuji, A. (2016). Assessment the Method of Fuzzy Logic to Determine the Quality of Service Expedition in Jabodetabek Area. *Scientific Journal of Informatics*, 3(2), 11-20. doi:10.15294/sji.v3i2.7906

Pamuji, A. (2017). Fuzzy Logic Inference System for Determining the Quality Assesment of Student's Learning ICT. *Scientific Journal of Informatics*, 4(1), 57-65. doi:10.15294/sji.v4i1.7082

Poli, J.P., & Boudet, L. (2017). A Fuzzy Expert System Architecture for Data and Event Stream Processing. *Elsevier International Fuzzy System Association*, 1-31. doi:10.1016/j.fss.2017.10.005

Putri, T. D., Mongan, A. E., & Memah, M. F. (2016). Gambaran Kadar Albumin Serum pada pasien Penyakit Ginjal Kronik Stadium 5 Non Dialisis [Description of serum albumin levels in non-dialysis stage 5 chronic kidney disease patients]. *Jurnal e-Biomedik (eBm),* 4(1), 173-177. doi:10.35790/ebm.4.1.2016.10861

Rochana, S., Andriani, K. K. W., & Utami, Y. R. W. (2011). Implementasi Fuzzy Logic dalam Sistem Pakar untuk Mendeteksi Penyakit Kanker Serviks [Implementation of Fuzzy Logic in Expert Systems to Detect Cervical Cancer]. *Jurnal Ilmiah SINUS*, 27-38.

Sanaei, F., Kazemi, M. A. A., & Ahmadi, H. (2015). Designing and Implementation of Fuzzy Expert System for Diagnosis of Hepes Zoster. *International Conference on Knowledge-Based Engineering and Innovation*, 1032-1040. doi:10.1016/j.bbe.2019.09.004

Sudoyo, A. W., Setiyohadi, B., Alwi, I., Simadibrata, M., & Setiati, S. (2009). *Buku Ajar Ilmu Penyakit Dalam Jilid II [Textbook of Internal Medicine Volume II] (5th Ed.)*. Jakarta: Interna Publishing.

Widaningrum, I. (2015). Analisis Hubungan Proses Pembelajaran dengan Kepuasan Mahasiswa Menggunakan Logika Fuzzy [Analysis of the Relationship between Learning Process and Student Satisfaction Using Fuzzy Logic]. *Scientific Journal of Informatics*, 2(1), 91-98. doi:10.15294/sji.v2i1.4532

Wulandari, F., & Yuliandri, I. (2014). Diagnosa Gangguan Gizi Menggunakan Metode Certainty Factor [Diagnosis of Nutritional Disorders Using Certainty Factor Methods]. *Jurnal Sains, Teknologi dan Industri*, 11(2), 305-313. doi:10.24014/sitekin.v11i2.760