Android Based Expert System Application for Diagnose COVID-19 Disease: Cases Study of Banyumas Regency

Research Article

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ABSTRACT

Since being confirmed by WHO, the status of COVID-19 outbreak has become a global pandemic, the number of cases has been confirmed positive, cured, and even death worldwide. Artificial intelligence in the medical has given rise to expert systems that can replace the role of experts (doctors). Tools to detect someone affected by COVID-19 have not been widely applied in all regions. Banyumas Regency, Indonesia has included the confirmed region of COVID-19 cases, and it's difficult for someone to know the symptoms that are felt whether these symptoms include indications of someone ODP, PDP, positive, or negative COVID-19, and still at least a referral hospital handling COVID-19. Expert systems with certainty factors can help someone make a self-diagnose whether including ODP, PDP, positive, or negative COVID-19. This expert system provides ODP diagnostic results with a confidence level of 99.96%, PDP 99.99790%, positive 99.9999997%, negative 99.760384%, and the application runs well on Android OS.

Keywords: Expert system, artificial intelligence, certainty factor, forward chaining, covid19, android.

1. INTRODUCTION

So far, as of May 28, 2020, the SARS-CoV-2 virus has infected more than 5,817,317 people with 216 infected countries, and WHO has established a global pandemic status (WHO, 2020). The first case of COVID-19 that occurred in China was severe enough for medical treatment, but the total number of people infected was very difficult to record. The death ratio (Case Fatality Rate) of the COVID-19 pandemic is estimated at 2% among medically treated patients (Lipsitch et al., 2020).

The symptoms of COVID-19 are mostly non-specific symptoms (uncertain) such as fever, cough, myalgia (muscle aches), weakness, diarrhea, and nausea a few days before fever. Some headaches and hemoptysis (blooding cough), even relatively asymptomatic for some cases (Yue Zu et al., 2020). Implementation of technology for medical has become commonplace in helping doctors to diagnose diseases. This technology is very helpful in all aspects such as data archiving and information media. One of the current technological trends in the expert system. The expert system is a computer-based system that uses knowledge, facts, and reasoning techniques for solving problems that are usually only can be solved by an expert in a particular field (Wiyanti et al., 2018). The expert system with MYCIN of the certainty factor method is the solution for the medical issue of diagnosing symptoms and illness (Safira et al., 2019). MYCIN is the part of an expert system that can provide an expert medical level solution to complex problems, within gives some advice through consultative dialogue or sometimes likes the medical consultation system. MYCIN including the knowledge base and an inference mechanism or inference engine. MYCIN can explain conditional statements or rules that represented the knowledge base (Meena & Kumar, 2015).

The expert system is expected to be able to diagnose the disease by analyzing the symptoms of the disease into a decision by using forward chaining method as its tracking method and certainty factor method as a method for calculating the value of trust in symptoms given by patients (Ritonga, 2013). Referring to the description above, this research will try to uncover how to diagnose someone for COVID-19 disease (ODP, PDP, positive, or negative) by using an Android-based expert system application, as well as knowing the distribution of COVID-19. In this case, a case study located in Banyumas Regency, Central Java, Indonesia. Referring to the background, the objectives to be achieved through this research are to make it easier for someone to do self-diagnosis using the Android-based COVID-19 disease diagnosis expert system application, and to find out the distribution of COVID-19 disease with case studies in Banyumas Regency, Central Java, Indonesia.

2. LITERATURE STUDY

2.1. Expert System

The expert system is a computer system that emulates its ability to make decisions replacing human experts. It also includes a series of intelligence programs that use inference knowledge and procedures to solve problems that are difficult enough that require adequate human experts to solve them. Expert systems are intended to act in all aspects like an expert human being (Suryadi, 1994).

The expert system is a branch of artificial intelligence (AI) that makes extensive use of specialized knowledge to be able to solve problems at the level of human experts. Knowledge in the expert system itself is in the form of a collection of books, magazines, and knowledge of a human expert. The expert system is a system based on expert knowledge or expert system based on expert knowledge (Suryadi, 1994).

Expert systems make extensive use of specialized knowledge for solving expert human-level problems. Expert systems make ordinary people can solve the problem or just looking for quality information that can only be obtained with the help of experts in their fields (Lestari et al., 2017). The development of science and technology helps human work based on knowledge (Abdar et al., 2017).

2.2. Artificial Intelligence

Artificial Intelligence (AI) is the study of a computer that can do what humans want, which contains learning knowledge (Rich & Knight, 1991). AI is a branch of computer science that specifically studies how to understand human intelligence. AI itself has a new studio branch on a fuzzy system, soft computing, evolutionary computing, and also data mining. There are 4 basic techniques: searching, reasoning, planning, and learning. Examples of implementation of reasoning techniques are expert systems in medicine (Suyanto, 2014).

2.3. Reasoning Technique

Reasoning technique (reasoning) is problem-solving techniques by representing problems in the knowledge base using logic or computer language. There are 3 types of logic used in technical reasoning: propositional logic, first-order logic or calculus predicate, and fuzzy logic (cryptic logic). The logic of propositions and predicate calculus is used specifically to overcome the problem of certainty (Suyanto, 2014).

2.4. Certainty Factors

When dealing with a problem it is not uncommon to find results that do not contain full certainty. The answer to the uncertainty is caused by the uncertainty rule factor and the user's uncertain answers to the questions raised by the system. An expert (for example, a doctor) often diagnoses information in a patient with the phrase "most likely", "possible", "almost certain". For this to be overcome, the solution uses certainty factors (CF) to explain the level of expert confidence in the problem being faced. Certainty Factor explains the certainty measure of a fact or existing rules. The mathematical notation is explained below.

Theorem 1: Certainty Factor equations:

$$CF [h, e] = MB [h, e] - MD [h, e] \quad (1)$$

With CF [h, e] is Certainty Factor; MB [h, e] is a measure of confidence in hypothesis h if given evidence e (between 0 and 1); MD [h, e] is a measure of mistrust of evidence h if given evidence e (between 0 and 1) (Lestari et al., 2017).

2.5. Virus

Viruses are invisible microorganisms that occupy a special place compared to other groups of microorganisms (bacteria, micro plasm, rickettsia, chlamydia, fungi, germs; they belong to a group of true microorganisms). Viruses have simple structures and are so small that they cannot be seen under an ordinary microscope, and also have special characteristics that other microorganisms do not have. Viral nucleic acid (genetic information) can be single or multiple chains, RNA or DNA only, and not both of them, do not have ribosomes, mitochondria, and other organelles that are useful for build proteins and energy. A virus cannot grow and reproduce on non-living media. Virus required living cells as host/hospes. Components in the body of the virus are made with the help of host cell equipment (organelles of a cell). Viruses are obligate intra-cell level parasites, which after the virus attacks the host cell, virus' genome will affect the host's cell and controlling it for synthetic transfer between virus' genetics and the host's genetics (Syahrurachman, 1994).

2.6. Corona Virus and Coronavirus Disease-19

Coronavirus is a large virus, sheathed RNA virus. The coronavirus in humans causes coughs in colds and has triggered gastroenteritis in infants. Coronavirus in animals that cause disease in pets. Coronaviruses from lower animals taxonomy are over serious infections in their natural host. Human coronaviruses are difficult to breed (Sastrawinata, 2008).

Coronaviridae is a family of the Genus Coronavirus, which is pleomorphic, sheathed, the genome is single-stranded RNA, not segmented, rounded virions with diameter 80-160 nm, there are protuberances, on the surface, they have envelopes, the shape of a double or flower leaf with a length of 20 nm wide apart on the surface of the sheath (like a sun's corona, so-called coronavirus) (Karsinah, 1994; Sastrawinata, 2008). Coronaviruses (Order Nidovirales, Familia Coronaviridae, Genus Coronavirus) are large, hardbound, positive-stranded RNA viruses that caused respiratory and enteric diseases in humans and other animals (Rota et al., 2003). Figure 1 illustrated the structure of Coronaviridae.

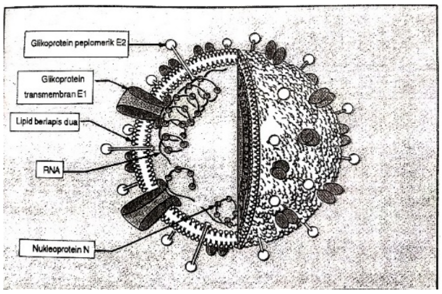

Fig. 1. Coronaviridae structure (Karsinah, 1994)

Since the novel Coronavirus (2019-nCoV) virus has been infected a human in Wuhan, China, in December 2019, and began to infect humans until it spread to several countries in the world. So far, 2019-nCoV has infected more than 43,000 patients in 28 countries and has been assigned a pandemic status by WHO (WHO, 2020). Since February 11, 2020, WHO has announced the name of a disease by the 2019-nCoV virus which caused an outbreak of a world pandemic called Coronavirus Disease (COVID-19) (Lai et al., 2020).

On January 26, 2020, more than 2000 cases of this virus infection were confirmed, most of which involved people living in/or visiting Wuhan, and confirmed human-to-human transmission (Lu et al., 2020). The International Committee on Taxonomy of Viruses (ICTV) then changed the name of the virus formerly called "2019-nCoV" to "Severe Acute Respiratory Syndrome Coronavirus-2 (SARS-CoV-2)" (Lai et al., 2020).

The 2019-nCoV virus (or SARS-CoV-2) is quite different from the SARS-CoV virus that causes the SARS outbreak. The SARS-CoV-2 virus is considered a new beta coronavirus that infects humans. Although phylogenetic analysis shows that bats may be native viruses, animals sold in the Wuhan seafood market may also be hosts that facilitate the emergence of this virus in humans. Structural analysis of this virus suggests that the SARS-CoV-2 virus may bind to the Angiotensin-Converting Enzyme 2 (ACE2) receptor enzyme in the human body. Evolution, adaptation, and spread of this virus in the future are predicted to occur (Lu et al., 2020).

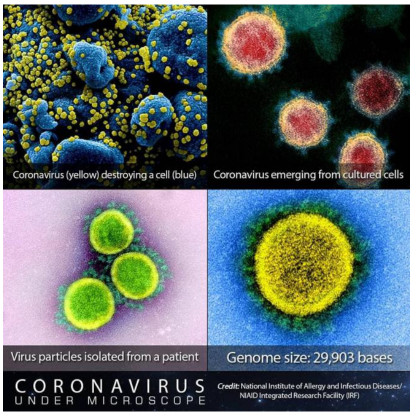

Fig. 2. SARS-CoV-2 Virus Seen under Electron Microscope (Docs from National Institute of Allergy and Infectious Diseases USA)

2.8. COVID-19 Incubation Period and Symptoms

The incubation period for the 2019-nCoV virus maybe about 3 days or less (Phan et al., 2020). The estimated incubation period for COVID-19 infections averaged about 6.4 days (95% credible interval of 5.6-7.7), competent between 2.1 to 11.1 days (percentile 2.5 to 9.5) from the earliest 88 cases were found of COVID-19 outbreak. WHO assumes a range for the incubation period of 0-14 days and 2-12 days assumed. On average 95% is about 8 days (Backer et al., 2020).

Reported by the Indonesian Ministry of Health, someone who has the possibility of contact with other patients is positive for COVID-19 and symptoms of fever, fever above 38°C accompanied by colds and respiratory problems. Also, other symptoms such as sore throat and fatigue and lethargy. Other symptoms such as those found include feeling uncomfortable, complaints continued, accompanied by difficulty breathing (shortness or rapid breathing), and there is a history of travel 14 days ago to a country/region with local transmission COVID-19 (Kemkes RI, 2020a). Emergency warning signs of contracting COVID-19 include difficulty breathing, intense pain or pressure in the chest, confusion, or the inability of the body to rise, and lips or face bluish (CDC, 2020).

2.9. COVID-19 Epidemiology

The age distribution of COVID-19 transmission cases was reported to be more inclined to the older age group for more than 44 years, based on statistical data for cases that are still alive. The average age of died case is 70 years. Some cases are under 15 years old. A significant increase in the possibility of 2019-nCoV infection begins at the age of 30 and above (Sun et al., 2020).

Reported by the Indonesian Ministry of Health, elderly groups and people who have only carrier disease, potentially infected with COVID-19, young people with good immunity are also prone to contracting, even symptoms are very minimal, and can be affected without symptoms. Without these symptoms, it is one of the factors that spread this virus faster. Because they are not aware of having been infected with COVID-19 and do not do independent isolation at home, so this becomes the basis for the spread of COVID-19 more quickly. If this is transmitted to relatives at home who are older and prone to contracting it, this will become a serious problem for the family. Youth can be a source of transmission for families (Kemkes RI, 2020c).

The SARS-CoV-2 virus can survive in the air for 3 hours (airborne), in plastic and stainless steel about 72 hours, in copper about 4 hours, in cartons about 24-hour (van Doremalen et al., 2020). Then, the SARS-CoV-2 dynamic transmission virus can be accessed by someone who positively infects others and becomes protected. The latest knowledge of the epidemiology of COVID-19 is to determine the transmission time (Haushofer et al., 2020). Passengers after traveling from abroad will be given a health certificate by the Government of the Republic of Indonesia. On the card that contains information about 14 days ago, get the flu is advised to check to Fasyankes (Kemkes RI, 2020b). Reported as someone who infected 2019-nCoV and occurred outside China can be questioned regarding human-to-human transmission (Phan et al., 2020).

2.10. Android

Android is a Linux-based operating system (OS) made for touchscreen mobile devices such as smartphones and tablet PCs. Android was originally developed by Android Inc., then Google bought it in 2005. The operating system was officially released in 2007, in conjunction with the establishment of the Open Handset Alliance, a consortium of hardware, software, and telecommunications companies aimed at advancing the open standards of cellular devices. The first Android phone went on sale in October 2008 (Google, 2008).

The table and figure below show data on the percentage of the number of Android platform devices that accessed Google Play and running the latest version of the Android platform. The data explained below (Google Developer, 2020).

Table 1. Data of relative number of devices that running version of the android platform (data collected from (Google Developer, 2020))

Version	Platform Name	*API*	Global Distribution
2.3.3 - 2.3.7	*Gingerbread*	10	0.3%
4.0.3 - 4.0.4	*Ice Cream Sandwich*	15	0.3%
4.1.x	*Jelly Bean*	16	1.2%
4.2.x		17	1.5%
4.3		18	0.5%
4.4	*KitKat*	19	6.9%
5.0	*Lollipop*	21	3.0%
5.1		22	11.5%
6.0	*Marshmallow*	23	16.9%
7.0	*Nougat*	24	11.4%
7.1		25	7.8%
8.0	*Oreo*	26	12.9%
8.1		27	15.4%
9	*Pie*	28	10.4%
10	Android 10	29	(NA)
11	Android 11 (Android R)	DPI	(in developing)

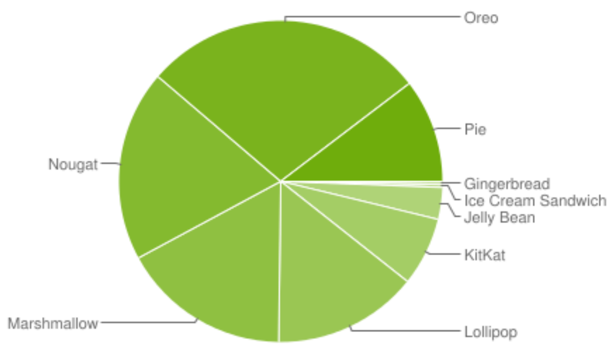

Fig. 3. Chart of Relative Number of Devices That Running Version of The Android Platform (Google Developer, 2020)

3. RESEARCH METHOD

The methods used in this research are Certainty Factors (CF) and forward chaining methods. CF was introduced by Shortliffe Buchanan in making MYCIN CF is the value of clinical parameters given by MYCIN to show the amount of trust (percentage of certainty), by representing MYCIN as a tool for modeling expert systems that are used in diagnosing a disease that can use the logic that produces solutions certainty (Agus et al., 2018). The use of forwarding chaining to display questions about the symptoms experienced by patients. Modeling the design process of the expert system that will be created can be illustrated by the author as follows.

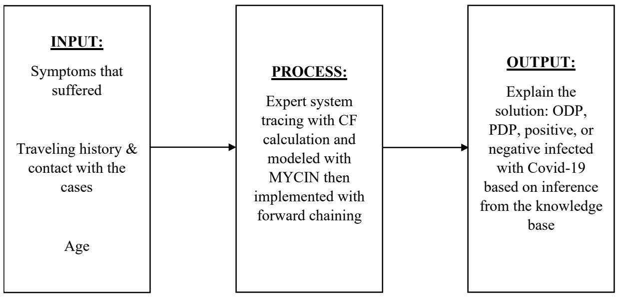

Fig. 4. Expert System Process

The flowchart of research can be explained as follows.

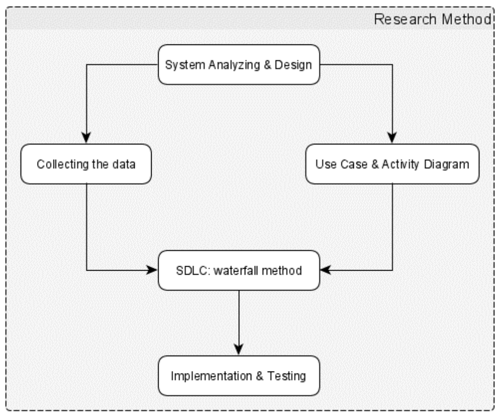

Fig. 5. Flowchart of Research

First, system analysis, to define the needs associated with the system to be developed. The result can explain the specification of software requirements. Next, analyze the system by collecting data through interview techniques, observation techniques, and questionnaire techniques. System design includes the design of use case diagrams and activity diagrams by modeling the Unified Modeling Language (UML) (Rosa & Shalahuddin, 2016).

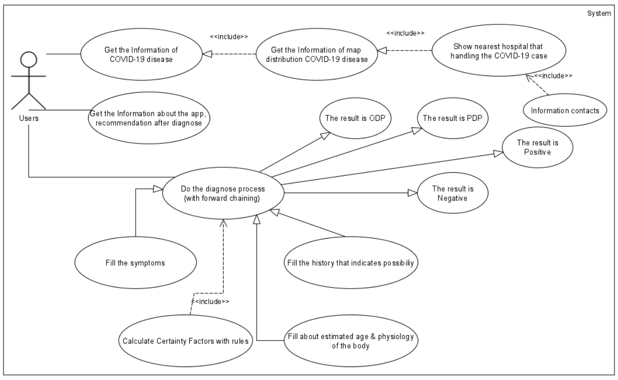

Fig. 6. Use case diagram

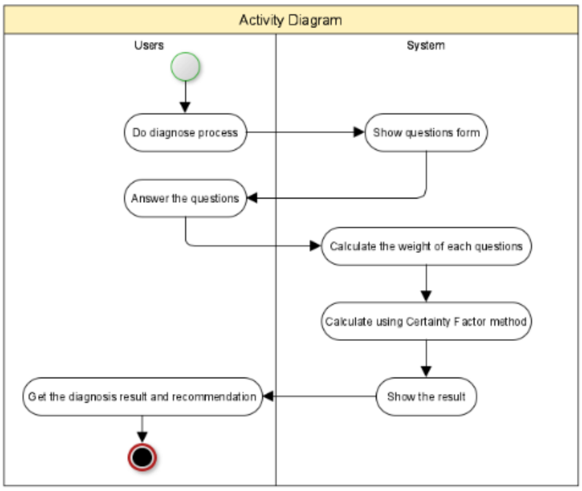

Fig. 7. Activity diagram

Second, system development includes the selection of the System Development Life Cycle (SDLC). SDLC used in this research is a waterfall model. Third, interface design, which is an implementation of the User Interface (UI) application. The author uses the Android Studio software to process source code. As for testing with black-box testing techniques, which is done by observing the results of the implementation through data tests and checking every function in the app whether it works well or not (Slamet et al., 2019).

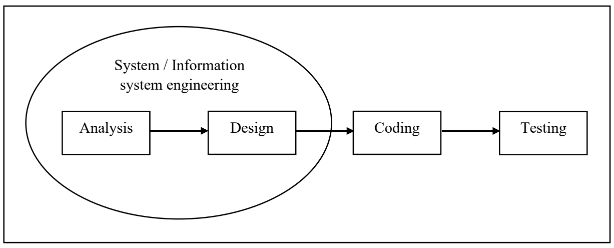

Fig. 8. Waterfall model (Rosa & Shalahuddin, 2016)

The waterfall model offers software development that has constant specifications and is suitable for simple software. This model is also called the sequential linear model or classic life cycle. This model provides a software life cycle approach in order to start from the analysis, design, coding, testing, and supporting stages (Rosa & Shalahuddin, 2016).

4. RESULT

4.1. CF Analyze

The following is a list of symptoms, activities history, and body (physiological) conditions (all of the lists written in the Indonesian language) that exist in this expert system.

Table 2. List of symptoms

Symptoms	Code
Throw up	G01
Fever > 38°C	G02
Tired and lethargic	G03
Diarrhea	G04
Flu	G05
Respiratory disorders	G06
Pneumonia	G07
Difficulty breathing and chest pain	G08
Throat pain	G09
Dry cough	G10
Feeling unwell	G11
Complaints continue	G12
Disoriented	G13
Difficult to wake up	G14
Bluish lips or face	G15

Table 3. Activities history

Activities History	Code
Trip 14 days ago to the COVID-19 transmission area	R01
Contact with confirmed COVID-19 cases	R02
Feel the symptoms after 3-6 days and have been in contact with COVID-19 cases	R03
Having the flu after 14 days of traveling to the COVID-19 transmission area	R04

Table 4. Physiological conditions

Physiological Conditions	Code
Elderly (65 older)	K01
Mature (15-65 years)	K02
Kid (under 15 years)	K03
Did not feel any symptoms but had contact with COVID-19	K04
Does not have any symptoms and never had contact with COVID-19	K05

The following rules to produce positive inferences, ODP, PDP, and negatives result. Tables

5 and 6 we calculated the value of CF rule. The value of CF rule that according to expert (this value adopted from a human expert that we interviewed) explained in Table 5. The value of CF rule that according to user trust (this value calculated based on **Theorem 1:** Certainty Factor equations in math equation (1) above) explained in Table 6. We have been calculated CF rule using *Microsoft Excel* software.

Table 5. CF rules according to an expert if positive inference (calculated from *Microsoft Excel*)

Rules of CF	**CF rule according to expert**
IF G01	0.60
AND G02	1.00
AND G03	0.40
AND G04	0.40
AND G05	1.00
AND G06	1.00
AND G07	1.00
AND G08	0.80
AND G09	0.80
AND G10	1.00
AND G11	0.40
AND G12	0.20
AND G13	0.00
AND G14	0.40
AND G15	0.20
AND R01	1.00
AND R02	1.00
AND R03	0.80
AND R04	0.60
AND K01	0.80
OR K02	0.60
OR K03	0.60
OR K04	0.40
NOT K05	1.00
THEN P01 (POSITIF)	

Table 6. CF rules according to the user if positive inference (calculated from *Microsoft Excel*)

Rules of CF	**CF(E) according to user trust**
IF G01	0.60
AND G02	0.80
AND G03	0.40
AND G04	0.40
AND G05	0.90
AND G06	0.80
AND G07	0.90
AND G08	0.60
AND G09	0.80
AND G10	0.90
AND G11	0.20
AND G12	0.00
AND G13	0.00
AND G14	0.20
AND G15	0.00
AND R01	0.80
AND R02	0.80
AND R03	0.80
AND R04	0.40
AND K01	0.80
OR K02	0.80
OR K03	0.60
OR K04	0.50
NOT K05	0.98
THEN P01 (POSITIF)	[redacted]

Table 7. CF(H,E) calculation

$CF(H,E)_n$	**CF(E) × CF *rules***
$CF(H,E)_1$	0.36
$CF(H,E)_2$	0.80
$CF(H,E)_3$	0.16
$CF(H,E)_4$	0.16
$CF(H,E)_5$	0.90
$CF(H,E)_6$	0.80
$CF(H,E)_7$	0.90
$CF(H,E)_8$	0.48
$CF(H,E)_9$	0.64
$CF(H,E)_{10}$	0.90
$CF(H,E)_{11}$	0.08
$CF(H,E)_{12}$	0.00
$CF(H,E)_{13}$	0.00
$CF(H,E)_{14}$	0.08
$CF(H,E)_{15}$	0.00
$CF(H,E)_{16}$	0.80
$CF(H,E)_{17}$	0.80
$CF(H,E)_{18}$	0.64
$CF(H,E)_{19}$	0.24
$CF(H,E)_{20}$	0.64
$CF(H,E)_{21}$	0.48
$CF(H,E)_{22}$	0.36
$CF(H,E)_{23}$	0.20
$CF(H,E)_{24}$	0.98

Table 8. CF combine CF(H,E) and positive inference

CF *combine* CF(H,E)	**CF(H,E) + CF_{n+1} × (1-CF(H,E)) calculation**	**Result**
CF *combine* $CF(H,E)_{1,2}$	$CF(H,E)_{1}$ + $CF(H,E)_{2}$ × (1-$CF(H,E)_{1}$)	0.872000000
CF *combine* $CF(H,E)_{old,3}$	$CF(H,E)_{old1}$ + $CF(H,E)_{3}$ × (1-$CF(H,E)_{old1}$)	0.892480000
CF *combine* $CF(H,E)_{old2,4}$	$CF(H,E)_{old2}$ + $CF(H,E)_{4}$ × (1-$CF(H,E)_{old2}$)	0.909683200
CF *combine* $CF(H,E)_{old2,4}$	$CF(H,E)_{old3}$ + $CF(H,E)_{5}$ × (1-$CF(H,E)_{old3}$)	0.990968320
CF *combine* $CF(H,E)_{old3,5}$	$CF(H,E)_{old4}$ + $CF(H,E)_{6}$ × (1-$CF(H,E)_{old4}$)	0.998193664
CF *combine* $CF(H,E)_{old4,6}$	$CF(H,E)_{old5}$ + $CF(H,E)_{7}$ × (1-$CF(H,E)_{old5}$)	0.999819366
CF *combine* $CF(H,E)_{old5,7}$	$CF(H,E)_{old6}$ + $CF(H,E)_{8}$ × (1-$CF(H,E)_{old6}$)	0.999906071
CF *combine* $CF(H,E)_{old6,8}$	$CF(H,E)_{old7}$ + $CF(H,E)_{9}$ × (1-$CF(H,E)_{old7}$)	0.999966185
CF *combine* $CF(H,E)_{old7,9}$	$CF(H,E)_{old8}$ + $CF(H,E)_{10}$ × (1-$CF(H,E)_{old8}$)	0.999996619
CF *combine* $CF(H,E)_{old8,10}$	$CF(H,E)_{old9}$ + $CF(H,E)_{11}$ × (1-$CF(H,E)_{old9}$)	0.999996889
CF *combine* $CF(H,E)_{old9,11}$	$CF(H,E)_{old10}$ + $CF(H,E)_{12}$ × (1-$CF(H,E)_{old10}$)	0.999996889
CF *combine* $CF(H,E)_{old10,12}$	$CF(H,E)_{old11}$ + $CF(H,E)_{13}$ × (1-$CF(H,E)_{old11}$)	0.999996889
CF *combine* $CF(H,E)_{old11,13}$	$CF(H,E)_{old12}$ + $CF(H,E)_{14}$ × (1-$CF(H,E)_{old12}$)	0.999997138
CF *combine* $CF(H,E)_{old12,14}$	$CF(H,E)_{old13}$ + $CF(H,E)_{15}$ × (1-$CF(H,E)_{old13}$)	0.999997138
CF *combine* $CF(H,E)_{old13,15}$	$CF(H,E)_{old14}$ + $CF(H,E)_{16}$ × (1-$CF(H,E)_{old14}$)	0.999999428
CF *combine* $CF(H,E)_{old14,16}$	$CF(H,E)_{old15}$ + $CF(H,E)_{17}$ × (1-$CF(H,E)_{old15}$)	0.999999886
CF *combine* $CF(H,E)_{old15,17}$	$CF(H,E)_{old16}$ + $CF(H,E)_{18}$ × (1-$CF(H,E)_{old16}$)	0.999999959
CF *combine* $CF(H,E)_{old16,18}$	$CF(H,E)_{old17}$ + $CF(H,E)_{19}$ × (1-$CF(H,E)_{old17}$)	0.999999969
CF *combine* $CF(H,E)_{old17,19}$	$CF(H,E)_{old18}$ + $CF(H,E)_{20}$ × (1-$CF(H,E)_{old18}$)	0.999999989
CF *combine* $CF(H,E)_{old18,20}$	$CF(H,E)_{old19}$ + $CF(H,E)_{21}$ × (1-$CF(H,E)_{old19}$)	0.999999994
CF *combine* $CF(H,E)_{old19,21}$	$CF(H,E)_{old20}$ + $CF(H,E)_{22}$ × (1-$CF(H,E)_{old20}$)	0.999999996
CF *combine* $CF(H,E)_{old20,22}$	$CF(H,E)_{old21}$ + $CF(H,E)_{23}$ × (1-$CF(H,E)_{old21}$)	0.999999997
CF *combine* $CF(H,E)_{old30,32}$	**CF *combine* =**	**99.9999997 %**

The value of CF for "positive" inference is also obtained from the calculation results of CF combine CF(H, E) listed in Table 8, with a confidence level of 99.9999997%. The following tables are other inference calculations namely PDP, ODP, and negative, along with their confidence level.

Table 9. ODP symptoms with CF combine CF(H,E) calculation and ODP inference

ODP Symptoms (P02)	**Rules**	**Result**
Fever > 38°C and Pneumonia	IF G02 AND G07	0.98
Trip 14 days ago to the COVID-19 transmission area	AND R01	1.00
Did not feel any symptoms but had contact with COVID-19	AND K04	1.00
Elderly (65 older)	AND K01	1.00
Mature (15-65 years)	OR K02	1.00
Kid (under 15 years)	OR K03	1.00
Level of Confidence	**THEN P02**	**99.96 %**

Table 9, shows that the symptoms for ODP inference (P02) together with the CF combine CF(H, E) calculation for ODP inference with a confidence level of 99.96%. Here are the symptoms of PDP related to the result of CF calculation with CF combine (H, E) for PDP inference.

Table 10. PDP symptoms with CF combine CF(H,E)

calculation and PDP inference

PDP Symptoms (P03)	Rules	Result
Fever > 38°C and Pneumonia	IF G02 AND G07	0.98000
Trip 14 days ago to the COVID-19 transmission area	AND R01	0.99600
Contact with confirmed COVID-19 cases	AND R02	0.99920
Feel the symptoms after 3-6 days and have been in contact with COVID-19 cases	AND R03	0.99971
Having the flu after 14 days of traveling to the COVID-19 transmission area	AND R04	0.99978
Elderly (65 older)	AND K01	0.99992
Mature (15-65 years)	OR K02	0.99996
Kid (under 15 years)	OR K03	0.99997
Did not feel any symptoms but had contact with COVID-19	OR K04	0.99998
Level of Confidence	**THEN P03**	**99.99790 %**

Table 11. Negative symptoms with CF combine CF(H,E) calculation and negative inference

Negative Symptoms (N01)	Rules	Result
Does not have any symptoms and never had contact with COVID-19	IF K05	0.9928
Elderly (65 older)	AND K01	
Mature (15-65 years)	OR K02	0.996256
Kid (under 15 years)	OR K03	0.99760384
Positive Symptoms (P02)	NOT P01	0
Level of Confidence	**THEN P03**	**99.760384 %**

Table 11 shows the symptoms for PDP inference (P03) related to the calculation of CF combine CF(H, E) for PDP inference with a confidence level of 99.99790%. Table 11 shows the symptom-conclusion for negative inference (N01) together with the calculation of CF combine CF(H, E) for negative inference the confidence level of 99.760384%.

4.2. Implementation

The implementation of this expert system is the Android-based app. 4 displays explain the implementation of this app. The first, the homepage view, is a display that contains the title or name of the app, header image, and list of diagnostic questions. The Homepage view also provides a diagnostic process button "Check Am I Positive / Negative COVID-19?" which will result in inference if the symptoms that have been selected (if checked). This homepage view at the bottom after the diagnostic section, there is a button to see the current condition of COVID-19 cases and the button of the distribution of current COVID-19 cases.

Fig. 9. Homepage View

Second, the page of the current condition of COVID-19 cases. This page is a display that containing the growth (always updated) of COVID-19 cases with the distribution map in real-time that obtained from the official website of the Banyumas Regency Government, the data contains the number of ODP, number of completed monitoring, total ODP, number of PDP, number of patients with negative lab results, number of patients who were negative waiting for lab results, number of PDP patients died, total PDP, number of positive patients, number of patients cured, number of positive patients who died, and total positive patients. This page also displays detailed information on the list of referral hospitals in Banyumas District that handles COVID-19 cases. The data was officially released from the Banyumas Regency Government.

Third, about the app page. This page is a page containing information about the application, an appeal to do a swab test at the nearest hospital, and about the author's information.

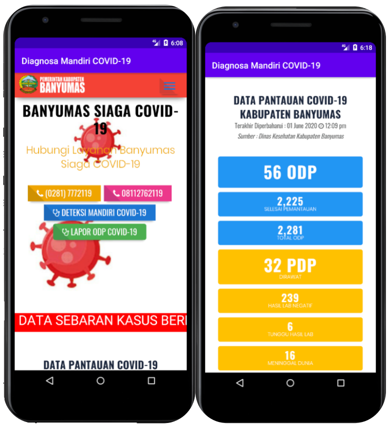

Fig. 10. Page of Current Condition of COVID-19 Cases

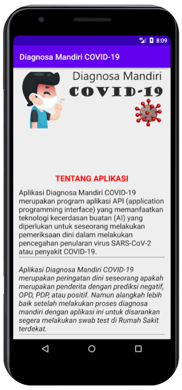

Fig. 11. About app page

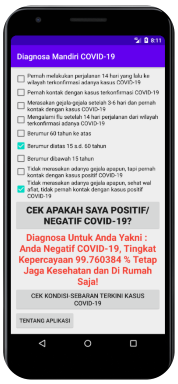

Fig. 12. Diagnose Result View

The last display is about diagnose result views. This page is a display of COVID-19 diagnostic results that appears when we carry out the diagnostic process for the questions on it. The inference of the diagnosis results is based on the production rules issued by forward chaining in processing existing logics in this expert system. For example, to produce an inference result someone is exposed to "negative with a confidence level of 99.760384%" and given a recommendation in the form of "staying healthy and at home only" to ensure the validity of a diagnosis of this expert system.

4.3. System Analysis and Evaluation

This expert system research resulted in an Android-based application that can carry out the process of diagnosing the symptoms of whether someone predicted to ODP, PDP, positive, or negative COVID-19. The system is built using the method of using short-term memory or working memory (for memory efficiency and supported API from 19 or higher). Each question as a representation of expert knowledge is used directly to conduct inference analysis with forward chaining which has previously been calculated to produce a percentage of the level of confidence of each inference from the use of MYCIN combination rules in the CF method.

The use of short-term memory in building a system, especially an expert system, is proven to be simple, efficient, fast, and easy because it does not require database storage to store symptoms. These symptoms can be directly displayed, and are processed using the logic that is in the rules of forward chaining production and can display recommendations on existing inferences to advise the user to immediately take further action to handle the results of the diagnosis (Farizi, 2014).

4.4. Output Analyze and Evaluation

The author in analyzing the system output tests the app's accessibility, appropriateness of responding to the app, app content, and opinions about the contribution of technology in the COVID-19 pandemic. Tests were conducted on respondents amounting to 12 people. These twelve people consisted of 10 students, 1 person worked as an civil servants, and 1 freelancer, obtaining the following results.

Table 12. App output evaluation

No	Function	Features	Output Evaluation
1.	App accessibility	Perform diagnostics, the results according to the condition of the body	Satisfying
		Displays the main page with questions for diagnosis	Good enough
		Open the latest information page and map distribution of *COVID-19* in Banyumas	Satisfying
		Open the page about the application	Satisfying
2.	Skill and precision	App is easy to use	Very agree
		App is very interactive to user	Very agree

No	Function	Features	Output Evaluation
	responded app	App is very informative	Very agree
		App is very helpful for self diagnose	Very agree
3.	App contents	The purpose of the app is clear	Very agree
		App content is well organized and planned	Agree
		Appropriate diagnosis	Very agree
		App structured to allow all communities to participate fully	Very agree

4.5. Black-box Testing

According to him (Farizi, 2014), the use of the black-box method to be able to find problems in the system such as function is correct or missing, UI error, database error, error initializing, and ending the program, performance errors. The author tests the product with black-box testing and is described in tabular form as follows:

Table 13. App output evaluation

No	Tested Functions	How to Test	Test Results	OK	Info
1	Home page	Opening COVID-19 Self Diagnose app in the list of apps on Android phone	Display list of symptoms, activity history, age; diagnosis process button, current COVID-19 info page button, latest COVID-19 map cases button.	OK	The results as great.
2	Detection Progress	Choosing the symptoms are felt, then choose the command "check positive/ negative COVID-19?" in the app	Showing the diagnosis results by the system.	OK	The results as great; show the diagnosis results with the level of confidence.
3	Current conditions& distribution page of COVID-19 cases	Opening the page "Current condition-distribution COVID-19 cases"	Display realtime info about ODP, PDP, Positive COVID-19 cases with maps	OK	The results as great.
4	About page	Opening "About app" page	Display info about the app, an appeal to do a swab test, and about the author.	OK	The results as great.

5. CONCLUSION

Based on the results and discussion, it can be concluded that (1) The application of this expert system can provide a diagnosis of someone including ODP with a confidence level of 99.96%, PDP with a confidence level of 99.99790%, positive with a confidence level of 99.9999997%, and a negative COVID- 19 with a confidence level of 99.760384%, and the application can run well on the Android operating system. (2) This application can provide information on ODP, PDP, COVID-19 positive cases, and information on COVID-19 disease distribution in Banyumas Regency in the visualization map.

REFERENCES

Abdar, M., Zomorodi-Moghadam, M., Das, R., & Ting, I. H. (2017). Performance analysis of classification algorithms on early detection of liver disease. *Expert Systems with Applications*, *67*, 239–251. https://doi.org/10.1016/j.eswa.2016.08.065

Agus, F., Wulandari, H. E., & Astuti, I. F. (2018). Expert System With Certainty Factor For Early Diagnosis Of Red Chili Peppers Diseases. *Journal of Applied Intelligent System*, *2*(2), 52–66.

https://doi.org/10.33633/jais.v2i2.1455

Backer, J. A., Klinkenberg, D., & Wallinga, J. (2020). Incubation period of 2019 novel coronavirus (2019-nCoV) infections among travellers from Wuhan, China, 20-28 January 2020. *Euro Surveillance : Bulletin Europeen Sur Les Maladies Transmissibles = European Communicable Disease Bulletin*, *25*(5). https://doi.org/10.2807/1560-7917.ES.2020.25.5.2000062

DC. (2020). *Covid-19 Symptoms*. Centers for Disease Control and Prevention USA. https://www.cdc.gov/coronavirus/2019-ncov/symptoms-testing/symptoms.html

Farizi, A. (2014). Sistem Pakar Untuk Mendiagnosa Kerusakan Komputer Dengan Menggunakan Metode Forward Chaining. *Edu Komputika Journal*, *1*(2), 21–32.

Google. (2008). *What is Android*. Android. https://www.android.com/what-is-android/

Google Developer. (2020). *Dashboard: Developer of Android*. Google. https://developer.android.com/about/dashboards

Haushofer, J., Jessica, C., Metcalf, E., Björkegren, D., Chandrasekhar, A., De Quidt, J., Grenfell, B., Hussam, R., & Jayachandran, S. (2020). Combining behavioral economics and infectious disease epidemiology to mitigate the COVID-19 outbreak *. *Princeton University*, *March 6*, 1–10.

Karsinah. (1994). Coronaviridae. In *Buku Ajar Mikrobiologi Kedokteran* (Revised, pp. 341–342). Binarupa Aksara.

Kemkes RI. (2020a). *Lakukan Protokol Kesehatan Ini Jika Mengalami Gejala Covid-19*. Kementerian Kesehatan Republik Indonesia. https://www.kemkes.go.id/article/view/20031700002/lakukan-protokol-kesehatan-ini-jika-mengalami-gejala-covid-19.html

Kemkes RI. (2020b). *Suspek nCoV di Wuhan Capai 5 Ribuan Ini Rekomendasi WHO*. Kementerian Kesehatan Republik Indonesia. https://www.kemkes.go.id/article/view/20012800**001/suspek-ncov-di-wuhan-capai-5-ribuan-ini-**rekomendasi-who.html

Kemkes RI. (2020c). *Tanpa Gejala Usia Muda Bisa Menjadi Sumber Penularan Covid-19*. Kementerian Kesehatan Republik Indonesia. https://www.kemkes.go.id/article/view/20032200001/tanpa-gejala-usia-muda-bisa-menjadi-sumber-penularan-covid-19.html

Lai, C. C., Shih, T. P., Ko, W. C., Tang, H. J., & Hsueh, P. R. (2020). Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) and coronavirus disease-2019 (COVID-19): The epidemic and the challenges. *International Journal of Antimicrobial Agents*. https://doi.org/10.1016/j.ijantimicag.2020.105924

Lestari, Y., Mesran, Suginam, & Fadlina. (2017). Sistem Pakar Untuk Mendiagnosis Penyakit Tumor Otak Menggunakan Metode Certainty Factor (CF). *Infotek*, *2*(1), 82–86. https://ejurnal.amikstiekomsu.ac.id/index.php/infotek/article/view/98

Lipsitch, M., Swerdlow, D. L., & Finelli, L. (2020). Defining the Epidemiology of Covid-19 — Studies Needed. *New England Journal of Medicine*, NEJMp2002125. https://doi.org/10.1056/NEJMp2002125

Lu, R., Zhao, X., Li, J., Niu, P., Yang, B., Wu, H., Wang, W., Song, H., Huang, B., Zhu, N., Bi, Y., Ma, X., Zhan, F., Wang, L., Hu, T., Zhou, H., Hu, Z., Zhou, W., Zhao, L., … Tan, W. (2020). Genomic characterisation and epidemiology of 2019 novel coronavirus: implications for virus origins and receptor binding. *The Lancet*, *395*(10224), 565–574. https://doi.org/10.1016/S0140-6736(20)30251-8

Meena, A. K., & Kumar, S. (2015). Study and Analysis of MYCIN expert system. *International Journal of Engineering and Computer Science*, *4*(10), 14861–14865. http://103.53.42.157/index.php/ijecs/article/view/3009

Phan, L. T., Nguyen, T. V., Luong, Q. C., Nguyen, T. V., Nguyen, H. T., Le, H. Q., Nguyen, T. T., Cao, T. M., & Pham, Q. D. (2020). Importation and human-to-human transmission of a novel coronavirus in Vietnam. In *New England Journal of Medicine* (Vol. 382, Issue 9, pp. 872–874). Massachussetts Medical Society. https://doi.org/10.1056/NEJMc2001272

Rich, E., & Knight, K. (1991). *Artificial Intelligence* (2nd ed.). McGraw-Hill Education.

Ritonga, N. A. (2013). *Sistem Pakar Mendiagnosa Penyakit Pada Buah-Buahan Pascapanen*. *1*(1), 338–346. https://doi.org/10.12928/jstie.v1i1.2549

Rosa, A., & Shalahuddin, M. (2016). *Rekayasa Perangkat Lunak: Terstruktur dan Berorientasi Objek*. Informatika.

Rota, P. A., Oberste, M. S., Monroe, S. S., Nix, W. A., Campagnoli, R., Icenogle, J. P., Peñaranda, S., Bankamp, B., Maher, K., Chen, M. Hsin, Tong, S., Tamin, A., Lowe, L., Frace, M., DeRisi, J. L., Chen, Q., Wang, D., Erdman, D. D., Peret, T. C. T., … Bellini, W. J. (2003). Characterization of a novel coronavirus associated with severe acute respiratory syndrome. *Science*, *300*(5624), 1394–1399. https://doi.org/10.1126/science.1085952

Safira, L., Irawan, B., Si, S., & Setianingsih, C. (2019). Implementation of the Certainty Factor Method for Early Detection of Cirrhosis Based on Android. *J. Phys*, 12053. https://doi.org/10.1088/1742-6596/1201/1/012053

Sastrawinata, U. S. (2008). *Virologi Manusia* (1st ed.). PT ALUMNI.

Slamet, C., Firmanda, B., Ramdhani, M. A., Darmalaksana, W., Enjang, E., & Kaffah, F. M. (2019). Android-based expert system design for drug selection using certainty factor. *Journal of Physics: Conference Series*, *1280*, 22018.

https://doi.org/10.1088/1742-6596/1280/2/022018

Sun, K., Chen, J., & Viboud, C. (2020). Early epidemiological analysis of the 2019-nCoV outbreak based on a crowdsourced data. *MedRxiv*, 2020.01.31.20019935. https://doi.org/10.1101/2020.01.31.20019935

Suryadi, H. (1994). *Pengantar Sistem Pakar*. Universitas Gunadarma.

Suyanto. (2014). *Artificial Intelligence: Searching, Reasoning, Planning, dan Learning*. Informatika.

Syahrurachman, A. (1994). Virologi Dasar. In *Buku Ajar Mikrobiologi Kedokteran* (Revised, pp. 242–244). Binarupa Aksara.

Van Doremalen, N., Bushmaker, T., Morris, D. H., Holbrook, M. G., Gamble, A., Williamson, B. N., Tamin, A., Harcourt, J. L., Thornburg, N. J., Gerber, S. I., Lloyd-Smith, J. O., de Wit, E., & Munster, V. J. (2020). Aerosol and Surface Stability of SARS-CoV-2 as Compared with SARS-CoV-1. *The New England Journal of Medicine*, NEJMc2004973. https://doi.org/10.1056/NEJMc2004973

WHO. (2020, June 26). *Dasbor WHO Coronavirus Disease (COVID-19)*. https://covid19.who.int/

Wiyanti, D., Yanuar, A. S., Gustri Wahyuni, E., & Wiyanti, D. T. (2018). Certainty Factor Method for Neurological Disease Diagnosis Based on Symptoms. *ICCSET*, 851–856. https://doi.org/10.4108/eai.24-10-2018.2280500

Yue Zu, Z., Di Jiang, M., Peng Xu, P., Chen, W., Qian Ni, Q., Ming Lu, G., & Jiang Zhang, L. (2020). Coronavirus Disease 2019 (COVID-19): A Perspective from China. In *Radiology*. https://doi.org/https://doi.org/10.1148/radiol.2020200490

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