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Expert System and IoT for Diagnose of Feline Panleukopenia Virus Using Certainty Factor

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ABSTRACT

Cats are animals that are loved by many people and are widely used as pets. All things related to cat health will be pursued by cat owners. However, sometimes the prevention efforts that have been made by cat owners cannot stop the spread of cat diseases, especially those caused by viruses. One of the viruses that can infect cats is feline panleukopenia virus. Where this virus can be deadly and can spread easily. Sometimes the symptoms caused are like ordinary diseases and can not be easily understood by cat owners. Early diagnosis is needed to prevent this disease. What can be done is to create an expert system, which with this system can diagnose feline panleukopenia based on the initial symptoms seen. In addition, to support diagnosis, use IoT devices to determine the body temperature and heart rate of the cat. The purpose of this study is to provide an early prediction of Panleu disease in cats, so that it can make it easier for users to immediately follow up from the initial diagnosis obtained. The research was conducted by conducting a literature study, collecting and analyzing data, making designs and tools, implementing, and testing. The results obtained from this study used 13 samples obtained from veterinarians, where the results of the expert diagnosis were eight samples of acute panleukopenia, four samples of chronic panleukopenia, and 1 sample of non-panleukopenia. The results were obtained with an accuracy of 92 %. The average deviation value of the pulse sensor is 2.40 % and the average deviation value of the LM35 sensor is 1.30 %..

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1. INTRODUCTION

Who doesn't love cats? This adorable furry creature, known as the anabul among Indonesian cat lovers, is one of the most popular types of pets nurtured by humans. By keeping an animal, it means that we as the owner of the animal must dare to commit and be responsible for the welfare of our pets, one of which is by ensuring their health [1]. Cats in Indonesia are now increasing in number, this is because cats are in demand by the Indonesian people as pets. This is what triggers people to pay more attention to their cats to be checked at the nearest veterinary clinic or hospital if they have a disease [2].

Feline panleukopenia virus is a deadly virus that can attack cats in the age range of 3-5 months [3]. Domestic cats or feral cats are more vurnerable to get exposed by panleukopenia virus because the risk of environmental impacts (stress) is higher and usually domestic cats and almost feral cats do not receive vaccinations [2]. The virus is excreted in feces, vomit, urine, and saliva. So that hygiene factors for both cats and the environment must be maintained properly in order to prevent the development of parvovirus [4]. Therefore, handling the virus needs to be done quickly because the virus spreads quickly from one cat to another [5]. The incubation period of the virus is very quickly causing the cat to die suddenly because of complications caused by the infection and the virus can usually survive for at least one year in an exposed environment [2].

From the existing problems, this research was made to minimize the spread and prevent the virus from an early stage. This research invents an expert system application that uses the certainty factor method and vital sign test kits in IoT-based cats which include body temperature and heart rate. IoT devices are used for vital signs of existing symptoms, namely body temperature and heart rate of cats. An expert system is a computer system that is regulated to combine human knowledge into a computer which aims to solve a complex problem and can make decisions like an expert in the field they master [6]. The existence of this expert system itself is not to replace the experts (experts) but to be able to assist and function as an expert assistant to facilitate the work of the experts. The existence of technology that is increasingly developing today helps make it easier for humans to predict and analyze problems from a set of data [7, 8].

There are many expert system methods, such as decision tree, fuzzy, nave Bayes, certainty factor, and forward chaining [9]. When compared between decision trees, the certainty factor algorithm has better accuracy compared to the same data, this can be seen from the research conducted by Ratama using the same data, namely asthma data [10]. From another research conducted by Yunitasari, et al. The data used in this study is postnatal depression data. The results showed that with the existing datasets and the algorithms compared were the dempster shafer and certainty factor, the certainty factor algorithm produced an accuracy rate of 90% while using the dempster shafer the results obtained were 70% [11]. From several literature studies comparing algorithms, a certainty factor algorithm was chosen to diagnose the symptoms of viral panleukopenia.

Several studies related to expert systems and the use of certainty factor methods aim to show the accuracy of identification of panleukopenia in cats. Research conducted by Kurniati, et al, where he conducted research to diagnose skin diseases in cats using certainty factors. The calculation results obtained a confidence percentage of about 94.5%, this is determined again by the input answers entered by the user [12]. Setyawan, et al conducted a study to detect cat diseases using the nave Bayes method. With 8 test data and 19 symptom data, the result is a system solubility rate of 87.5%. Cat diseases analyzed were scabies, fungus, fleas, ear mites, intestinal worms, collibacillosis, panleukopenia, urolithiasis, chlamydia, accidents [13]. Larasati and Arief in their research conducted a diagnosis of cat skin disease using the certainty factor method, where the skin diseases observed were ear mite, scabies, ringworm, lice, stud tail, allergic dematits, eosinorphilic granuloma, yeast infection. The results obtained using the system, the accuracy results for ear mite disease reach 98.43% and ringworm 95.24% [14].

Syafri Arlis in his journal entitled Arthritis with Disease Diagnosis Methods, creates a website-based expert system that can diagnose this joint disease, including the causes and triggering factors for the disease in the elderly [15]. Research using the certainty method in an expert system can also be carried out to determine cataract disease as the cause of blindness. The results of this study also state that the accuracy of the system that uses the factor certainty method is 93% and the use of the factor certainty method diagnoses more types of cataracts in accordance with expert beliefs than other methods [16]. Research conducted by [17], created an expert system for the identification of formalin content, from the results of the study, the percentage of confidence level was 58.99%.

Research related to other expert systems was carried out by [18], researchers diagnosed broiler chicken diseases using the forward chaining method and certainty factor, the results obtained were 100% confidence percentages with five trials. Based on some of the research that has been described, it can be concluded that the expert system used to diagnose a disease has not yet been integrated with IoT tools. The novelty of this research is to integrate IoT with applications to help facilitate the early diagnosis of the symptoms of Panleu disease.

In this research, an application is made that can run on the Android operating system. Android-based applications are made because, it is easier to use and flexible. So, this application was made with the main aim of diagnosing panleukopenia with a severity level, which can be seen from the existing symptoms. In addition, another feature that can be used is the feature to be able to monitor the physical and vital condition of the cat (using the LM35 temperature sensor and pulse sensor). The purpose of this research is to

provide a new approach to make it easier for users to determine the initial diagnosis of Panleu disease, thereby speeding up medical action. With an application that is integrated into a device that is attached to a cat's body, it can help users assess the parameters that will be used for the process of determining the initial diagnosis of Panleu disease. On the other hand, with this application, the owner can find out the history of a pet cat that has been infected with panleukopenia with the aim of minimizing the spread of the virus and handling it quickly and precisely.

2. RESEARCH METHOD

2.1. 2.1 Research Flow

In this study, there are several steps that must be taken to build an expert system and vital sign test kit for the cat. The steps to realize these applications and tools are shown in Figure 1:

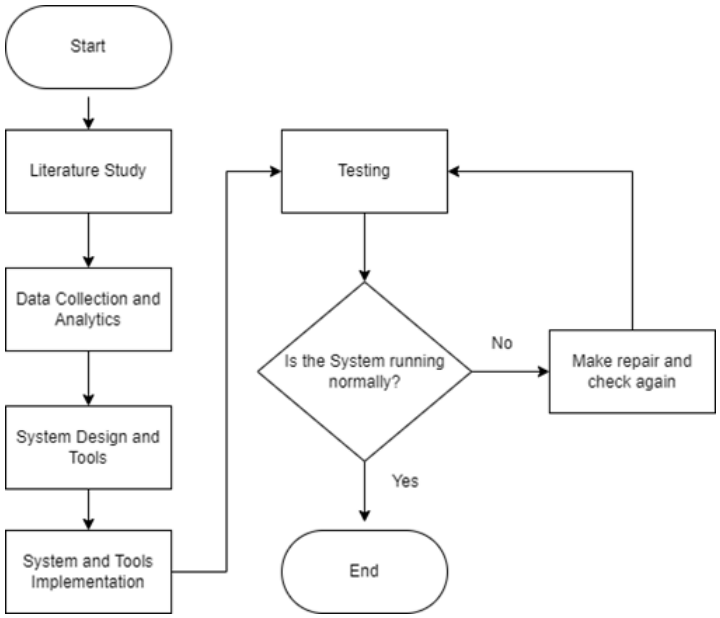

Figure 1. Research Flow

1. Literature Study
   At this stage, theoretical learning is carried out related to research on expert systems for diagnosing feline panleukopenia virus in cats and health monitoring derived from research that has been done previously, in the form of references found in journals, books, internet, and other references.
2. Data Accumulation dan Analysis
   (a) Data Accumulation
   In designing an expert system application and animal vital sign test equipment, a knowledge base and valid data sources are needed. This knowledge base and data source is of course obtained from an expert who is an expert in his field, in this case, the expert is a veterinarian at one of the clinics in Bandar Lampung. Data accumulation was carried out by interview method with experts as resource persons of this study.
   (b) Analysis
   Collecting supporting data needed in the processing, grouping, and knowledge base stages in the analysis stage.
3. System and Tool Design
   At this stage, activities are carried out that describe in detail how the system and tools can work. This design includes the design of the system and the steps in its operation.
4. System and Tool Implementation
   At this stage, the implementation and completion of the systems and tools contained in the approved system and tool design documents are carried out.

5. Testing
   At this stage, testing was carried out on applications and tools that were implemented and built to determine the level of accuracy of the expert system for diagnosing feline panleukopenia virus disease in cats and IoT-based health monitors.

2.2. System Development Method

As previously stated, the system development method used in this research is ESDLC. These stages consist of the acquisition or gathering stage of knowledge to represent knowledge, create a knowledge base, validate knowledge, inference, and provide an explanation of the inference results which can be seen in the following flowchart [19]:

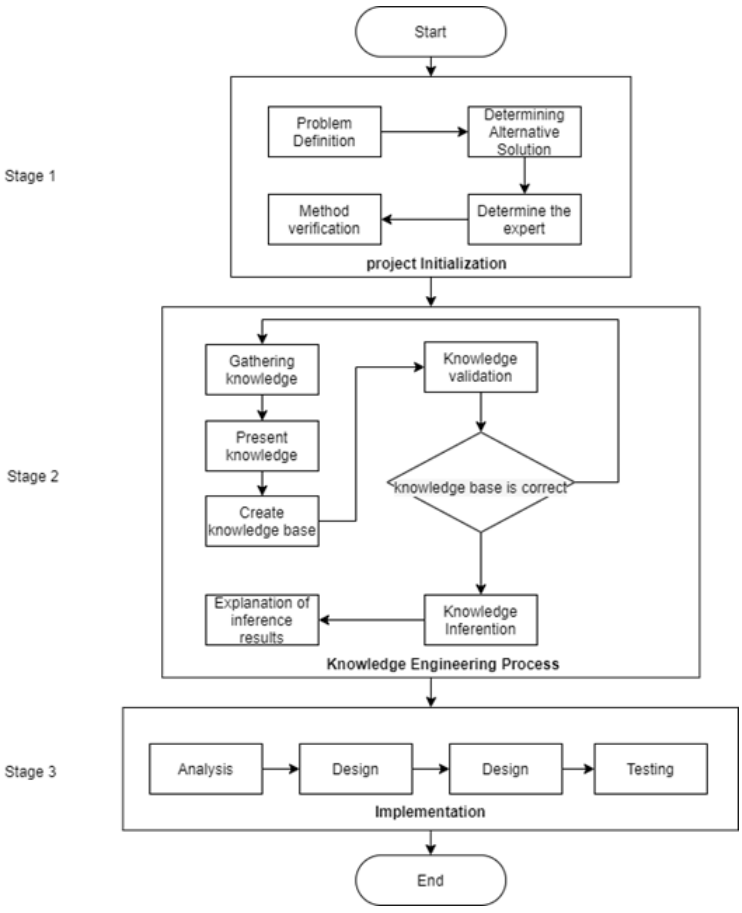

Figure 2. System Development Stage

1. Stage 1, Project Initialization
   At the initialization stage, this project consists of four phases: defining the problem phase, providing alternative solutions, determining the expert phase, and verifying the method phase.
2. Stage 2, Knowledge Engineering Process
   Knowledge acquisition is collecting data, representing knowledge, validating knowledge, inference, and providing an explanation of the inference results (conclusions) regarding panleukopenia cat disease and its symptoms, as well as related to normal body temperature and heart in cats, and what steps can be taken if the cat is diagnosed with feline panleukopenia. Knowledge is obtained through direct interviews with veterinarians as experts, and from several journals, books, and the internet that support research on panleukopenia in cats.
3. Stage 3, Implementation
   At this stage, a prototype of an expert system for diagnosing cat panleukopenia was carried out at several stages including:

analysis, design, making basic programs, and testing. Testing is then carried out on the features that exist in the expert system with the black box testing method. The purpose of testing these features is to find out whether the system can run properly without any errors (bug free) or experiencing a system crash. To make it easier to understand the relationship between IoT tools and applications, a general description is made as shown in Figure 3.

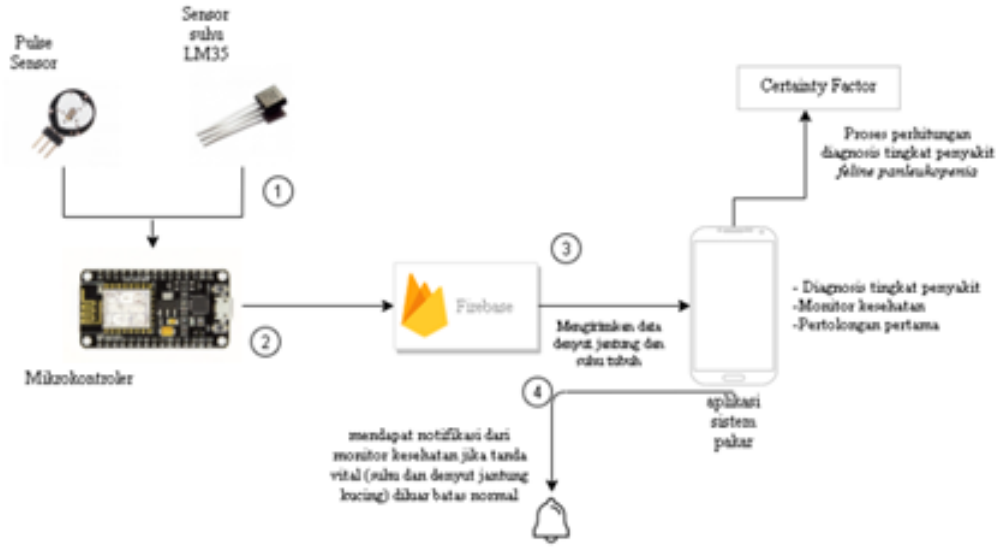

Figure 3. General Description

The pulse sensor and the LM35 temperature sensor are connected to a microcontroller in charge of sending data to Firebase, then after that the data from Firebase will be sent to an expert system application for monitoring the cat's health condition. The microcontroller is used to regulate the work of the Pulse Sensor and LM35 Sensor, so that it can send data in real time to the application.

3. RESULT AND ANALYSIS

In the results and discussion in this study, there are several activities carried out including:

3.1. Data

The data used in this study is data obtained from the interview process with experts who are resource persons and research in the field. These data include data on symptoms of disease, data on disease levels, as well as normal limits for the cat's heart rate and body temperature. For data related to heart rate and normal body temperature, cats themselves have a value of 37.80C - 39.0C for normal body temperature and 140-210 bpm (beats per minute) for normal heart rate [20]. The research was carried out with experts to obtain results from testing the data that had been obtained from the experts. The data obtained directly from interviews with the experts are shown in Table 1.

Table 1. Data on Types of Panleukopenia in Cats

Disease Code	Disease Name
PK01	Chronic Panleukopenia
PK02	Acute Panleukopenia

Panleukopenia in cats has general symptoms such as mild to severe illness in cats. There are eleven common symptoms obtained from experts, the Table 2 is a table of common symptoms and symptom codes.

Table 2. Panleukopenia Symptoms Data

Symptom Code	Symptom Name
GP01	Gag
GP02	Diarrhea without blood
GP03	Diarrhea with blood
GP04	Weak
GP05	No appetite and drink
GP06	dirty ears
GP07	Hyperthermic body temperature
GP08	Hypothermic body temperature
GP09	Anemia
GP10	Thrush
GP11	convulsions

After getting the symptoms and disease data, to make it easier for the next step separation is made between the symptoms of acute panleukopenia and chronic panleukopenia. The relationship data between symptoms and panleukopenia disease are shown in Table 3.

Table 3. Disease and Symptoms Relation

Sympton Code	**Disease Code**	
	PK01	**PK02**
GP01	✓	✓
GP02	✓	
GP03		✓
GP04		✓
GP05	✓	✓
GP06	✓	
GP07		✓
GP08	✓	
GP09		✓
GP10	✓	✓
GP11		✓

Diagnosis Scheme of Panleukopenia Disease Level Using Certainty Factor Method

Certainty factors was introduced by Shortliffe Buchanan (1975) in making MYCIN (Kusumadewi, 2003), which aims to show the amount of trust and show the size of a fact [4]. The first process to calculate the certainty factor can be seen in equation (1) [6]:

$$CF(H,E) = CFuser * CFpakar \tag{1}$$

On which $CF(H,E)$ shows H as a hypothesis which is influenced by E as a symptom. Meanwhile, the value of the expert CF is the confidence value of the symptoms determined by the expert and the value of the $CFuser$ is the value inputted by the user which has a value range of 0 to 1 with the following conditions [6]:

Table 4. User Input CF Value

Uncertainty	Certainty Factor
No	0
Do not know	0.2
A little convinced	0.4
Pretty convinced	0.6
Convinced	0.8
Very confident	1

After getting the CF value (H, E), the next step is to calculate the RF value of the symptom combination can be seen in formula (2) [6]:

$$CFcomb[H,E]1,2 = CF[H,E]1 + [CF[H,E]2 * (1 - CF[H,E]1)] \tag{2}$$

After getting the results from the combination, then the last step that needs to be done to get the confidence value is as shown in formula (3) [6]:

$$CF\ Persentation = CFcombx100\% \quad (3)$$

The calculation of the data that has been obtained through research in the field with experts is shown in Table 5.

Table 5. Calculation CF (H, E)

Symptom	CFexpert	CFuser	CF(H, E)
GP01	0.7	1	0.7
GP03	0.5	0.4	0.2
GP04	1	0.6	0.6
GP06	0.5	1	0.5
GP07	0.6	0.8	0.48

If you have obtained the CF value (H, E), the next step is to calculate the combined CF value:

CF1 = 0.7 + [0.2 x (1 0.7)]
= 0.76
CF2 = 0.76 + [0.6 x (1-0.76)]
= 0.904
CF3 = 0.904 + [0.5 x (1-0.904)]
= 0.952
CF4 = 0.952 + [0.48 x (1-0.952)]
= 0.975

After getting the last value of the combination, then the next step is to calculate the value of the confidence:

Confidence Value Percentage = 0.975 x 100% = 97.5%

Based on the results of the calculation of the five symptoms above, the cat was suffering from acute panleukopenia with a confidence value percentage of 97.5

3.2. Expert System Test Results

Of the thirteen data samples obtained from patients, there were five samples of cats that were positive for acute panleukopenia, three samples of chronic panleukopenia, and five samples of non-panleukopenia. The following is a table of cat sample data that has been tested together with experts:

Table 6. Cat Sample Test Data

Data Code	Symptoms Experienced	Expert Diagnosis	Output By System
K1	1. Gag 2. Weak 3. Dirty ear 4. Hyperthermic body temperature	*Acute Feline Panleukopenia*	*Acute Feline Panleukopenia*
K2	1. Gag 2. Diarrhea with blood 3. Weak 4. Dirty ear 5. Hyperthermic body temperature	Acute Feline Panleukopenia	*Acute Feline Panleukopenia*
K3	1. Gag 2. No appetite and drink 3. Hyperthermic body temperature 4. Convulsion	Acute Feline Panleukopenia	Acute Feline Panleukopenia
K4	1. Weak 2. No appetite and drink 3. Dirty ear 4. Hypothermic body temperature	Chronic Feline Panleukopenia	Chronic Feline Panleukopenia
K5	1. Gag 2. Diarrhea with blood 3. Weak 4. Dirty ear 5. Hyperthermic body temperature	Acute Feline Panleukopenia	Acute Feline Panleukopenia
K6	1. Gag 2. Diarrhea with blood 3. Weak 4. No appetite and drink 5. Hyperthermic body temperature	Acute Feline Panleukopenia	Acute Feline Panleukopenia
K7	1. Diarrhea without blood 2. Weak 3. Hypothermic body temperature 4. Convulsion	Acute Feline Panleukopenia	Acute Feline Panleukopenia
K8	1. Diarrhea without blood 2. Weak 3. No appetite and drink 4. Hypothermic body temperature	Chronic Feline Panleukopenia	Chronic Feline Panleukopenia
K9	1. Gag 2. Diarrhea with blood 3. Weak 4. Hyperthermic body temperature	Acute Feline Panleukopenia	Acute Feline Panleukopenia
K10	1. Diarrhea without blood 2. Weak 3. No appetite and drink 4. Hypothermic body temperature	Chronic Feline Panleukopenia	Chronic Feline Panleukopenia
K11	1. Gag 2. Dirty ear 3. Hyperthermic body temperature 4. Anemia	Malnutrition	Acute Feline Panleukopenia
K12	1. Diarrhea without blood 2. No appetite and drink 3. Hyperthermic body temperature 4. Thrush	Chronic Feline Panleukopenia	Chronic Feline Panleukopenia
K13	1. Diarrhea with blood 2. Weak 3. No appetite and drink 4. Hyperthermic body temperature	Acute Feline Panleukopenia	Acute Feline Panleukopenia

From the thirteen data samples tested, it can be seen the level of accuracy of the expert system application by using the confusion matrix formula [7]:

$$ACCURACY = \frac{TP + TN}{TP + TN + FP + FN} \times 100\% \quad (4)$$

Information:
Accuracy : comparison of correctly identified cases to the total number of cases.
TP : term which is used if the predicted result is positive, and the actual result is positive.
TN : term which is used if the predicted result is negative, and the actual result is negative.
FP : term which is used if the predicted result is positive, but the actual result is negative.
FN : term which is used if the predicted result is negative, but the actual result is positive.
From this formula, the accuracy level of this expert system can be obtained as follows:

$$ACCURACY = \frac{12 + 0}{12 + 0 + 1 + 0} \times 100\% = 92\%$$

3.3. Vital Signs Test Results

The test of this vital sign test tool aims to determine the standard deviation or percent deviation in order to find out how much error value occurs in vital sign test equipment (LM35 temperature sensor and pulse sensor) designed for health test equipment (thermometer and stethoscope) by veterinarians.

The calculation of the percent deviation to find out how much error in the vital sign test kit can be calculated by the formula:

$$\%devitiation = |\frac{\text{hasil uji dokter} - \text{hasil uji alat}}{\text{hasil uji dokter}}| \times 100\% \quad (5)$$

Of the thirteen cat sample data that have been tested by experts, here is the table of heart sensor test results (pulse sensor):

Table 7. Pulse Sensor Testing

Data Code	Stethoscope (BPM)	Pulse Sensor (BPM)	Percentage of Deviation (%)
K1	111	114	2.73
K2	120	118	1.87
K3	138	142	2.93
K4	104	101	2.92
K5	128	131	1.57
K6	140	136	2.89
K7	108	107	1.88
K8	116	119	2.63
K9	130	134	3.15
K10	112	113	1.84
K11	165	160	2.43
K12	113	110	2.68
K13	130	129	1.56
Average percentage of deviation			2.40

From the results of the sample data that has been tested, the average value of the percent deviation is 2.40% for the pulse sensor for veterinary medical test equipment (stethoscope). Meanwhile, the results of the LM35 temperature sensor test can be seen in the following table.

Table 8. LM35 Temperature Sensor Testing

Data Code	Thermometer (^oC)	LM35 Temperature Sensor (^oC)	Percentage of Deviation (%)
K1	39.8	39.1	1.52
K2	39.6	39.3	0.54
K3	38.5	38.2	0.71
K4	37.5	37.2	1.07
K5	39.1	38.5	1.54
K6	39.6	39.4	1.02
K7	37.1	37.1	0.28
K8	37.4	37.2	0.81
K9	38.1	37.7	1.06
K10	37.3	36.8	1.08
K11	38	36.5	3.96
K12	39.3	39.1	0.52
K13	38.8	38.2	1.82
Average percentage of deviation			1.30

From the test results of thirteen cat samples that were paired with the LM35 temperature sensor, the average value of the percent deviation was 1.30% for the LM35 temperature sensor to the veterinarian's medical test instrument (thermometer). From previous research conducted by [1, 3], the new finding in this study is to integrate an expert system using IoT to facilitate the early diagnosis of Panleu disease.

4. CONCLUSION

Based on the research that has been done, it can be concluded as follows: The implementation of an expert system using the certainty factor method results in a tentative diagnosis of the level of panleu disease in cats with a veterinarian as an expert. Of which the confidence value for each symptom and the classification of symptoms at the Panleu disease level is determined by the expert. The novelty of this research is the integration of applications with IoT to assist users in diagnosing the symptoms of panleucopenia. This expert system that has been built has an accuracy rate of 92% for acute and chronic feline panleukopenia from the test results of thirteen cat samples. The vital sign test tool in this study had an average percent deviation value of 2.40% for the heart rate sensor and 1.30% for the LM35 temperature sensor. The pulse sensor has its own library of functions which are used on ARDUINO boards which are not compatible if directly used on ESP32 boards. This causes the pulse sensor to not work optimally with the LM35 temperature sensor (which is flexible for use on ARDUINO boards and ESP32 boards) and does not produce the proper output (it should produce a bpm value at the set time, not counting beats per second). The next research development is to integrate IoT as a whole to help establish an early diagnosis of Panleu disease and choose a more accurate sensor.

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