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Swine-Vet : a Web-based Expert System of Swine Disease Diagnosis

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Abstract

A web-based expert system of swine disease diagnosis was developed for swine farmers and animal husbandmen. Our expert system was divided into three steps. First step was disease screening. We established the novel model of knowledge representation for inference using swine's gender and age range which defined by the veterinarian. Second step was disease diagnosis using the symptoms. To make a diagnosis using symptoms which are accurate and efficient, we established the novel model of uncertain knowledge representation for inference using determination of significant weight of each symptom which defined by the veterinarian and using the certainty factor of occurred symptom, the value was specified by user. Third step was the disease diagnosis using swine necropsy lesion. We established the novel model of knowledge representation for inference using major lesion group which defined by the veterinarian for confirmation of morbidness. From the results of diagnosis by our expert system compared with veterinarian, we found that it could disease screening accurately for 97.50 %, could diagnose by symptom accurately for 92.48% and could diagnose by lesion accurately for 95.62%. And the results of evaluation of satisfaction with Likert-scale by the swine farmers and animal husbandmen were 4.7 and 4.5 respectively.

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Keywords: expert system; swine disease diagnosis; knowledge representation

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1. Introduction

Currently in Thailand, there are issues with the disease in swine[1] which swine; an economic animal that favourably treats. Therefore, we developed a web-based expert system in swine disease diagnosis for swine farmers and animal husbandmen. Our expert system covers all swine diseases (40 diseases) in Thai language. Previously, there was only one research in expert system of swine disease diagnosis in Thai language was expert system for pre-diagnosis of important swine gastrointestial diseases[2]. Our expert system is useful to swine farmers and animal husbandmen for the care of ill swine health which the disease diagnosis result, protection and therapy let them troubleshoot. And, also decrease the disease spread in the farm and neighbourhood and to decrease veterinary shortage problem. There are several researches on the expert system for the animal diseases diagnosis[2-8]. All studies have the same objective was to provide a diagnostic expert system is equivalent to the veterinarian. Therefore, there are researches on establishing the method or technique for developing the system that leads to an efficient expert system.

Our expert system of swine disease diagnosis was divided into three steps. First step was disease screening, second step was disease diagnosis using the symptoms that user noticed and found by considering from all ten body systems and third step was disease diagnosis using animal necropsy lesion. First step and second step were suitable to swine farmer while the animal husbandman can use all three steps. First step, disease screening using swine's gender and age range, from the veterinarian's knowledge and experience found that each disease occurs in swine's different gender and age range. Some diseases occur in female only such as Mastitis metritis agalactia (MMA) and some diseases occur in some age range such as Swine pox occurs in sucking and nursing. Therefore, swine's gender and age range can be used for occurred disease screening. In this step, we established the novel model of knowledge representation for inference using swine's gender and age range which defined by the veterinarian for disease screening. Second step, the disease diagnosis using the symptoms, from the veterinarian's knowledge and experience found that various symptoms are important in identifying the disease is not the same and that symptom is important in identifying types of diseases that aren't same as well. Furthermore, because animals cannot tell symptoms like people, so, users have to specify the symptoms from the observation which may cause specifying incomplete symptom and not confident in specifying occurred symptoms. To make a diagnosis using symptoms which are accurate and efficient, we established the novel model of uncertain knowledge representation for inference using determination of significant weight of each symptom which defined by the veterinarian. In each diagnosis, the user must also specify certainty factor of occurred symptom. Therefore, our expert system must have provided images and descriptions of the symptoms which caused the user to specify the certainty factor correctly. Third step, the disease diagnosis using swine necropsy lesion, the animal necropsy has major lesion group which is important and frequently found in such diseased animals. This could use in identifying the disease. Therefore, we established the novel model of knowledge representation for inference using major lesion group which defined by the veterinarian for confirmation of morbidness. Therefore, our model causes an accurate diagnosis in swine disease diagnosis expert system.

The previous research on swine disease diagnosis had not applied swine's gender, a significant weight of each symptom, an occurred symptom certainty factor and major lesion group for the disease diagnosis. Such as expert system for pre-diagnosis of important swine gastrointestial diseases [2] used symptoms, severe disease level, age span and feces for diseases diagnosis. A swine's gender, age range, significant weight of each symptom, an occurred symptom certainty factor and major lesion group were applied in our research.

2. The swine disease knowledge acquisition

The collection of veterinarian's knowledge and experience which passed validation and verification was corroborated by the veterinarian team, the Faculty of Veterinary Science, Rajamangala University of Technology Srivijaya. The swine disease knowledge includes 40 swine diseases frequently occurred in Thailand[9-11]. The disease occurs in males or females or both genders. The diseases occur in different 4 age range such as sucking, nursing, growing, and breeding. The example of swine gender and age range is shown in the Table 1. The symptoms occur in 10 body systems, which are digestive, endocrine, nervous, reproductive, respiratory, urinary, intergumentary, circulatory, muscular and skeletal system. The symptoms that caused various diseases consist of 86 symptoms, the symptoms images of 120, and a significant weight of each symptom indicated the disease. The example of the significant weight of each symptom is shown in Table 2. The swine necropsy lesions of 183,the lesion images of 196, each disease consists of major lesion group which is important and frequently found for confirmation of morbidness and minor lesion group is less important and rarely found(the example is shown in section 5.3). In addition, the swine disease knowledge includes symptom order, disease prevention, diseased animal care and disease spread prevention.

Table 1. The example of swine gender and age range

Disease	Gender	Age range
-Classical swine fever	Male,Female	sucking, nursing, growing, breeding
-Salmonellosis	Male,Female	nursing, growing, breeding
-Mastitis metritis agalactia (MMA)	Female	breeding

Table 2. The significant weight of each symptom

Disease	Symptom	Body system	significant weight factor
Classical swine fever	cyanosis	Circulatory system	0.2
	high fever	Circulatory system	0.1
	watery yellowish diarrhea	Digestive System	0.3
	convulsion/seizures	Nervous system	0.1
	reddening of skin	Intergumentary system	0.2
	depress	Nervous system	0.1

3. Model of knowledge representation in knowledge base

We used rule based knowledge representation in knowledge base for disease diagnosis. The disease diagnosis was divided into three steps.

3.1 First step: disease screening

We established the novel model of knowledge representation using swine's gender and age range, which was defined by the veterinarian.

- *Model of knowledge representation for disease screening*

The knowledge in the form of rule is expressed as equation (1).

$$\text{IF } G \text{ AND } (A_1 \text{ OR } A_2 \text{ OR } \ldots \text{ OR } A_n) \text{ THEN } H \quad (1)$$

Where, G is gender

$A_1, A_2, ,..., A_n$ is age range

H is a disease of swine.

If user input swine's gender and age range match with the rule, the rule was used for disease screening and the result showed the preliminarily possible diseases.

3.2 Second step: Disease diagnosis using symptom

We established the novel model of uncertain knowledge representation using determination of significant weight of each symptom, which was defined by the veterinarian. In each diagnosis, the user must also specify certainty factor of occurred symptom.

- *Model of uncertain knowledge representation for disease diagnosis using symptom*

The knowledge in the form of rule is expressed as equation (2).

$$\text{IF } e_1(\omega_1) \text{ AND } e_2(\omega_2) \text{ AND } e_3(\omega_3) \text{ AND } \ldots \text{ AND } e_n(\omega_n) \text{ THEN } H\ (CF, Min) \quad (2)$$

Where, $e_1, e_2, e_{3,...,} e_n$ is the symptoms.

ω_i (i = 1,2,3,…,n) is a significant weight of symptom to disease diagnosis, $\sum_{i=1}^{n} \omega_i = 1$

H is a disease of swine.

CF is a certainty factor of rule.

Min is the acceptable minimum. CF and Min defined by the veterinarians.

For the evidences, $E = e_1(\omega_1)$ AND $e_2(\omega_2)$ AND $e_3(\omega_3)$ AND… AND $e_n(\omega_n)$

The calculation of the certainty factor of E (CF(E)) uses equation (3)

$$CF(E) = \sum_{i=1}^{n} \left(CF(e_i) \times \omega_i \right) \tag{3}$$

Where, $CF(e_i)$ is the certainty factor of occurred symptom, the value was specified by the user. The range of certainty factor is 0 to 1.

The calculation of the certainty factor of occurred disease (CF(H,E)) uses equation (4).

$$CF(H,E) = CF(E) \times CF \tag{4}$$

If $CF(H,E) \geq Min$, the rule was used for disease diagnosis and the result showed the possible disease.

3.3 Third step: Disease diagnosis using lesion

We established the novel model of knowledge representation using determination of major lesion group and minor lesion group, which was defined by the veterinarian.

- *Model of knowledge representation for disease diagnosis using lesion*

The knowledge in the form of rule is expressed as equation (5).

$$\text{IF } Ls_1 \text{ AND } Ls_2 \text{ AND } Ls_3 \text{ AND}\ldots\text{AND } Ls_n \text{ OR}(Lm_1 \text{ OR } Lm_2 \text{ OR } Lm_3 \text{ OR } \ldots \text{ OR } Lm_n)\text{THEN } H \tag{5}$$

Where, $Ls_1, Ls_2, Ls_3, \ldots Ls_n$ is lesion in major lesion group.

$Lm_1, Lm_2, Lm_3, \ldots Lm_n$ is lesion in minor lesion group.

H is a disease of swine.

If user inputted all lesions in major lesion group, the rule was used for confirmation of morbidness.

4. Inference process

The swine disease diagnosis used a forward inference. The inference process was divided into three steps. First step was inference in disease screening, second step was inference in the diagnosis using symptom and third step was inference in the diagnosis using lesion are shown in fig.1

First step, the inference began from taking the input swine's gender and age range. Result of disease screening was preliminarily possible disease. Second step, the inference began from taking the input symptoms and its certainty factor to calculate the certainty factor of the E (CF(E)), and then calculated the certainty factor of occurred disease (CF(H,E)), performed rule selection and made diagnosis respectively. Result of diagnosis was possible swine disease. Third step, the inference began from taking the input lesion and made diagnosis respectively. Result of diagnosis was confirmation of morbidness.

5. Application of knowledge representation model and inference

We used the model of knowledge representation and inference in the process of swine disease diagnosis.

5.1 First Step : disease screening

Example of disease screening is presented as follows.

When a user inputs gender and age range would be: gender is female. age range is breeding.

The preliminarily possible diseases consist of 31 diseases.

5.2 Second Step : the disease diagnosis using symptom

Example of diagnosis is presented as follows.

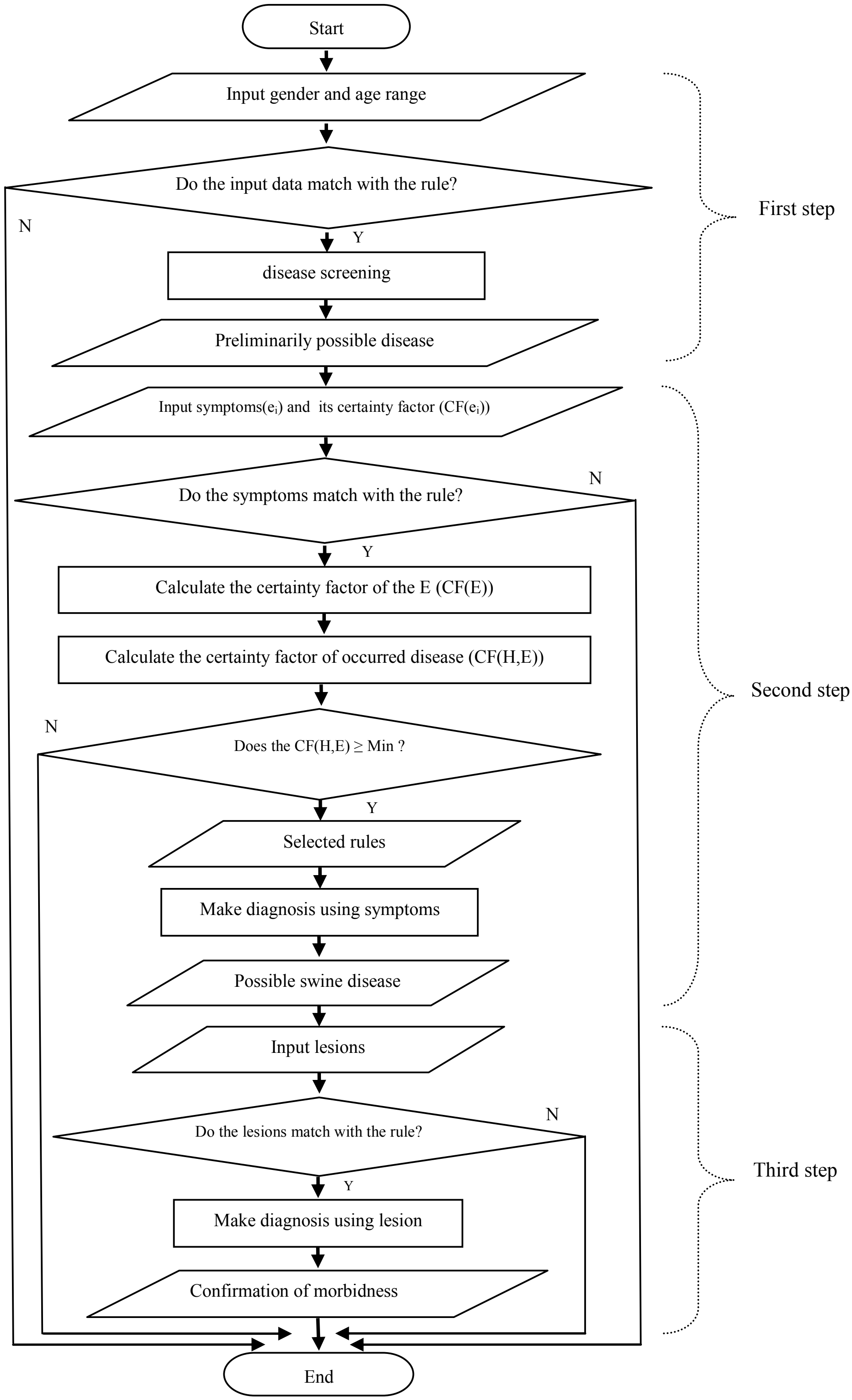

Fig.1 Inference process

When a user inputs the symptoms and its certainty factor would be:
cyanosis. And its certainty factor is $CF(e_1) = 0.8$;
high fever. And its certainty factor is $CF(e_2) = 1$;
watery, yellowish diarrhea. And its certainty factor is $CF(e_3) = 1$;
convulsion/seizures. And its certainty factor is $CF(e_4) = 1$;
reddening of skin. And its certainty factor is $CF(e_5) = 0.9$;
What disease did the swine have?
From our expert system**,** the input symptoms match with thirteen rules. In this case, we present only three rules (with high CF(H,E) in descending order) as follows.

R1: IF cyanosis ($\omega_1 = 0.2$)
AND high fever ($\omega_2 = 0.1$)
AND watery, yellowish diarrhea ($\omega_3 = 0.3$)
AND convulsion/seizures ($\omega_4 = 0.1$)
AND reddening of skin ($\omega_5 = 0.2$)
AND depress ($\omega_6 = 0.1$)
THEN Classical swine fever (1, 0.75)

R2: IF cyanosis ($\omega_1 = 0.13$)
AND high fever ($\omega_2 = 0.14$)
AND watery, yellowish diarrhea ($\omega_3 = 0.17$)
AND convulsion/seizures ($\omega_4 = 0.16$)
AND restlessness ($\omega_5 = 0.1$)
AND inappetence ($\omega_6 = 0.13$)
AND hemorrhag ($\omega_7 = 0.17$)
THEN Salmonellosis (1, 0.7)

R3: IF cyanosis ($\omega_1 = 0.15$)
AND high fever ($\omega_2 = 0.1$)
AND ataxia ($\omega_3 = 0.17$)
AND grinding of the teeth ($\omega_4 = 0.18$)
AND septicemia ($\omega_5 = 0.15$)
AND peddling ($\omega_6 = 0.12$)
AND sudden death ($\omega_7 = 0.13$)
THEN Streptococcal (1, 0.7)

Then, calculate the certainty factor of E (CF(E)) .

$$CF(E) = \sum_{i=1}^{n}\left(CF(e_i)\times\omega_i\right)$$

$$CF(E)_{R1} = \left(CF(e_1)\times\omega_1\right)+\left(CF(e_2)\times\omega_2\right)+\left(CF(e_3)\times\omega_3\right)+\left(CF(e_4)\times\omega_4\right)+\left(CF(e_5)\times\omega_5\right)$$

$$= (0.8\times0.2)+(1\times0.1)+(1\times0.3)+(1\times0.1)+(0.9\times0.2) = 0.84$$

$$CF(E)_{R2} = \left(CF(e_1)\times\omega_1\right)+\left(CF(e_2)\times\omega_2\right)+\left(CF(e_3)\times\omega_3\right)+\left(CF(e_4)\times\omega_4\right)$$

$$= (0.8\times0.13)+(1\times0.14)+(1\times0.17)+(1\times0.16) = 0.574$$

$$CF(E)_{R3} = \left(CF(e_1)\times\omega_1\right)+\left(CF(e_2)\times\omega_2\right)$$

$$= (0.8\times0.15)+(1\times0.1) = 0.22$$

And calculate the certainty factor of occurred disease (CF(H,E)).

$CF(H,E) = CF(E) \times CF$
$CF(H,E)_{R1} = 0.84\times1 = 0.84$ ($CF_{R1}= 1$)
$CF(H,E)_{R2} = 0.574\times1 = 0.574$ ($CF_{R2}= 1$)
$CF(H,E)_{R3} = 0.22\times1 = 0.22$ ($CF_{R3}= 1$)

Does the $CF(H,E) \geq Min$?
$CF(H,E)_{R1} > Min_{R1}$, ($Min_{R1} = 0.75$)
$CF(H,E)_{R2} < Min_{R2}$, ($Min_{R2} = 0.7$)
$CF(H,E)_{R3} < Min_{R3}$, ($Min_{R3} = 0.7$)

So, the rule that $CF(H,E) \geq Min$ is R_1 only which is selected rule.

In this case, the rule R_1 was used for disease diagnosis and the result showed the possible disease is Classical swine fever.

5.3 Third step : the disease diagnosis using lesion

For example, we present diagnosis for morbidness confirmation of Classical swine fever.
If user inputted all lesions in major lesion group, the rule was used for confirmation of morbidness.

When a user inputs the lesion would be:

1. Haemorrhages in the skin especially body, abdomimal, ears, nose and inner thigh
2. Enlarged/swelling in body lymph nodes, area pharyngeal, submendibular, thorax and abdominal
3. Atrophy of the thymus
4. Button ulcers in the mucosa of cecum and colon
5. Bronchopneumonia necrosis, lung congestion and necrosis
6. Congestive hear and congestive splenomegaly
7. Pinpoint haemorrhages on the kidneys
8. Haemorrhages in body organs especially intestinal mucosa, lymph node, kidney, urinary bladder, lung, larynx, epiglottis, gall bladder and heart
9. Pericarditis and adhesions of lung
10. Pale skin, Mucous membranes of the eyes are pale
11. Diffuse necrotic enterrocolitis
12. Ulcerative proctitis
13. Colonic dilatation which causes abdominal distension
14. Inflammation around the heart

In this case, because the user inputted all lesions completely in major lesion group (No.1-9), the rule was used for morbidness confirmation of Classical swine fever.

6. Expert system design and development

Our web-based expert system for swine disease diagnosis consisted of the disease diagnosis, searching and showing disease data, searching and showing hospital data, web board, knowledge base, inference engine, data management and database. The architecture of expert system is shown in fig.2. The web-based expert system application was developed by ColdFusion Markup Language(ColdFusion 8), manages database system by SQL server 2008 and tested software by Black-Box testing technique.

6.1 Database

The database of swine disease diagnosis expert system consists of 16 tables; gender, age range, gender and age range relate with disease, disease, disease image, symptom group, symptom, symptom image, symptom relate with disease, lesion, lesion image, lesion relate with disease, hospital, question web board, answer web board, and admin. The relationship in the database is shown in Fig.3

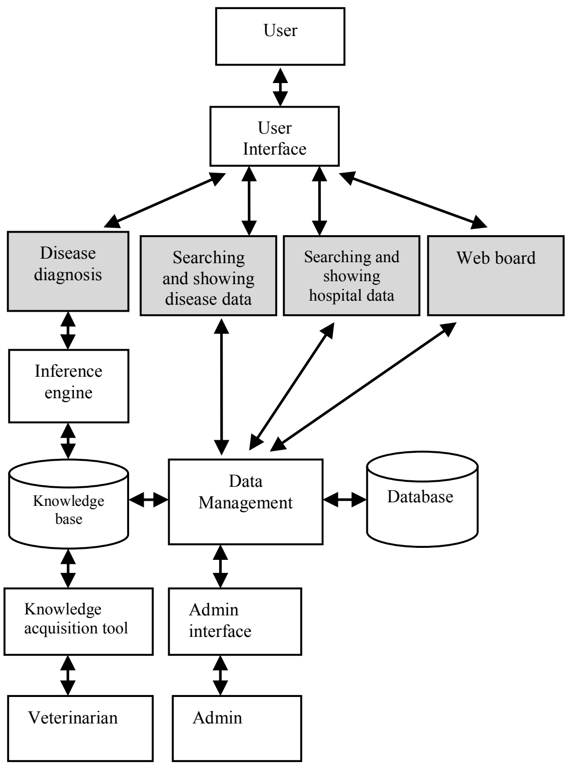

Fig.2 The architecture of expert system

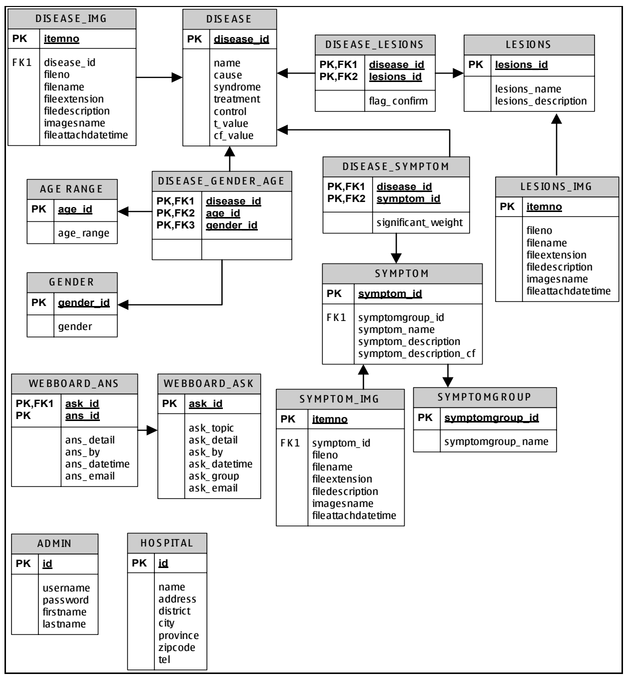

Fig. 3. Shows the relationship in the database

6.2 Data Management

The data management in the database of expert system is a role of admin. The admin interface for data management is shown as fig.4.

Fig.4 The admin interface for data management

6.3 Disease diagnosis

The disease diagnosis process was divided into three steps.

6.3.1 First step: disease screening

The user input swine's gender and age range. The user interface for input swine's gender and age range is shown as fig.5. The result of disease screening, the system displayed the preliminarily possible disease which is shown as fig.6.

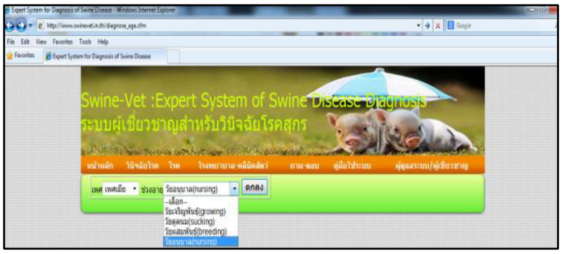

Fig.5 The user interface for input gender and age range

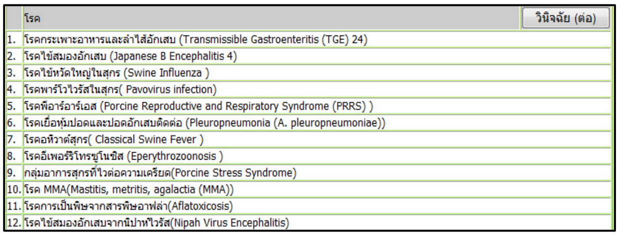

Fig.6 The result of disease screening

6.3.2 Second step: the disease diagnosis using symptom

The user must specify the swine symptom and certainty factor of occurred symptom in 10 body systems. The user interface for input symptoms and certainty factor of occurred symptom is shown as fig.7. The user could view co-information namely, symptom image, detailed description of symptom and description of certainty factor which is shown as fig.8.The result of disease diagnosis using symptom, the system displayed the probability of morbidness. In this sample, the possible disease namely Classical swine fever of 0.84 (84%) which is shown as fig.9.

Fig.7 The user interface for input symptoms and certainty factor of occurred symptom

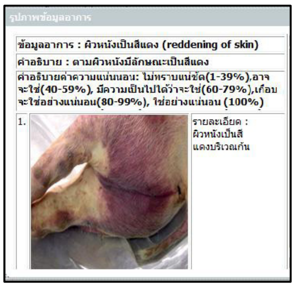

Fig.8 shows co-information

Fig.9 Result of disease diagnosis using symptom

6.3.3 *Third step: the disease diagnosis using lesion*

The user must specify lesion. The user interface for input lesion is shown as fig.10. The user could view co-information namely, lesion images, detailed description of lesion which is shown as fig.11.

The result of disease diagnosis using lesion, the system displayed result as confirmation of morbidness /no confirmation of morbidness. In this example, the system displayed result as morbidness confirmation of Classical Swine Fever which is shown in fig.12.

Fig.10 The user interface for input lesion

Fig.11 shows co-information

Fig.12 Result of morbidness confirmation of Classical Swine Fever.

7. System efficiency

7.1 System accuracy

We tested the diagnosis accuracy using comparison of obtained results between our expert system and veterinarian's diagnosis.

$$Accuracy(\%) = \frac{C}{A} \times 100 \quad (6)$$

Where, C is the number of correct answer (expert system answer match with veterinarian's answer)

A is the number of total answer

120 samples were diagnosed by our expert system and 4 veterinarians (which were not veterinarian team collected knowledge). The result showed that our expert system gave the disease screening accuracy of 97.50 % (veterinarian1= 97.50 %,veterinarian2= 100 %, veterinarian3= 95 %, veterinarian4= 97.50%, mean= 97.50%), the diagnosis by symptom accuracy of 92.48% (veterinarian1= 93.33 %,veterinarian2= 94.16 %, veterinarian3= 90.80 %, veterinarian4= 91.66 %, mean = 92.48%)and the diagnosis by lesion accuracy of 95.62%(veterinarian1= 97.50 %,veterinarian2= 97.50 %, veterinarian3= 92.50 %, veterinarian4= 95.00 %, mean = 95.62%).

7.2 *System user's satisfaction*

We evaluate satisfaction of the swine farmers and animal husbandmen with Likert-scale(5 points) in 4 aspects ; functional, usability, performance and reliability. The results of evaluation of satisfaction by 100 swine farmers and 20 animal husbandmen are 4.7 and 4.5 respectively.

8. Discussion and conclusion

The accuracy of disease diagnosis depends on diagnosis method. Our expert system, in first step, the disease screening, we established the novel model of knowledge representation for inference causes an accurate disease screening which the accuracy depends on the veterinarian team expertise who defined swine's gender and age range that indicates the disease. Second step, the disease diagnosis using the symptoms, we established the novel model of uncertain knowledge representation for inference causes an accurate diagnosis which the accuracy depends on the veterinarian team expertise who defined a significant weight of each symptom that indicates the disease. Furthermore, another important part is the completeness of the occurred symptoms and symptom certainty factor which are specified by the user. From the experiment, the occurred symptoms are incomplete or uncertain, but we can diagnosis through the significant weight and the certainty factor of occurred symptom. In third step, the disease diagnosis using the lesion, we established the novel model of knowledge representation for inference causes an accurate diagnosis which the accuracy depends on the veterinarian team expertise who defined major lesion group for confirmation of morbidness. In experiment, the occurred lesions are incomplete, but we can confirm morbidness through major lesion group.

The previous research on swine disease diagnosis had not applied swine's gender, a significant weight of each symptom, an occurred symptom certainty factor and major lesion group for the disease diagnosis. Such as expert system for pre-diagnosis of important swine gastrointestial diseases [2] used symptoms, severe disease level, age span and feces for diseases diagnosis; the accuracy of diagnosis was 75.4%. A swine's gender, age range, significant weight of each symptom, an occurred symptom certainty factor and major lesion group were applied in our research and the result of experiment showed that our system give the disease screening accuracy of 97.50%, the diagnosis by symptom accuracy of 92.48% and give the diagnosis by lesion accuracy of 95.62% that is higher than the previous research results. From the result of diagnosis, our system can disease diagnosis approximate to the disease diagnosis by the veterinarian. And the results of evaluation of satisfaction with Likert-scale by the swine farmers and animal husbandmen were 4.7 and 4.5 respectively.

Currently, our expert system has been applied in the animal hospital, Faculty of Veterinary Science, Rajamangala University of Technology Srivijaya and Nakhon Si Thammarat and Songkhla province Livestock Offices. Farmers and animal husbandman can operate the system through the Internet http://www.swinevet.in.th/swineindex.cfm.

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