Analysis and Design of Diagnosing Pet Diseases Remotely by Fusing Rule-Based Inference

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ABSTRACT

Pets serve as significant companions for their owners, who may give them food, housing, and medical attention. As pets can readily contract an illness unknowingly, their health should be a worry. Yet, several factors prevent pet owners from taking their animals to the vet as soon as they become ill, including the high expense of veterinary treatment, the lack of information among pet owners regarding pet health care, and the scarcity of veterinary facilities in rural regions. Using the symptoms that the pet is displaying; a smartphone application was created to diagnose pet diseases. Based on the symptoms that the pet is experiencing, the rule-based inference method is utilised to identify potential diseases. The application not only assists pet owners in quickly diagnosing a pet disease, but it also offers important treatment information. Before developing the actual application, system requirement analyses, system design diagrams, and wireframes are also created. The report also includes UML diagrams such as the use-case diagram, sequence diagram, and activity diagram. To make sure the programme is working properly and that all defects and errors have been repaired, a test strategy has been employed. To gauge the respondents' level of acceptability of an application feature, user acceptance testing is carried out. To enhance the quality of the application going forward, this report details the project's accomplishments, the application's limits, and the next work. The goal of creating the pet disease diagnosis mobile application is to raise awareness among pet owners of their pets' ailments and related concerns with pet health care.

Keywords:
Pet disease diagnosis; Application analysis and design; Cat

1. Introduction

Animals that you keep at home for enjoyment, as opposed to those that are kept for work or sustenance, are typically referred to as pets [1]. Pets like cats and dogs were cared for well by their owners as companions. Owners must take care of their pets by giving them nutritious food, a warm and comfortable home, and most importantly, medical attention [2]. A pet's daily schedule may include exercising its muscles and going outside to relieve tension and unhappiness. The pet may

occasionally drink from communal water dishes that may be contaminated with other animals' bacteria, viruses, or parasites. As bacteria and viruses might enter their bodies as a result, the pets may unknowingly contract diseases [3]. The health and behaviour of the pet must occasionally be examined. An animal's behaviour is directly influenced by its health and vice versa. Certain behavioural abnormalities may have a medical cause as their only or primary cause [4]. For pets, a thorough examination is required to prevent hazardous diseases if there are any unusual behaviours or symptoms [5]. Owners of pets should be worried about their pets' health. All the cues the animal gives off may aid veterinarians in making a more precise diagnosis of the illness so that the animal can receive efficient treatment to reverse the condition [6].

Nowadays, users do not frequently use technology for remotely diagnosing pet illnesses. The most frequent procedure for detecting a pet disease is a trip to the vet. They must register their information as well as the pet's information, including the animal's condition and medical history when they first arrive at the veterinarian clinic [7]. They must then wait till they see the veterinarian to have an examination. If a pet is being thoroughly examined, additional examination and observation must be done with the pet. Also, some veterinary clinics require appointments before visits [8]. Unfortunately, due to their difficulties, pet owners are unable to take their animals to a veterinarian. Due to the high expense of veterinary services, medications, and technology, the cost of veterinary care is a widespread issue. Moreover, owners' ignorance of their pets' medical needs will lead to pet medication mistakes. Rural areas' veterinary clinic shortages also contribute to pet owners foregoing the chance to address their animals' illnesses.

A pet disease diagnosis app is necessary to provide proper and adequate health care for pets, allowing pet owners to identify potential ailments before their animals develop chronic illnesses. In this project, a tool for diagnosing pet diseases is created to identify potential illnesses in pets based on their symptoms. The owner of the animal may be given some suggestions or alternatives for how to proceed with treating the animal [9]. To meet the information needs of pet owners, this application also provides information and knowledge on pet issues and medical treatment.

Three of the existing accessible pet health care systems and applications, including PetMD Symptom Checker [13], PetCoach Application [14], and Vets4Pets Pet Symptom Checker [15], have been researched to improve the features of the suggested pet disease diagnosis mobile application. Table 1 contrasts three existing systems with the proposed system.

The literature shows how current systems and applications were created with features that are similar to those of the proposed system. The PetMD application isn't accessible in Malaysia, but the PetMD Symptom Checker can be obtained on the PetMD website and in the Apple App Store. PetMD provides comprehensive, reliable, and up-to-date information on pet health to assist pet owners in managing challenging times with their animals. Users are given access to the resources, guidance, and knowledge they need to maintain the health of their pets. Cats and dogs were the main target audience for this system. Users can search through about 2,000 news stories and articles about pet health care supplied by PetMD depending on the symptoms that animals experience.

The system known as Pet Coach is designed to provide the quickest advice and pet care instructions from reputable pet experts and physicians. Both a web-based system and a mobile application are available from Pet Coach. Both iOS and Android users can access their mobile applications through the respective app stores. Account registration is possible by Facebook, Apple, Google, or email. More than one pet profile may be registered under a user account. To access the pet's medical information, including the medical history, prescriptions, lab results, reminders, and appointments, the Pet Coach account can be connected to the veterinarian's office or practice.

In 2001, the UK business Vets4Pets began incorporating veterinary services into their routine [12]. Many pets care and counselling services are offered to guarantee that pets live happy, healthy lives.

A wide range of animals, including dogs, cats, reptiles, rabbits, fish, and other small pets, are covered by the services offered by Vets4Pets. Pets can get a wide range of veterinary services, including treatment for common animal ailments, routine checks and counselling, and emergency medical procedures.

Table 1
Comparison of existing systems with the proposed application

	PetMD Symptom Checker	PetCoach Application	Vets4Pets Pet Symptom Checker	Proposed Application
Android-based	Not Available	Available	Available	Available
Application available in Malaysia	Not Available	Available	Not Available	Available
Clear navigation	Available	Available	Available	Available
Login	Not Available	Available	Not Available	Available
Diagnose pet disease	Available	Not Available	Available	Available
Easier to understand diagnosis result	Available	Not Available	Available	Available
Disease advice	Not Available	Not Available	Available	Available
Treatment explanation	Available	Not Available	Not Available	Available
Diagnostic history	Not Available	Not Available	Not Available	Available
Pet health care article	Available	Available	Available	Available
Feedback	Available	Available	Available	Available

The proposed app, Pet Buddies, is a mobile Android app for diagnosing pet diseases that will provide the service depending on the symptoms of the pet. The suggested application is intended for pet owners who are worried about the actions, signs, and illnesses of their animals. By offering a symptom checker to identify cat sickness, it primarily focuses on cats. A guide and first aid advice are provided to cat owners to treat their cats in the event of an emergency accident or any other barriers to receiving veterinary treatment in this application, which helps users obtain correct results regarding the cat ailment. Pet Buddies also offers a selection of information about pet health care to increase pet owners' awareness of their animals. Any feedback regarding the application and services that are supplied to the app can be used to update and improve the proposed application.

2. Methodology
2.1 Analysis Phase

The analysis phase focuses on who utilises the system, what functions it has, and how and when it would be used [16]. This procedure includes early enquiry, which entails examining any existing systems, making enhancement suggestions, and coming up with a system idea. It begins with an analysis of the current system and its problems, then offers recommendations for how to design a future system. The proposed application is contrasted with current systems to identify areas for improvement and spark fresh ideas for its development. Interviews and surveys are undertaken to determine the precise user needs and expectations so that the proposed application may fulfil the project's objectives. The project's hardware and software standards have also been set to enable a smooth and organised execution [17]. The examination of this information, along with opinions and impressions, results in the development of a new system design.

2.1.1 Interview

Interviewing a study subject can help obtain quantitative, qualitative, or mixed data. According to Johnson and Christensen [18], an interview is a type of data collection in which the interviewer questions the interviewee. The advantage of doing interviews is that the researcher can ask open-ended questions. Regardless of what the interviewee says, the interviewer must remain impartial. The suggested project conducts an online interview to learn more about the needs and expectations of the veterinarian. Twelve questions have been created in advance of the interview to learn more about a veterinary clinic, typical cat issues and treatments, the process of diagnosing a condition, and the qualities expected of the candidate.

On November 29, 2021, Dr. Siti Hawa Binti Anurdin, a veterinarian, was interviewed through Zoom meeting. The interview procedure is documented, and the response is converted into the text found in Appendix A. Dr. Hawa's key comments have been underlined to show how they relate to the project idea. According to the information given, Malaysia does not have a system or application for diagnosing pet diseases. Dr. Hawa endorses the proposed application and suggests that it be user-friendly and simple for the public to grasp.

The purpose of this application is to improve awareness among pet owners regarding their pets' health care by efficiently disseminating information about pet health care such as pet first aid training and pet insurance. It is advised that at least four symptoms be present to correctly diagnose a disease.

2.1.2 Questionnaire

The questionnaire is the most widely used method in investigations. Each respondent completes a questionnaire as part of a survey to obtain personality data. Researchers utilise questionnaires to collect the opinions, experiences, preferences, personalities, and behavioural intentions of the respondents. Many different characteristics are measured using a questionnaire. Those who have kept pets are given a questionnaire via a Google Form. The survey's goal is to gather more information about pet owners' behaviour and interactions with their animals. In order to find out what features of the suggested application pet owners like, a series of closed-ended questions are asked of them. The data is examined and calculated in terms of the number of replies selected and the percentages for each question after collecting twenty-five responses from respondents. The pie charts and bar charts are then used to display all of the evaluated data. According to the respondents' comments, most of them had trouble getting to the vet, yet they were worried about their pet's health. The respondents anticipate that the suggested application will be simple to use, beneficial, and educational. The respondents said that a pet disease symptoms checker, information on pet diseases, first aid suggestions, and treatment processes were the items they most anticipated.

2.2 Rule-Based Inference

Application software called inference engines (or reasoners) is used to compute or derive new facts from preexisting knowledge sets. An engine for rule-based inference uses data and rules to reason and produce new facts. The inference engine can modify the knowledge base, for example, by asserting or refuting facts, or it can perform operations, such as displaying the derived facts, when the data matches the requirements of the rules.

The suggested application will diagnose feline illnesses using rule-based inference. A rules-based approach to regulation, according to Conradie, L. [10], "prescribes how to behave in detail or presents a set of norms." It makes it possible to represent a person's knowledge of a certain subject matter as

a collection of unique constraints. A rule-based system can serve as a consultant, problem solver, expert, or decision-maker in these disciplines and is often used in many different types of technology from many different fields [11]. According to Tuan Nur Allia [26], this is due to the fact that the system will be phased in utilizing if-then rules to determine the problem and its remedy using a rule-based approach. The regulations that are created will therefore be the solution to the issue.

Information is encoded using facts and the IF-THEN rule. These commercial ideas enable the uncomplicated encoding of specific information in a variety of contexts. The IF section of the rule describes the elements of a circumstance that lead to one or more of the actions mentioned in the THEN component. The action is a course of action that may be taken if the condition is true, the outcome is a statement that is true if the statement is true, and the criterion is a set of truths that must be true for the condition to be met [12]. Rules are a general approach to expressing knowledge. It works in a manner similar to that of the brain's short- and long-term memory. The Rule-based for the application is in Table 2.

Table 2
Rule-based for the proposed mobile application

No.	Condition 1	Condition 2	Result
1	IF (cat)	IF (hair loss)	THEN (ringworm)
2		IF (itching)	THEN (flea allergy dermatitis)
		IF (inflammation)	
3		IF (change in behavior)	THEN (rabies)
		IF (paralysis)	
		IF (disorientation)	
		IF (seizures)	
4		IF (swelling)	THEN (cancer)
		IF (skin infections)	
		IF (weight loss)	
		IF (diarrhea)	
		IF (vomiting)	
		IF (bad breath)	
5		IF (weight loss)	THEN (diabetes)
		IF (excessive thirst and urination)	
		IF (sweet-smelling breath)	
6		IF (diarrhea)	THEN (kidney disease)
		IF (vomiting)	
		IF (frequent urination)	
		IF (bloody urine)	
7		IF (fever)	THEN (feline leukemia virus (FeLV))
		IF (diarrhea)	
		IF (vomiting)	
		IF (loss of appetite)	
		IF (weight loss)	
		IF (enlarged lymph nodes)	
8		IF (redness)	THEN (gingivitis)
		IF (swelling)	
		IF (discomfort)	
		IF (bleeding gums)	
		IF (cry or yowl when eating)	
9		IF (cough)	THEN (heartworm)
		IF (depression)	
		IF (sporadic vomiting)	
10		IF (loss of appetite)	THEN (feline immunodeficiency virus (FIV))
		IF (fever)	
		IF (chronic or recurring infections)	

11	IF (limping)	THEN (broken bones)
	IF (swelling)	
	IF (hiding behavior)	
12	IF (diabetes)	THEN (obesity)
	IF (joint problems)	
	IF (difficulty in walking)	
	IF (sleeping more than usual)	

3. Results

3.1 Design Phase

The essential hardware and software are purchased during the design phase, and the specifics of the finished product are developed. All technical requirements are identified, assessed, and acquired at this phase. Also, the requirements for each element of the finished product are described, including the methods for input and output as well as the possible user actions. The prototype of the finished product is shown in the wireframes along with a mock-up of the sample product that will be developed.

A working model that shows how the application functions is called a prototype. In this stage with the prototype, user interface and user experience are taken into consideration. This phase determines the user interface, forms, and reports that will be utilised, as well as the applications, databases, and files that will be required. It also determines the hardware, software, and network infrastructure that will be put in place.

Following that, UML diagrams are also created to provide a visual representation of the project's design. With the use of the Draw.io software's capabilities and resources, a complete UML diagram can be created. Among the diagrams created were use-case diagrams, sequence diagrams, activity diagrams, and class diagrams.

3.1.1 System design diagram

A high-level overview of an existing or future piece of software is provided by a system design diagram [20]. It is a straightforward design that enables interactive creation in either a short amount of time or gives people a clear, thorough, and comprehensive explanation of the objective. The system design diagram for the suggested application is shown in Figure 1 and includes the admin, pet owner, user interface, database, and features for each user, including login, register, feedback, pet health articles, and pet disease diagnosis.
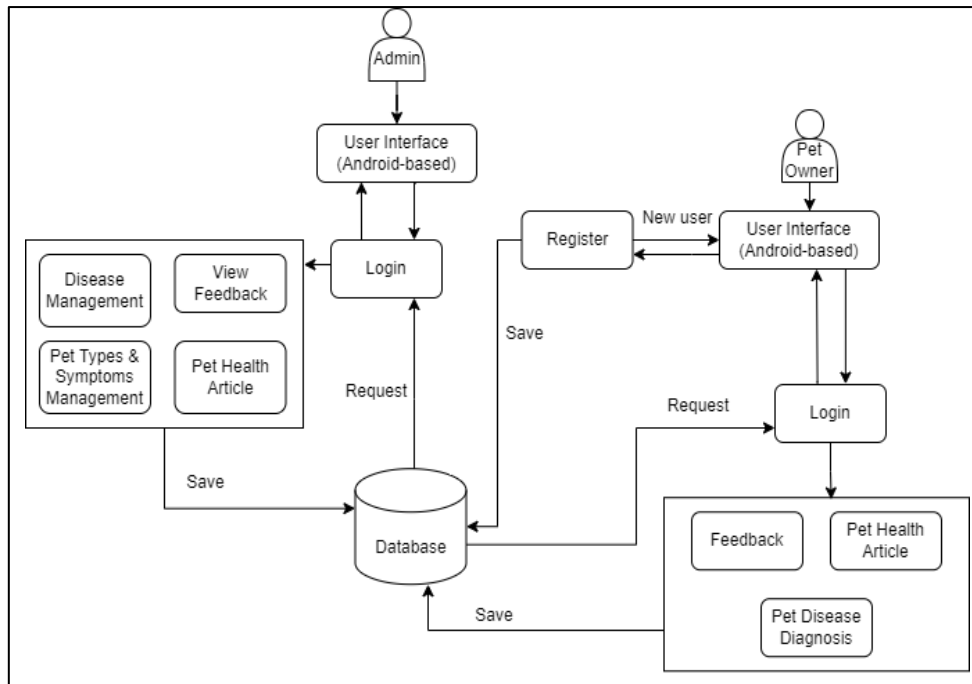
Fig. 1. System design diagram for the proposed application

3.1.2 Functional and non-functional requirements

The creation or rejection of a system would seem to depend heavily on requirement analysis. Written, executable, quantifiable, observable, highly responsive, and related to identified specific needs or possibilities, with sufficient knowledge for system design, are all requirements that should be met [21]. The functional and non-functional requirements for the proposed application are described in the following subtopic.

The functional requirements of a system, or one of its subsystems, describe the tasks that an application can perform. A functionality, operations, or activities that describe what task an application is going to execute can all be considered [22]. A non-functional necessity establishes the quality attribute of an application. To guarantee the performance and usability of the entire software system, a non-functional requirement is required. Through numerous iterative queues, non-functional requirements enable users to impose restrictions or prohibitions on the system's architecture. Table 3 displays the proposed application's functional and non-functional requirements.

Table 3
Functional and non-functional requirements specification for the proposed application

	No.	Requirements	Specification
Functional	1	Register	Allow pet owners to register an account by filling in a valid email address, username, password and confirm password.
	2	Login	Allow users to log in to the application using email and password.
	3	Pet healthcare article	• Allow users to view published pet health articles. • Allow admin to create, update or delete the articles.
	4	Disease diagnosis	• Allow pet owners to choose the type of pet. • Allow pet owners to select multiple symptoms of their pet. • Allow admin to create, update or delete the disease and its relevant information such as treatment and advice.
	5	Diagnostic result	Allow pet owners to view the simple explanation of the disease, treatments, and advice.
	6	Diagnostic history	Allow pet owners to view the previous diagnostic results.
	7	Feedback	Allow users to give feedback to an admin about the usability of this application.
Non-functional	1	Operational	The application only operates with an internet connection.
	2	Security	Users may only log in to the application with a valid email and password.
	3	Performance	The application can be accessed anytime.

3.1.3 Unified modelling language (UML diagram)

UML diagrams are a crucial tool for software documentation and modelling. It is founded on graphical characterizations of application parts. UML was developed because of the uncertainty around application development and documented evidence [23]. The next subtopics develop and discuss the use-case diagram, sequence diagram, and activity diagram.

The expectations and usage of the programme are described in the use case. Use cases are verbs that specify the action and serve as a reminder of the requirements. Straight arrows are used to show relationships between actors and use cases, whereas actors are people who interact with the system. Figure 2 indicates the use-case diagram for the proposed application.
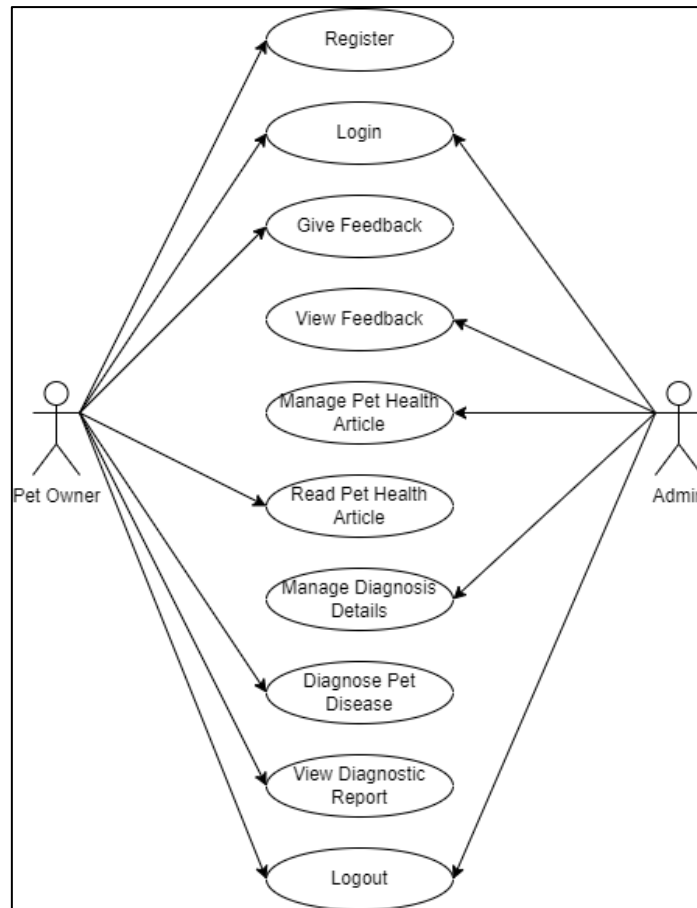
Fig. 2. Use case diagram for the proposed application

Sequence diagrams are used to describe the interactions between actors and objects that lead to communications and behaviour. Actors or objects will only be utilised when necessary or if another object wants to interact with them. The sequence diagrams for each user, including the admin and pet owner, are shown in Figure 3 and Figure 4.
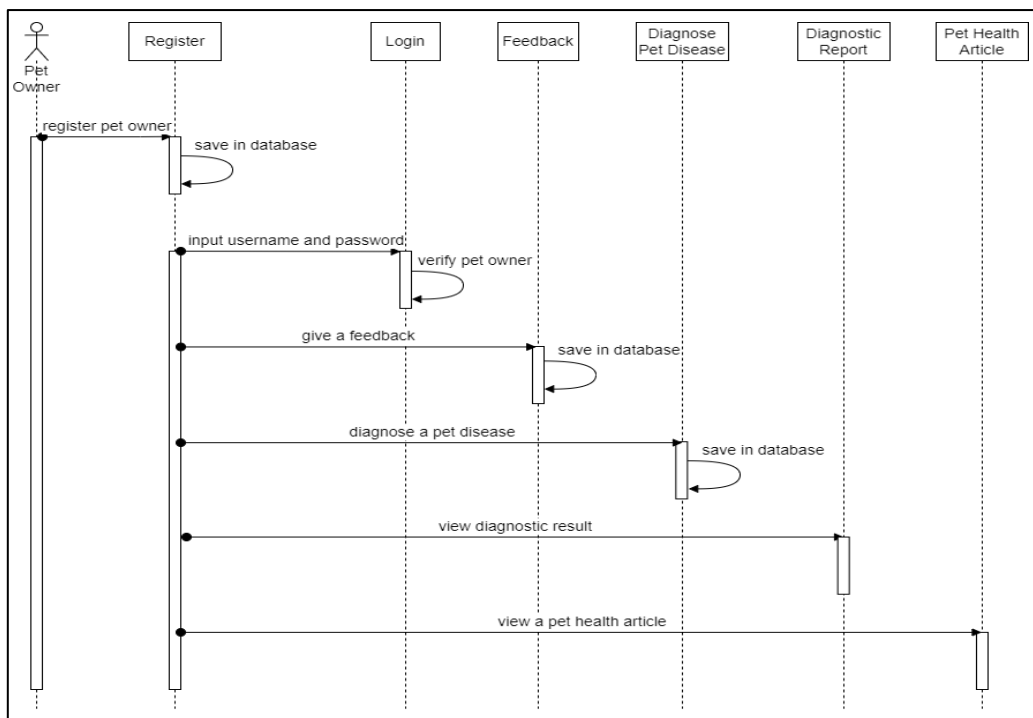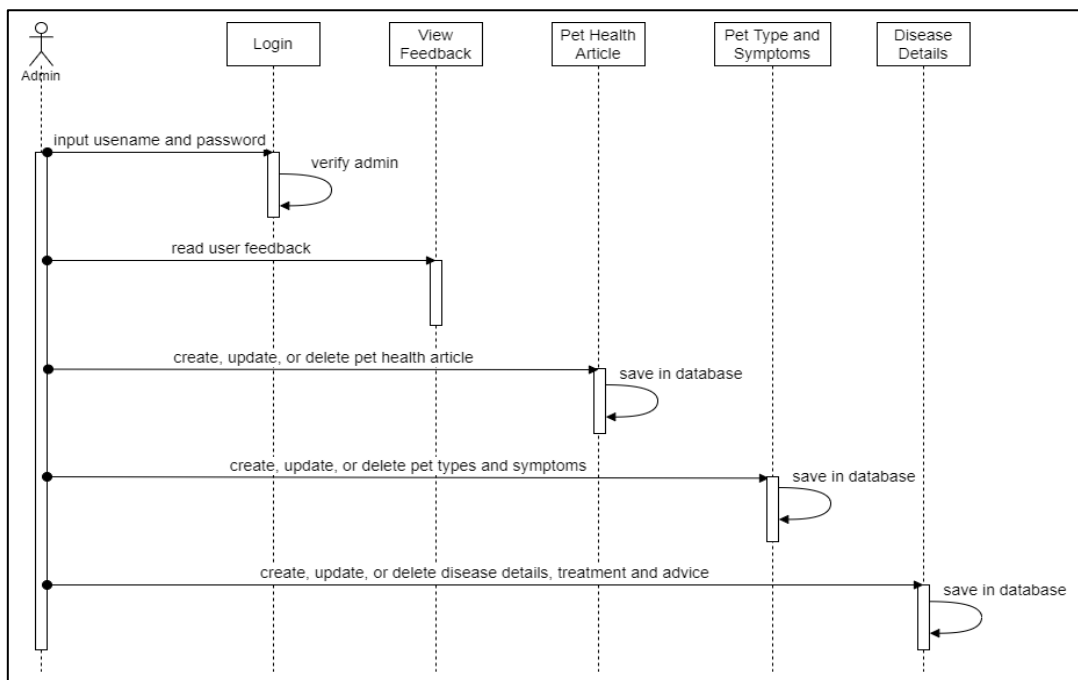
Fig. 3. Sequence diagram for the pet owner

Fig. 4. Sequence diagram for the administrator

This activity diagram illustrates the entire process of activities. It details the constituent parts of an action, their sources, and how they are related to one another. a set of actions with definite beginnings and ends that build upon one another and demonstrate how well they are related. The activity diagram for pet owners is shown in Figure 5, and the activity diagram for administrators is shown in Figure 6.
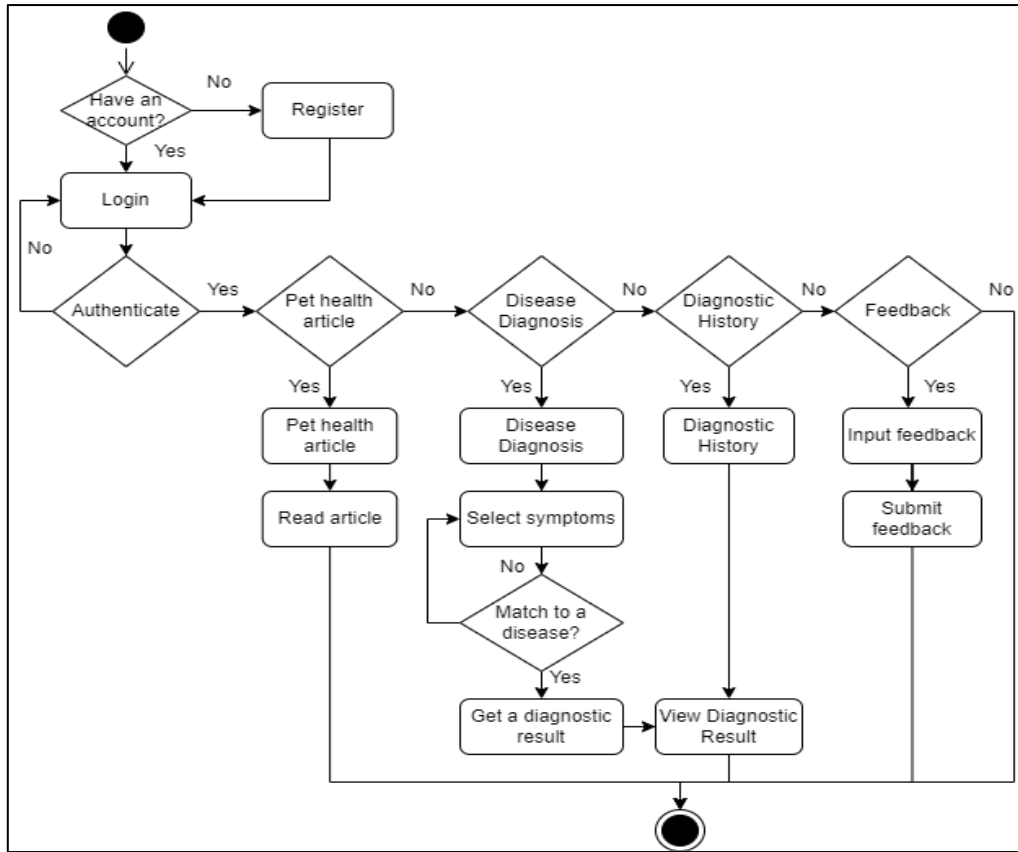
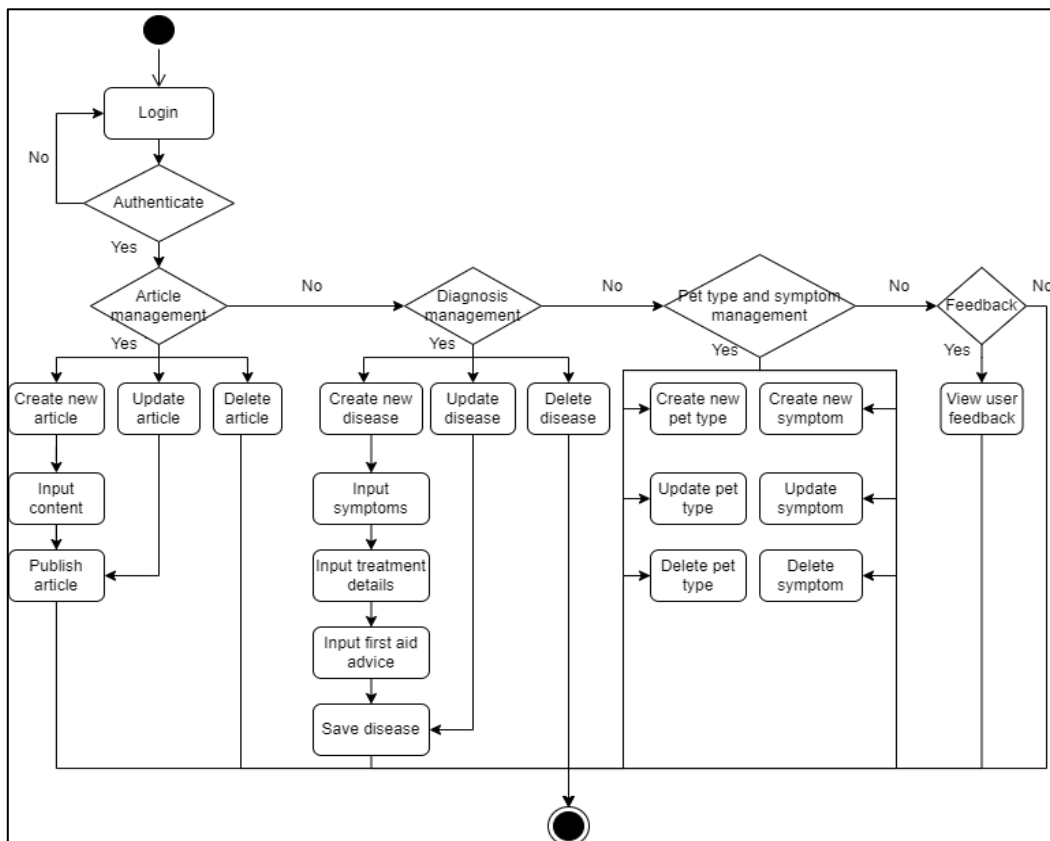**Fig. 5.** Activity diagram for the pet owner

Fig. 6. Activity diagram for the administrator

3.1.4 Class diagram

The following phase is database design, which is a methodical method for creating, putting into use, and maintaining data administration methods. It is utilised to produce logical data representations of database system architectures [24]. The database design produces the class diagram. Since the Object-Oriented Programming model is based on classes and their interactions, class diagrams are used to describe the proposed application. Class diagrams display the links among classes in addition to their characteristics and behaviours. The class diagram for the suggested application is shown in Figure 7.
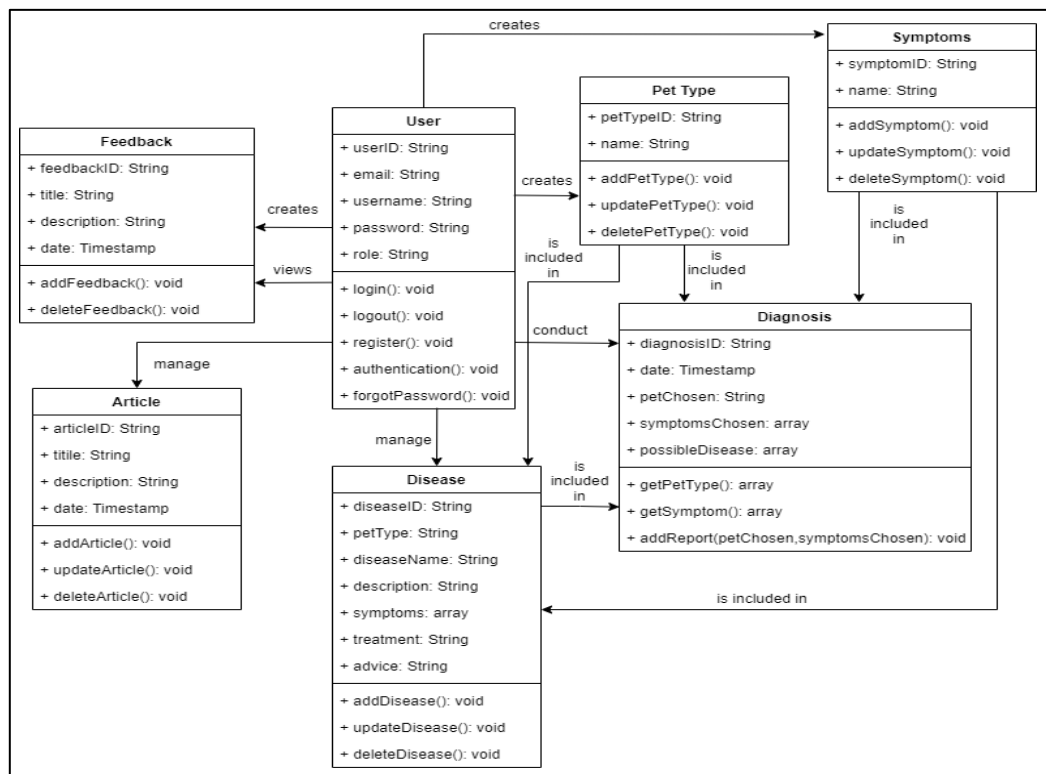

Fig. 7. Class diagram for the proposed application

4. Conclusions

The goal of the pet disease diagnosis app is to help users identify their pet's illness and learn more about their pet's health. One benefit of the suggested app is that it gives users a list of potential illnesses they may use as a resource in any situation. While determining their pet's symptoms, some pet owners who are unfamiliar with pet care may err. The suggested programme lists all potential illnesses for each potential symptom chosen, enabling users to identify the illness that their pet is most likely experiencing before it gets worse.

Pet owners have quick access to the application's diagnostic history at any time. Based on the date of diagnosis, the pet owner can peruse a list of reports that are stored in the diagnostic history. The diagnosis report contains information on the pet's kind, symptoms, and date of diagnosis as well as details on any potential illnesses, including the name of the illness, its exact symptoms, a description, a course of treatment, and recommendations. The user may look at the precise report that was used to determine the state of the pet, and all the explanations are easy to follow. Informing

the veterinarian of the current situation is not only convenient for the user, but it also makes getting information more productive.

Despite most of its features being constructed and adhering to the project's goals, the proposed application does have certain limitations. The consultation feature does not allow users to speak with specialists about their problems. The user who struggles to access veterinary treatment still lacks a workable answer to their pet's urgent problem. The proposed application might provide pet owners with too many options for resolving their problems, which could lead to confusion and possible application abandonment.

The article's lacklustre substance, which was included in the suggested application, is another negative. The application just displays the article's title, publication date, and brief summary, which the user may find distressing and unappealing to read. The user can get reluctant to read the article's content because of this scenario.

Also, if the content grows in the future, the user can experience problems. There are no classifiers for organising articles by content type. Users will also have a hard time finding the articles they want to read again. In addition, the disease list in the admin system is experiencing the same problem. The diseases are listed alphabetically because there are no categories to choose from.

A few suggestions can be made to improve the application's limits going forward when the study is complete, and the advantages and disadvantages of the application have been identified. The quality, usability, and user experience of a project in the future are crucial for the suggested application. First, it is suggested that a veterinarian consultation module be included in the programme so that a pet owner can contact specialists in an emergency and request more accurate information without going to the veterinary clinic. The specialists who will provide the consultation to pet owners must be vetted by the admin to prevent any phoney professionals from offering users incorrect advice.

It is suggested that the article module include media, such as photographs and videos, to persuade readers to read and see the articles. The use of photos or videos will benefit users because the content will be easier to understand, and they will learn new information about pet health care. The article content also needs to be approved by experts and checked by them to make sure that users aren't given any false information.

For the content to be quickly searched for and located in the application, it is advised that the article list and the disease list be divided into a few clusters. It avoids user confusion when they read the data list. The article list can be divided into categories such as disease, pet care advice, immunisation, insurance, and more. Admin can examine the disease list quickly based on the pet type since the disease list can be categorised based on the pet type.

Acknowledgement

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