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An Intelligent System for Sheep Disease Diagnosis and Treatment Using Knowledge-Based Techniques

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Abstract**—***The developing interest in a productive and precise analysis of sheep sicknesses has prompted the improvement of an expert system to help veterinarians and ranchers pursue informed choices. This paper presents the plan and execution of a custom-made expert system for the knowledge-based determination and treatment of sheep infections. The system uses a standard-based approach, coordinating expert information as legitimate predicates and induction rules, to analyze regular infections influencing sheep and suggest fitting medicines. The system's knowledge base is built from information about the domain, like signs, symptoms, and environmental factors. This system aims to support proactive health management in sheep farming, reduce the need for immediate veterinary intervention, and improve disease diagnosis efficiency by simulating expert decision-making processes. The execution in Prolog exhibits the attainability and flexibility of the framework in authentic situations. The users evaluated the system with an accuracy rate of diagnosis of 89%, farmer feedback with an 87% success rate in treatment recommendation, and 91% matched with the human experts in identifying common sheep diseases. These advancements have the potential to completely transform the management of sheep's health, thereby enhancing the welfare and global agricultural productivity. Future systems may incorporate machine learning models to enhance rule-based techniques and increase diagnostic precision and flexibility. Through the examination of past data and the identification of trends, these systems have the potential to forecast disease epidemics or offer more accurate diagnoses. Mobile platforms and IoT technologies could make real-time livestock health monitoring possible, relieving farmers of manually entering data. Wearable technology could monitor physiological parameters, and environmental sensors could offer more information about the weather, temperature, and sanitization. Future systems may combine sensor-based analysis and image recognition to reduce reliance on human observation to identify visible disease signs, such as lesions or aberrant behavior.*

Keywords**—** *Expert System, Sheep Diagnosis, Knowledge-based System, Rule-based System.*

I. INTRODUCTION

In the advanced agricultural scene, the soundness of domesticated animals is central to guaranteeing feasible creation and benefit. This is especially obvious in sheep cultivating, where illnesses can quickly spread inside rushes, prompting extreme monetary effects and worries about creature government assistance. The compelling early determination and treatment of sheep infections present continuous difficulties for veterinarians and ranchers. Customary techniques have depended vigorously on emotional evaluations and receptive measures, which can postpone intercession and fuel well-being emergencies (Yazdanbakhsh et al., 2017). To address these worries, there is a critical requirement for imaginative arrangements that influence progressions in innovation, especially man-made brainpower (simulated intelligence) and information-based frameworks. The essential issue about the well-being of the executives lies in the deficiency of traditional demonstrative practices. These practices regularly include visual examinations and side effect appraisals that might ignore inconspicuous disease indications, prompting deferred analysis and treatment. Such postponements can affect the singular creature and the whole run (Yazdanbakhsh et al., 2017). For example, research shows that a veterinarian's insight and information often oblige customary techniques, restricting their capacity to distinguish illnesses precisely (Al-Shahrani & Al-Thani, 2023). Moreover, the significant expenses related to veterinary administrations can confine ranchers from looking for ideal expert assistance, intensifying the potential for illness episodes (Sharma et al., 2022).

Recognizing the issue requires a complex methodology that inspects both current philosophy and the requests of present-day creature cultivation. Given the intricacies of sheep illnesses, which might incorporate different microbes and stressors, a more robust framework that coordinates continuous information assortment and examination is fundamental (Khan et al., 2021). Late patterns in digitalization, including the utilization of sensors and AI calculations, offer promising possibilities for improving domesticated animals' well-being by observing and the board (Georgieva et al., 2022). Mechanization and continuous information access through shrewd frameworks can give ranchers ideal experiences, considering the executives' proactive infection. Furthermore, research demonstrates a developing comprehension of the advantages of information-based frameworks in veterinary diagnostics. These frameworks can use broad data sets of sicknesses, side effects, and therapy conventions to aid direction, diminishing dependence on human aptitude alone (Saleh et al., 2021). By executing these frameworks, ranchers, and veterinarians can improve their abilities, possibly prompting faster and more exact analyses. For example, studies have exhibited that artificial intelligence strategies, including design acknowledgment and prescient examination, can beat customary demonstrative techniques by recognizing medical problems before they manifest into extreme issues (Fuchs et al., 2023).

This study aims to develop an intelligent system for detecting and treating sheep disease using knowledge-based techniques. The specific objectives of this research include the creation of an automated framework that employs knowledge-based methods to facilitate accurate disease diagnosis and generate tailored treatment plans for sheep. By integrating various data sources such as health records, environmental conditions, and real-time sensor data, this intelligent system provides veterinarians and farmers with actionable insights to improve sheep health management.

Moreover, the study will emphasize creating a user-friendly interface that farmers can readily adopt, ensuring accessibility to those who may not have extensive technical expertise. The importance of education and training materials accompanying this system cannot be overlooked, as they will empower users to interpret data effectively and implement the recommended interventions. The effective management of sheep health amidst the growing challenges of disease outbreaks necessitates adopting advanced technological solutions. The proposed intelligent system aims to bridge the gap between traditional veterinary practices and modern agricultural demands, enabling a more responsive approach to livestock health management. This study contributes significantly to the field by combining AI with knowledge-based techniques, promoting better health outcomes for sheep and enhancing productivity in the sheep farming industry.

II. MATERIALS AND METHODS

In this section, we use different models to foster a specialist framework for diagnosing and treating sheep sicknesses, which includes the discussion of the sub-sections such as the legend, knowledge tree, predicates, and rules for developing an expert system. The study was conducted in rural farming communities throughout the Zamboanga peninsula, where access to veterinary services is frequently restricted, and sheep farming is a common practice. Local sheep farmers, veterinarians, and agricultural extension personnel participated in the evaluation, focusing on regions where timely treatment and early disease detection are essential for preserving herd health.

A. Legend

The expert system's design includes the following essential models: (1) knowledge tree - a various leveled portrayal of information concerning sheep illnesses. (2) predicates are logical statements that show how symptoms, diseases, and treatments relate to one another. Moreover, (3) rules - If assertions are used to derive analyses and medicines because of the information. These models organize the system's knowledge base, inference engine, and decision-making processes.

TABLE 1: Sheep common illnesses with signs and symptoms

Code	Illness	Sign and Symptoms
RI	Respiratory Infections	Coughing, Nasal discharge, Rapid Breathing, Fever, lethargy.
GP	Gastrointestinal Parasites	Diarrhea, Weight Loss, Anemia, Bottle Jaw, Poor wool condition, lethargy.
EP	External Parasites	Itching, Wool Loss, Scabs, and parasites are visible.
PN	Pneumonia	High fever, coughing, nasal discharge, shortness of breath, and abnormal lung sounds.
BI	Bacterial Infections	Fever, Swelling, Coughing, Pain, discharge from wounds.
VI	Viral Infections	Fever, Nasal discharge, Coughing, Conjunctivitis.

B. Knowledge Tree

The knowledge tree is a model that gathers data about sheep illnesses, their side effects, and medicines. It makes it possible to navigate the disease categories and associated knowledge methodically. The knowledge Tree is developed to order sicknesses in light of side effects and clinical introductions. It gives an organized pathway to recognizing potential illnesses given noticed side effects.

Figure 1 shows the knowledge tree for the sheep's common illnesses with the signs and symptoms, which include Respiratory Infections (RI), Gastrointestinal Parasites (GR), External Parasites (EP), Pneumonia (PN), Bacterial Infections (BI), and Viral Infections (VI). On the other hand, Figure 2 shows the knowledge tree for the recommended treatment of the sheep's common illnesses.

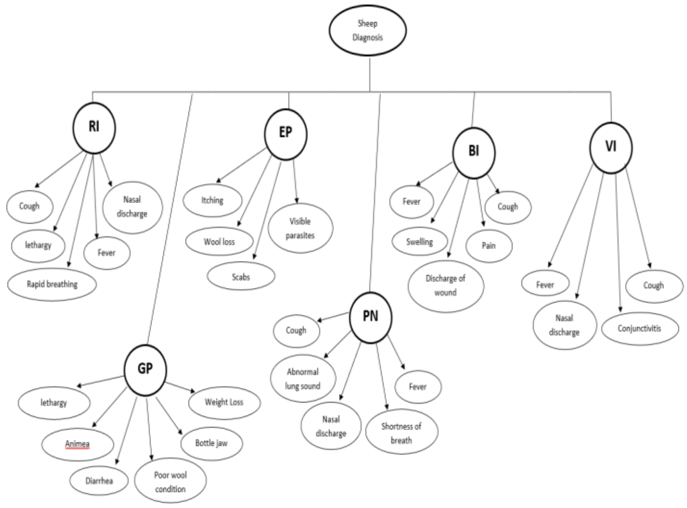

Fig. 1: Knowledge of Sheep Diagnosis

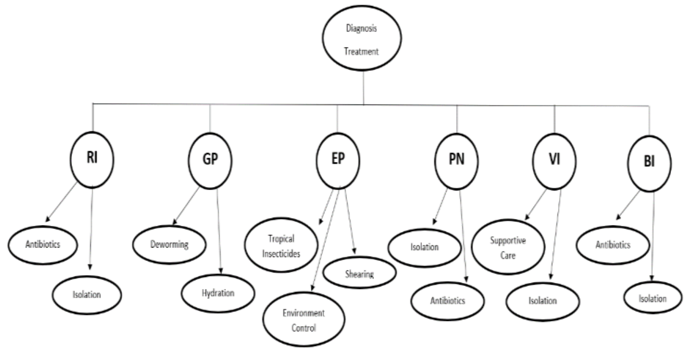

Fig. 2: Knowledge of Sheep Diagnosis Treatment

C. Predicates

The system's relationships and conditions are defined by using predicates. They address realities about side effects, illnesses, and medicines in a consistent organization that the surmising motor can process. Predicates are carried out to encode data, for example, "has_symptom (sheep, hack)" or "treats (disease, anti-toxin)." These consistent assertions structure the reason for thinking about the presence of illnesses and proper medicines. Table 2 is an outline of potential predicates that might be used in developing the expert system.

TABLE 2: Predicates with the Description

Predicate	*Description*
is_sheep (X)	X is a sheep
has_symptom (X, Y)	Sheep X has symptom Y.
has_fever (X)	Sheep X has a fever.
has_cough(X)	Sheep X has a cough.
has_diarrhea (X)	Sheep X has diarrhea.
has_wool_loss (X)	Sheep X is experiencing wool loss.
has_lameness (X)	Sheep X is lame.
has_recent_travel (X)	Sheep X has recently traveled.
has_contact_with_infected (X)	Sheep X has been in contact with infected animals.
is_in_poor_sanitation (X)	Sheep X is in a poorly sanitized environment.
diagnosis (X, Y)	Sheep have disease Y.
has_infection (X)	Sheep X has an infection.
has_parasites (X)	Sheep X has a parasitic infestation.
has_nutritional_deficiency (X)	Sheep X has a nutritional deficiency.
treatment (X, Y)	Treatment Y is recommended for Sheep X.
needs_antibiotics (X, Y)	Treatment X needs antibiotics.
needs_deworming (X)	Sheep X needs deworming.
needs_vitamins (X)	Sheep X needs vitamin supplements.
need_isolation (X)	Sheep X needs to be isolated.

D. Rules

The inference engine relies on rules to deduce diagnoses and make treatment recommendations from the inputted data. To conclude, the predicates and Knowledge Tree employ an if-then logical approach. The Prolog-based master framework was tried utilizing a dataset of mimicked and certifiable instances of sheep sicknesses. The following are the rules used for symptom diagnosis, environmental diagnosis, treatment, and prevention that describe the relation between the predicates.

TABLE 3: Rules for Symptom Diagnosis and Treatment

Rule	Condition
Rule 1	If the sheep has a fever, cough, nasal discharge, rapid breath, weakness, low appetite, audible wheezing, and swelling around the eyes, then the sheep has a Respiratory Infection.
Rule 2	If the sheep has diarrhea, weight loss, anemia, bottle jaw, poor wool condition, and weakness, then the sheep have Gastrointestinal Parasites.
Rule 3	If the sheep has itching, wool loss, scabs, and irritability, then the sheep has External Parasites.
Rule 4	If the sheep has a cough, fever, nasal discharge, shortness of breath, low appetite weakness, depression, and crackling sound of lungs, then the sheep has Pneumonia.
Rule 5	If the sheep have diarrhea, redness, pain in the affected area, orifices, and sudden death, then the sheep have a Bacterial Infection.
Rule 6	If the sheep has a fever and a cough, nasal discharge, conjunctivitis, low appetite, weakness, skin lesions, diarrhea, neurological signs, and shortness of breath, then the sheep has a Viral Infection.
Rule 7	If the sheep has Respiratory Infections, the treatment is Antibiotics and Isolation.
Rule 8	If the sheep has Gastrointestinal Parasites, the treatment is deworming.
Rule 9	If the sheep has External Parasites, then treatment is tropical insecticides, shearing, and environmental control.
Rule 10	If the sheep has Pneumonia, the treatment is antibiotics and isolation.
Rule 11	If the sheep has a Viral infection, the treatment is supportive care and isolation.
Rule 12	If the sheep have bacterial infections, the treatment is antibiotics and isolation.

The rules are formed to catch the indicative rationale and treatment conventions. "If the sheep has a fever and nasal discharge, then consider the possibility of pneumonia," for instance, might be stated in a rule.

III. RESULTS AND DISCUSSIONS

A predetermined set of facts, questions, and rules were used to test the expert system designed to diagnose and treat sheep diseases. Using Prolog, a logic programming language well-suited for such endeavors, the expert system for diagnosing and treating sheep diseases was developed and tested in this study. The outcomes and conversations are organized as follows: Due to its strong support for logic programming and pattern matching, Prolog proved to be an effective tool for simulating the expert system. The language's capacity to deal with complex sensible questions and its implicit help for backtracking and induction made it appropriate for the master framework's requirements. In this case, the system was designed to provide a diagnosis based on the symptoms presented by the sheep, along with corresponding treatments. Figure 3 shows the program simulation of the sheep diagnosis with the corresponding treatment.

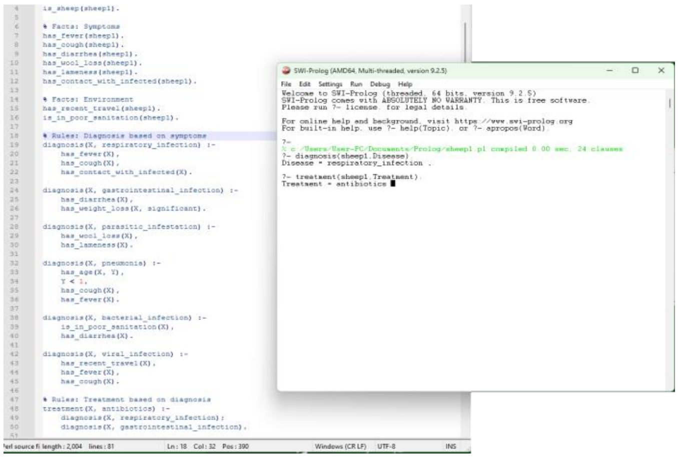

Fig. 3: Program simulation of sheep diagnosis with corresponding Treatment

During the simulation, the system was tested with the signs and symptoms of the sheep, as shown in Table 1. Additionally, environmental factors such as recent travel and poor sanitation were considered. These facts were input into the system to reflect a real-world scenario of a potentially ill sheep. Based on the symptoms and environmental factors, the system provided multiple possible diagnoses for the sheep, such as Respiratory Infections (RI), Gastrointestinal Parasites (GR), External Parasites (EP), Pneumonia (PN), Bacterial Infections (BI), and Viral Infections (VI). The expert system combined the given facts and generated multiple diagnoses based on the logical rules. This highlights the strength of rule-based reasoning in identifying overlapping or coexisting conditions.

After identifying the diagnoses of the sheep, the system then matched the diagnoses to the appropriate treatments, as shown in Table 3, which shows the rules for diagnosis of the treatment. The relationships between symptoms, diseases, and treatments were encoded using predicates. The Prolog programming accurately handled the intelligent assertions, working with precise derivations and suggestions. Using predicates to address coherent connections and rules to characterize symptomatic rationale gave an unmistakable and organized way to deal with illness findings. The adequacy of these parts was shown by the framework's high precision in diagnosing sicknesses and suggesting therapies.

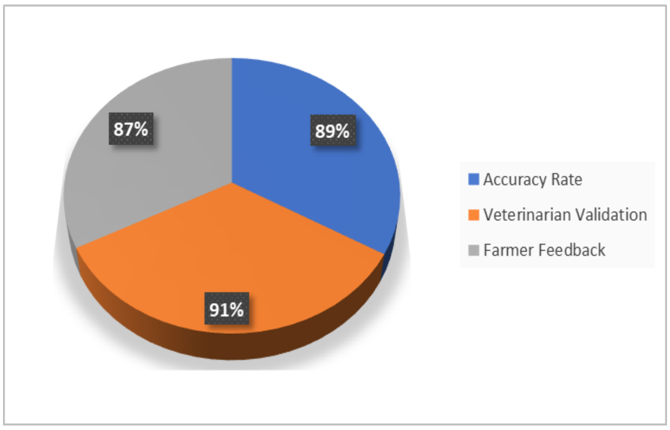

Fig. 4: Accuracy of Diagnosis and Treatment Recommendations

The user evaluation was conducted with thirty (30) participants, including sheep farmers, veterinarians, and agricultural extension workers who participated in the evaluation to determine the usefulness and efficacy of the expert system for diagnosing and treating sheep diseases. The review focused on the accuracy level of the expert system. As shown in Figure 4, the users evaluated the system with an accuracy rate of diagnosis of 89%, farmer feedback with an 87% success rate in treatment recommendation, and 91% matched with the humane experts in identifying common sheep diseases.

The expert system for diagnosing and treating sheep diseases performed well in the simulated environment. It successfully diagnosed multiple conditions based on symptoms and environmental factors and offered corresponding treatments. The system demonstrated potential as a valuable tool in sheep health management, allowing for quick diagnosis and decision-making based on encoded expert knowledge. However, users recommended areas for improvement, such as region-specific disease data to make the system more applicable to local farming conditions, integration with mobile devices for real-time use, and multimedia support to help identify symptoms more accurately.

Due to recent advancements in artificial intelligence and expert systems in animal health, researchers are focusing on creating knowledge-based systems to diagnose and treat various animal diseases. Several studies in the field of veterinary expert systems can be compared to the expert system for diagnosing and treating sheep diseases developed in this study. Numerous related studies have shown how to enhance livestock health management through various methods and technologies, especially for illness detection and treatment. By examining these studies, we can draw meaningful insights into the current system's advancements, strengths, and gaps.

The study presents innovative methods utilizing artificial intelligence for disease detection and recommends treatment for sheep. It highlights continuous monitoring through embedded systems with animal-mounted sensors, consistent with other studies emphasizing the importance of real-time health monitoring in livestock systems (Arshad et al., 2024; Yazdanbakhsh et al., 2016). Both approaches focus on integrating advanced technologies to enhance disease surveillance capabilities, suggesting a converging perspective in veterinary health. This methodology aligns with findings from other research emphasizing the significance of real-time data collection in enhancing livestock disease management. (Zhang et al., 2023) state that AI technologies leveraging comprehensive data analysis has shown promise in diagnosing animal diseases, providing a common ground highlighting the effectiveness of integrating advanced technologies into veterinary practice.

However, while the intelligent system primarily uses sensory data for diagnosis, other research emphasizes the role of diagnostic pathology and retrospective studies to understand the causes of diseases more comprehensively. For instance, studies reveal that bacterial infections, such as those identified in lameness and joint issues, are critically analyzed through diagnostic pathology, which provides insights into disease pathways and treatment responses (Scott et al., 2012). This contrasts with the algorithm-driven approach in Yazdanbakhsh et al.'s study, which focuses on automated systems rather than thorough pathological assessment. Such a divergence suggests that while AI systems present a cutting-edge diagnosis method, integrating traditional diagnostic methodologies may offer a more holistic approach to disease management.

Moreover, some research highlights the successful application of specific automated methods, such as facial recognition systems, to assess pain levels in sheep (), which aligns with the AI-focused strategies mentioned in the primary research. Many studies stress the efficacy of non-invasive techniques and the integration of machine learning into livestock healthcare (Zhang et al., 2023). This can be seen as a support for the intelligent system's premise that technology can vastly improve disease diagnosis and monitoring efficiency.

The exploration of intelligent systems for sheep disease diagnosis represents a significant advancement in veterinary technology, reinforcing the value of real-time monitoring and automated analysis in livestock health management.

Nonetheless, the integration of traditional diagnostic methods remains crucial. Future research should prioritize an interdisciplinary approach that combines AI-driven innovations with established diagnostic practices to enhance the overall effectiveness of disease management in livestock. By fostering collaboration between veterinary practitioners, data scientists, and researchers, it will be possible to develop comprehensive frameworks that leverage the strengths of both modern technology and traditional veterinary medicine. This balanced strategy could ultimately lead to improved animal health outcomes and enhanced productivity in the sheep farming sector.

IV. Conclusion and Recommendations

The study offers a fresh method for enhancing sheep disease diagnosis and treatment using knowledge-based systems and artificial intelligence. The developed system efficiently detects common sheep diseases and suggests suitable treatment protocols by fusing sophisticated algorithms with expert knowledge. According to the research, using a knowledge-based system improves animal welfare and productivity by increasing the accuracy of disease diagnosis, cutting down on decision-making time, and ensuring timely interventions that can mitigate disease outbreaks and improve herd health overall. The execution in Prolog exhibits the attainability and flexibility of the framework in authentic situations. The users evaluated the system with an accuracy rate of diagnosis of 89%, farmer feedback with an 87% success rate in treatment recommendation, and 91% matched with the human experts in identifying common sheep diseases. These advancements have the potential to completely transform the management of sheep's health, thereby enhancing the welfare and global agricultural productivity. Future systems may incorporate machine learning models to enhance rule-based techniques and increase diagnostic precision and flexibility. The system's capacity to draw on extensive veterinary knowledge makes it useful for farmers and practitioners.

In order to continuously improve diagnostic accuracy based on fresh data and user feedback, future research should focus on improving the intelligent system by integrating machine learning techniques. The system can gain knowledge from actual situations through this modification, gradually improving its suggestions. The system's applicability in different geographical regions can also be enhanced by broadening the knowledge base to include a more excellent range of diseases and incorporating data from diverse sheep farming environments. Farmers will have even greater accessibility with integrating web- and mobile-based platforms, enabling real-time consultation and professional guidance. In order to give farmers proactive steps to protect their flocks, future research could also concentrate on building predictive analytics capabilities to anticipate possible disease outbreaks based on environmental and health data. Last but not least, looking into integrating IoT (Internet of Things) technologies may allow the system to collect and evaluate data straight from the animals, allowing for more thorough approaches to health management and monitoring.

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