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Web-Based Expert System for Diagnosing Chicken and Duck Diseases Using the Dempster–Shafer Method

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ABSTRACT
Poultry farming, particularly chicken and duck production, makes a significant contribution to the supply of animal-based protein in Indonesia. However, the high vulnerability of poultry to infectious diseases such as Newcastle Disease, Avian Influenza, Cholera, and Pullorum often results in severe economic losses and impacts public health. The problem is further complicated because disease diagnosis in the field is still largely performed manually by farmers or veterinary personnel, which often requires considerable time, cost, and expertise, while similarities in symptoms among diseases frequently lead to misidentification. To address these issues, this study developed a web-based expert system using the Dempster-Shafer method. This method was selected because it can process uncertain data by combining evidence to generate more representative measures of belief and plausibility. The research stages included problem identification, data collection through interviews and literature studies, system design using the CodeIgniter framework based on the MVC model with PHP and MySQL, implementation of the Dempster-Shafer algorithm in the inference engine, and field testing at Ternak Hasbuan Kebun IV, Kotabumi. The developed system provides features such as a dashboard, symptom input, inference process, diagnosis results, and diagnosis history. Testing results showed that the system achieved an average compatibility rate of 88.76% compared to veterinary expert diagnoses, with system confidence values ranging from 84.6% to 92.4%. These findings demonstrate that the system can serve as a practical solution for farmers to perform independent diagnoses, accelerate disease identification, and effectively support poultry health management. The novelty of this research lies in the integration of dual-species (chicken and duck) diagnosis within a single web-based platform, validated directly through field testing.

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INTRODUCTION

The poultry farming sector particularly chicken and duck production serves as one of the strategic pillars supporting food security in Indonesia. Alongside population growth and increasing nutritional awareness, the demand for poultry products such as meat and eggs has risen significantly, making this subsector the backbone of affordable national animal protein supply (Putra & Anggraini, 2023). The dominant contribution of the poultry subsector in fulfilling community nutrition underscores that improving its productivity is a crucial factor in ensuring food availability, enhancing farmers' welfare, and strengthening national economic stability (Pertiwi, 2023)..

However, the productivity of the national poultry industry often faces serious challenges in the form of infectious disease outbreaks that can cause massive economic losses. Viral diseases such as Newcastle Disease (ND) and Avian Influenza (AI), as well as bacterial infections like Cholera, consistently cause spikes in mortality rates, reduced egg production, and slower poultry growth (Lubis et al., 2021; Sanbio, 2022). The impacts of these diseases not only directly harm farmers but also threaten the food supply chain and pose potential zoonotic risks that endanger human health (Dewi et al., 2022). Therefore, early detection and accurate diagnosis are essential to mitigate disease spread and minimize losses.

Current diagnostic practices in the field still heavily rely on manual observation by farmers or clinical examination by veterinary practitioners. These conventional methods have several weaknesses, such as being time-consuming, costly, and highly dependent on expert experience [6]. The problem is further compounded by the similarity of symptoms among diseases, which often leads to misidentification, as well as the limited number and uneven distribution of veterinary experts, particularly in rural areas, (Sanbio, A. 2022).

To overcome these challenges, the application of artificial intelligence technologies such as expert systems offers a promising solution. Expert systems are designed to replicate the reasoning process of human experts within a specific domain by utilizing a knowledge base and an inference mechanism to support decision-making N. Handayani. In the livestock context, an expert system can facilitate disease diagnosis based on symptoms inputted by users, making the identification process faster, more objective, and accessible anytime it is needed.

Given the inherent uncertainty in diagnosis where a single symptom may indicate several possible diseases this study implements the Dempster-Shafer method. This evidential theory excels in managing and combining uncertain or incomplete information to generate more reliable measures of belief and plausibility compared to conventional deterministic approaches, (Munandar. 2024; A. Rani, 2024).

The key novelty of this research lies in developing an integrated web-based expert system for diagnosing diseases in two poultry species chickens and ducks simultaneously. The web-based platform was chosen to ensure broad accessibility across various devices, both computers and mobile, enabling real-time field implementation (Ahsanuddin, et al. 2024. Unlike previous studies that often focused on a single animal type or were tested only in simulated environments, this system was directly validated in an actual poultry farm setting (Case Study: Ternak Hasbuan Kebun IV, Kotabumi), significantly enhancing its practical relevance and applicability.

Therefore, this study aims to design and implement a functional web-based expert system to diagnose diseases in chickens and ducks using the Dempster-Shafer method. The developed system is expected to serve as an effective self-diagnosis tool for farmers, helping reduce poultry mortality rates, support disease control efforts more efficiently, and ultimately enhance the overall productivity of the poultry sector.

METHODS

The research methodology in this study was systematically designed to develop and implement a web-based expert system for diagnosing chicken and duck diseases using the Dempster-Shafer method. The research approach consists of several stages, including problem identification, data collection, system design, algorithm implementation, as well as field testing and validation. This framework is supported by relevant theoretical foundations to clarify the flow and working mechanism of the system.

Research Stages

1. Problem Identification
   The research began with a field analysis identifying the difficulties farmers face in early detection of poultry diseases. Key factors such as farmers' limited knowledge of specific symptoms, restricted access to veterinary services, and high symptom similarity among diseases are the main causes of delayed and inaccurate diagnosis, (Ahsanuddin et al., 2024; Siahaan, 2021).
2. Data Collection
   Data for constructing the knowledge base were collected through two main approaches.
   a. First, semi-structured interviews were conducted with experts and farmers at *Ternak Hasbuan Kebun IV Kotabumi* to gather empirical knowledge about clinical symptoms, disease frequency, and practical treatments.
   b. Second, an in-depth literature review was conducted by examining scientific journals, reference books, and relevant publications to validate and supplement field data, ensuring that the knowledge base developed is both comprehensive and scientifically accurate (Rani, 2024; Munandar, 2024).
3. System Design
   The system was developed using the CodeIgniter framework with a Model View Controller (MVC) architecture to ensure modularity and ease of development. The programming language used was PHP, supported by a MySQL database, while the user interface was designed responsively using HTML, CSS, and Bootstrap. The choice of a web-based platform aims to provide high accessibility, allowing real-time use from various devices both computers and smartphones without the need for special installation (Azmi, M., & Ismail, S. A. 2022).
4. Implementation of the Dempster-Shafer Method
   The Dempster-Shafer algorithm was implemented as the system's main inference engine. This method was chosen due to its superior capability in handling uncertainty. The algorithm effectively combines multiple related pieces of evidence (symptoms), calculates belief and plausibility values, and produces reliable diagnostic probabilities even when available data are incomplete or ambiguous (Putra, I. M. D. S. P., & Setiawan, I. M. A. D. 2021).
5. System Testing and Analysis
   The testing process consisted of two stages:
   a. First, functional testing (*black-box testing*) to ensure that all system features operated as expected.
   b. Second, accuracy testing conducted directly at *Ternak Hasbuan Kebun IV Kotabumi*, where system diagnoses were compared with veterinary expert

diagnoses in real cases. Validation analysis was performed by calculating the *accuracy rate* between the system's output and expert evaluations to assess performance and reliability (Siregar, H. F., et al. 2021).

System Architecture

The system architecture was designed with three main layers to separate processing logic from the user interface, as illustrated in Figure 1.

1. The input layer captures symptom data selected by users.
2. The process layer acts as the system's core, where the Dempster-Shafer inference engine processes the data.
3. The output layer presents the diagnosis results, including disease identification, confidence percentages, and initial treatment recommendations.

Figure 1. System Architecture of the Web-Based Expert System for Diagnosing Chicken and Duck Diseases

Knowledge Base

The knowledge base is a fundamental component containing expert knowledge representations. It consists of:

1. Symptom Table: A complete list of clinical symptoms observable in chickens and ducks.
2. Disease Table: Contains common poultry diseases (e.g., Newcastle Disease, Cholera, Avian Influenza, Coryza, and Pullorum) along with their descriptions, causes, and treatment recommendations.
3. Rule Base: Defines relationships between symptom sets and possible diseases, where each rule is assigned an initial belief weight determined by experts. These weights serve as the foundation for inference calculations using the Dempster-Shafer method (Lestari, N. L. G. P., et al. 2021).

Dempster-Shafer Inference Flowchart

The workflow of the Dempster-Shafer inference process, illustrated in Figure 2, represents the core reasoning engine of this expert system. The process begins when users interact with the interface and select a set of symptoms observed in poultry. Each selected symptom is treated as an *evidence* to be evaluated.

The system then accesses the knowledge base to retrieve the *mass function* (belief value) assigned by experts for each symptom–disease relationship. This value represents the

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initial confidence that a specific symptom indicates a certain disease. Next, the system iteratively applies Dempster's Combination Rule to merge the mass functions from each piece of evidence. For example, belief derived from Symptom 1 is combined with that from Symptom 2 to produce a new combined mass function; this result is then merged with Symptom 3, and so on, for all selected symptoms.

Through this iterative process, the belief in a particular disease hypothesis becomes stronger as more supporting evidence is accumulated. The final result consists of a set of belief and plausibility values for each disease in the knowledge base. The system then displays the disease with the highest belief value as the most likely diagnosis, along with its corresponding confidence percentage.

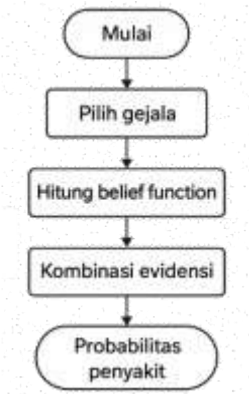

Figure 2. Flowchart of the Dempster-Shafer Inference Process

Theoretical Framework

The methodological foundation of this research is built upon the synergistic integration of three main technological concepts: expert systems, Dempster-Shafer evidential theory, and web-based MVC architecture. Together, these components form a robust framework for transforming expert knowledge into a functional and impactful application.

1. Expert System as the Foundational Framework:
   The expert system concept provides the fundamental architecture, consisting of a knowledge base (containing facts and rules about diseases and symptoms) and an inference engine. This framework serves as a medium to represent and manage an expert's (veterinarian's) knowledge in a structured digital format.
2. Dempster-Shafer Theory as the Reasoning Core:
   This theory functions as the "brain" of the system's inference engine. Unlike simple *IF–THEN* rule-based reasoning, the Dempster-Shafer method mathematically handles the uncertainty inherent in medical diagnoses. It allows the system to reason with incomplete or even conflicting information, combining each piece of evidence (symptom) to strengthen or weaken a diagnostic hypothesis. This capability enables the system to produce nuanced and reliable conclusions.
3. Web-Based MVC Architecture as the Delivery Framework:
   If the expert system serves as the framework and Dempster-Shafer as the brain, then the web-based MVC architecture is the "body" that enables wide accessibility and usability.
   a. Model: Responsible for managing data and business logic, including direct interaction with the knowledge base and execution of Dempster-Shafer calculations.

b. View: Represents the user interface (UI) that farmers interact with to input symptoms and receive diagnostic results.
c. Controller: Acts as a bridge between the Model and View, receiving user input, instructing the Model to process it, and then displaying the results through the View.

This MVC pattern ensures that application development remains structured, maintainable, and scalable. The combination of these three pillars establishes a strong methodological foundation, enabling the creation of a diagnostic system that is not only theoretically accurate but also practical, accessible, and applicable in addressing real-world field challenges [18].

RESULTS AND DISCUSSION

The web-based expert system for diagnosing chicken and duck diseases using the Dempster–Shafer method has been successfully implemented. The system was built using the CodeIgniter framework (Model, View, and Controller architecture), the PHP programming language, and a MySQL database. The user interface was developed with HTML, CSS, and Bootstrap, resulting in a simple, responsive design accessible via both computers and mobile devices.

System Implementation

The implementation of the web-based expert system for diagnosing chicken and duck diseases was carried out by integrating the research methodology into an application built on the CodeIgniter, PHP, and MySQL framework. The system utilizes the Dempster-Shafer method as the core inference process to analyze user-selected symptoms and generate diagnostic results with confidence levels. Functionally, the system displays symptom data, disease data, diagnostic results, and diagnosis history in a simple, responsive web interface. The implementation results show a structured workflow—from symptom input to output in the form of diagnosis and recommended treatments.

1. **System Dashboard**

The dashboard serves as the main page displaying key information summaries from the expert system, including the number of diseases, symptoms, total diagnoses, and user data. A notification panel on the right-hand side shows recent activity. The dashboard layout is designed for simplicity and ease of use.

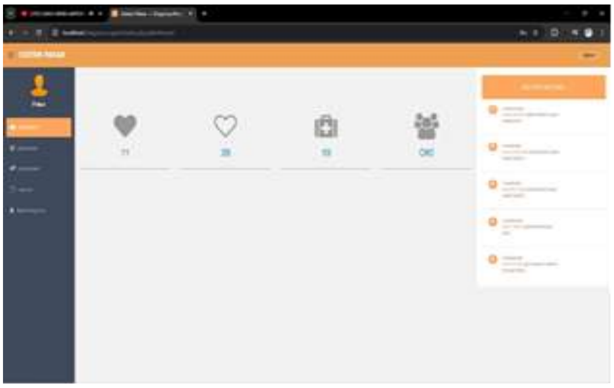

Figure 3. System Dashboard

Through the dashboard, users can monitor overall data conditions and access key menus such as chicken data, duck data, reports, and user data. This feature enhances navigation and accelerates the diagnostic process since all crucial information is presented concisely and informatively.

2. Symptom Input Page

The symptom input page displays a list of symptoms stored in the knowledge base. Each symptom has a unique code (e.g., G001 for "white diarrhea") and a short description for user clarity. The table includes search, edit, and delete features for easy data management.

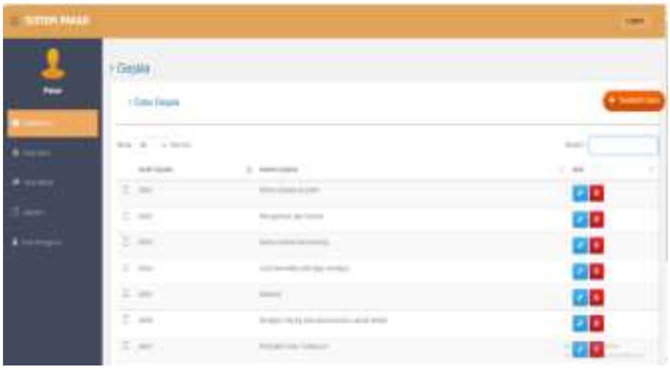

Figure 4. Symptom Input Page

Here, users can select multiple symptoms according to the observed conditions of chickens or ducks. The selected symptoms are processed using the Dempster-Shafer method to generate a diagnosis and its corresponding confidence level, providing more accurate and representative identification results.

3. Diagnostic Question Page

Besides the symptom list, the system provides an interactive diagnostic question page. Users are presented with simple yes/no questions related to symptoms relevant to their poultry's condition. Each question is uniquely coded, such as G032 for "Is the egg quality poor?" This approach allows farmers to evaluate their poultry more systematically.

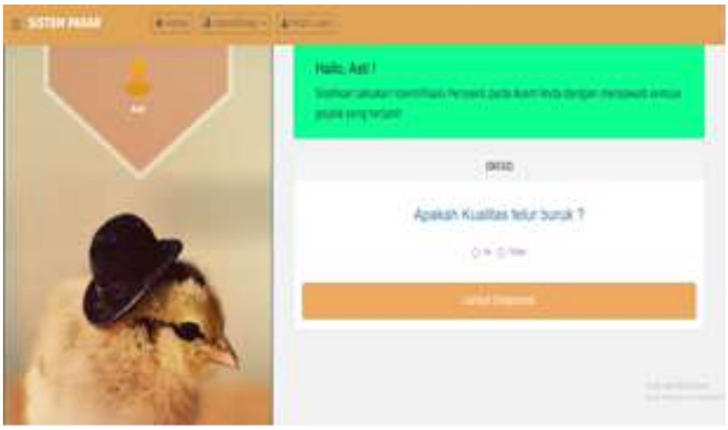

Figure 5. Diagnostic Question Page

User responses are processed as *evidence* within the Dempster-Shafer framework, which then combines them to calculate confidence levels for possible diseases. This feature minimizes input errors, simplifies usage for farmers with limited technological literacy, and ensures a more directed and accurate diagnostic process.

4. Diagnostic Results Page

The diagnostic results page records previous examinations in a table showing the date, animal type, selected symptoms, diagnosed disease, and confidence level.

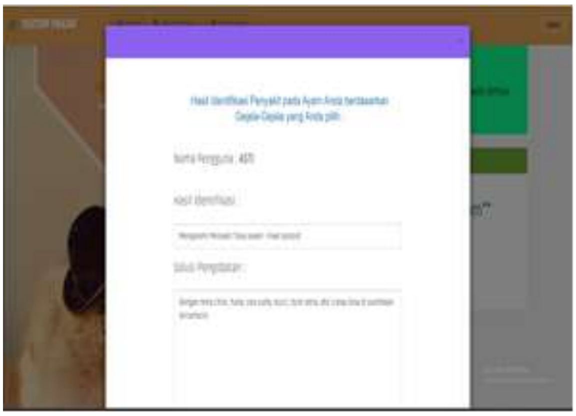

Figure 6. Diagnostic Results Page

This feature serves as a traceable health log, allowing farmers to monitor recurring disease patterns. The data can be filtered, searched, or exported into reports, supporting ongoing poultry health management.

5. **Diagnosis History Page**

To support sustainable poultry health management, the system integrates a Diagnosis History page that functions as a digital archive and analysis tool. It automatically records and organizes each consultation session, converting raw data into meaningful historical insights. The table format includes key details such as:

1. Diagnosis Date: Indicates when the examination was conducted.
2. User Name: Identifies who performed the diagnosis.
3. Disease Identification Result: Displays the final system diagnosis.
4. Treatment Recommendations: Provides actionable suggestions.
5. Confidence Level: The Dempster-Shafer-derived probability value representing the reliability of the system's conclusion.

Figure 7. Diagnosis History Page

This feature serves as a reliable, accessible poultry health log. It allows farmers to monitor health longitudinally, analyze disease trends, evaluate past treatments, and generate structured reports for documentation or further consultation with experts.

Knowledge Base

The system's knowledge base consists of:

1. Symptom Table: Contains a list of clinical symptoms for chickens and ducks, such as diarrhea, lethargy, respiratory distress, and reduced egg production.

2. Disease Table: Includes major poultry diseases such as Newcastle Disease, Cholera, Avian Influenza, Coryza, and Pullorum, complete with descriptions, causes, and treatments.
3. Rule Relations: Connects symptoms with diseases and assigns confidence weights used in Dempster Shafer inference calculations.

System Testing

System testing was conducted at *Ternak Hasbuan Kebun IV Kotabumi* using real data. The system's diagnostic results were compared with those of veterinary experts. The summary of the tests is shown in Table 1, where the system achieved an average compatibility rate of 88.76% compared to expert diagnoses.

These results are also visualized in Chart 1, illustrating the comparison of the system's confidence levels against expert benchmarks. The system's confidence values consistently ranged between 84.6% and 92.4%, approaching the expert reference value of 100%.

Table 1. System and expert diagnosis test results

No	Animal Type	Main Symptoms	Expert Diagnosis	System Diagnosis	Confidence Level (%)	Status
1	Chicken	Loss of appetite, diarrhea, dull feathers	Newcastle Disease	Newcastle Disease	89.5	Match
2	Duck	Lethargy, nasal discharge, sudden death	Cholera	Cholera	87.2	Match
3	Chicken	Respiratory disorder, sneezing, drooping wings	Avian Influenza	Avian Influenza	90.1	Match
4	Duck	Loss of appetite, diarrhea, slow growth	Pullorum	Pullorum	84.6	Match
5	Chicken	Lethargy, twisted neck, high mortality	Newcastle Disease	Newcastle Disease	92.4	Match

Data Source: Field testing conducted at *Ternak Hasbuan Kebun IV*, Kotabumi, North Lampung, Indonesia.

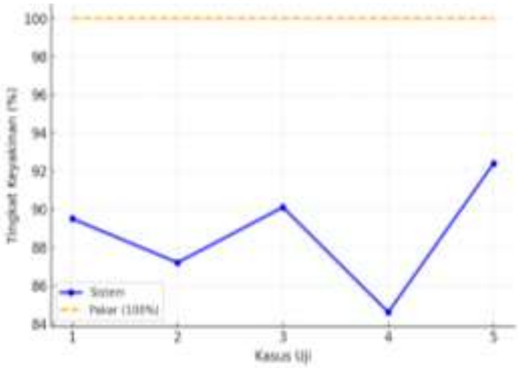

Chart 1. Comparison of System Diagnosis Confidence Levels with Expert Reference

Results Analysis

Quantitatively, the testing results show that the system provides highly accurate diagnoses over 85% across all test cases. Qualitatively, farmers who tested the system reported that the interface was user-friendly, the instructions were clear, and computation time was very short (less than 10 seconds).

From a practical standpoint, the system helps farmers accelerate disease identification, provides initial treatment recommendations, and stores diagnostic histories for monitoring purposes. Compared to manual methods, it standardizes the diagnostic process and reduces dependence on the physical presence of veterinary experts.

The uniqueness of this research lies in its broader scope: the system can diagnose both chickens and ducks within a single platform. Moreover, validation was conducted directly under real farm conditions, which strengthens the research's relevance and increases the likelihood of practical adoption by farmers.

CONCLUSION

Based on the research results and system implementation, it can be concluded that this study successfully designed and implemented a web-based expert system for diagnosing chicken and duck diseases using the Dempster-Shafer method. The developed system is capable of processing user-input symptoms into diagnostic information that includes representative belief and plausibility levels. The implementation at *Ternak Hasbuan Kebun IV* in Kotabumi demonstrated that the system can be effectively applied in real field conditions (Siregar et al., 2021)., achieving an accuracy rate of over 85 percent compared to veterinary expert diagnoses. These findings confirm that the system is not only theoretically valid but also practically applicable for farmers. Furthermore, the system provides tangible benefits by accelerating disease identification, offering initial treatment recommendations, and storing diagnosis histories for poultry health monitoring. The major contribution of this research lies in developing an expert system that does not focus solely on a single poultry species but can diagnose both chickens and ducks within one accessible web-based platform (Ahsanuddin et al., 2024; Siahaan, 2021). Although the research results show significant achievements, several aspects remain open for further development. The system should be expanded by incorporating additional disease types and enriching the knowledge base to produce more comprehensive diagnostic outcomes.

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