Generative AI and Design Thinking for Lumpy Skin Disease Prediction using Machine Learning

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Abstract. The Capripox virus is responsible for the Lumpy Skin Disease (LSD) that infects cattle and is transmitted by biting insects such as flies and mosquitoes. It creates skin nodules, fever and a general feeling of malaise that has a significant impact on the health and productivity of livestock. The illness leads to breeding issues, poor quality meat and reduced milking for the cattle, and in the most extreme cases, fatalities among humans, leading to substantial financial damages in cattle-raising regions. It is in fact difficult to control LSD due to its" propensity for spreading rapidly and dependence on classical diagnosing methods such as clinical observation and symptom evaluation. These procedures can be inaccurate, however, because LSD symptoms can mimic those of other cattle diseases, causing delays in the administration of treatment. In this study, an AI-based diagnostic system employing image classification and ML is suggested to address these challenges. Based on a multi-modal database integrating the clinical features (e.g., fever and the size of lesions) and the images of affected skin regions, the system automatically and standardly diagnoses the disease. Early and accurate diagnosis not only prevents misdiagnosis and halts the spread of the disease, but also strengthens intervention capacity. Diminished economic losses, enhanced animal health and long-term industry sustainability are all conceivable future benefits of how this new approach could revolutionize LSD and other livestock diseases control.

Keywords: Capripox virus, Cattle health, Skin nodules, Fever, Economic losses, Livestock productivity, AI-enhanced diagnostic system, Clinical features, Early detection, Disease management.

1 Introduction

The Capripox virus is the cause of the infectious viral disease Lumpy Skin Disease (LSD), which has a significant impact on the health and performance of animals worldwide. The disease is spread by gnawing insects like mosquitoes and flies, and episodes are influenced by environmental factors. It is characterized by skin knobs, fever, and decreased milk yields. While the death rate is low, LSD causes huge monetary misfortunes through diminished efficiency, high veterinary expenses, and disturbed supply chains, especially in asset inrestricted settings. Conventional demonstrative techniques, such as clinical perception and PCR testing, are tedious, costly, and prone to mistakes. To improve early detection and symptomatic precision,

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this task proposes a simulated intelligence-fueled indicative framework that coordinates AI and picture grouping. The framework uses clinical data and injury images to make quick, solid decisions that reduce the use of pesticides and improve natural manageability. This novel approach, which is adaptable, adaptable, and simple to comprehend, aims to alleviate the effects of LSD, safeguard animal well-being and backcountry economies, and serve as a model for treating other animals' illnesses with computer-based intelligence.

In rural areas, traditional analytical methods like clinical perception and PCR testing take a long time, cost a lot of money, and are often far away, which delays analysis and mediation even more. This project proposes a creative AI-driven demonstrative arrangement to improve indicative exactness, speed, and openness. It combines AI (ML) and picture grouping. The framework employs a hybrid approach in which convolutional neural networks (CNNs) process images of skin lesions to identify LSD-specific visual side effects while ML models examine clinical data such as fever and injury patterns. Together, these components provide a double-layered examination that focuses on the reliability and accuracy of conclusions.

A computer-based generative AI model that integrates symptomatic findings in a detailed report is part of the solution. The latter includes important items such as Risk Factors for LSD, possible etiologies (probable explanations), and proposed control measures. Such a detailed survey can help veterinarians and owners to take decisions based on practical information and thus help to restrict the spread of disease and economic losses. The approach is extendable and easy to apply. It is portable, easy to operate, and can be suitable for multiple applications, including resource-limited settings.

In limiting the pesticide application used for vector control, the simulated intelligence tool also ensures supportability, preserving the biodiversity and curtailing natural decay. The flexibility of this model ensures that the model evolves with emergence of disease patterns, maintaining its relevance in the long run. Beyond LSD, this project showcases the revolutionary potential of simulated intelligence in veterinary medicine by offering a flexible model that can be used to treat diseases in other domesticated animals. This programme addresses a major development in horticultural diversity and global food supply through enhanced animal welfare, economic viability and sustainable practices.

2 Related works

This [1] investigated an explainable AI (XAI)-improved ML model for KED diagnosis in cattle. “I was super keen to see how SHAP values and LIME would actually feed into that explanation of how variables are having an effect on the result, which would make veterinarians and farmers have more trust.” This process is effective in providing data driven predictions, while simushing the necessity for early detection in agro-environment sectors. ML Models [2] used decision trees, support vector machines (SVMs) and neural networks to predict LSD outbreaks from environmental and demographic information. The performance comparison of models contributes to the knowledge for choosing the methods appropriate for precise disease predictions, thus aiding in proactive disease control and the sustainable management of animal livestock.

Deep Learning [3], proposed a hybrid automatic diagnostic structure merging clinical and image data using deep learning feature fusion. The system enhanced sensitivity and specificity for LSD snd reduced human mistakes. This scalable strategy can potentially improve early detection in resource-poor settings with the potential for substantial on-farm benefits to livestock management. Deep Learning for Image• [4] used CNNs and RNNs to automatically detect LSD symptoms from cattle images. Deep learning models had better accuracy in this study, suggesting that they are a feasible method for farmers in fields to achieve faster and more accurate diagnosis in agricultural and health sectors.

ML [5], a paper on automated classification of LSD using Decision trees and SVMs based on structured clinical data. This strategy allowed for early detection of infected casts before the onset of lesions visible to the naked eye, would minimize spread of infection to non-infected casts, and would help reduce economic losses in areas with limited resources. Available Diagnostic [6] have been used machine learning models such as random forests and SVM for the creation of a diagnostic and portableset instrument for LSD. Based on clinical data analysis, the research probed into the low-cost and high-accuracy diagnostics and has consent in the treatment, because farmers in remote area cannot treatment in timely.

Model Comparison [7], evaluated random forests, gradient boosting, and neural networks for LSD prediction, highlighting ensemble methods for their superior diagnostic accuracy. The study advocated integrating ML models into mobile applications for real-time monitoring, enhancing disease management strategies. Ensemble Learning [8] analyzed ensemble techniques like random forests and gradient boosting to predict LSD. These methods improved diagnostic accuracy, supporting robust and accessible diagnostic tools critical for early intervention and disease management.

Capsule Networks [9] employed capsule networks with hyperparameter optimization to detect LSD from skin images. CapsNets preserved spatial hierarchies, offering nuanced image analysis for accurate visual diagnostics, particularly in subtle or localized symptom scenarios. Advanced CNN Framework [10] proposed a CNN-based model for detecting LSD lesions from cattle images. The approach emphasized high-precision classification, differentiating LSD from other skin conditions, and making it suitable for field applications.

IoT Integration [11] combined ML with IoT to monitor LSD outbreaks in real time. The system analyzed clinical and environmental data, offering a proactive, automated solution for livestock health management, particularly in areas with limited veterinary resources. Deep Learning [12] reviewed CNNs and transfer learning for cattle breed identification and disease diagnosis, including LSD. The study highlighted challenges like dataset quality while showcasing deep learning's potential to automate veterinary diagnostics and improve livestock health monitoring.

3 Proposed System

The proposed system employs a hybrid AI-driven strategy with Generative AI as a key component to enhance the accessibility and accuracy of cattle diagnosis of LSD. In addition to overcoming conventional limitations, this generative strategy improves interpretability and provides users with useful insights for effective disease management. In order to assist users in making medical assessments or decisions based on images and clinical data, this appears to be a high-level architecture for a clinical decision support system that integrates ML (ML), convolutional neural networks (CNN), and a large language model (LLM).

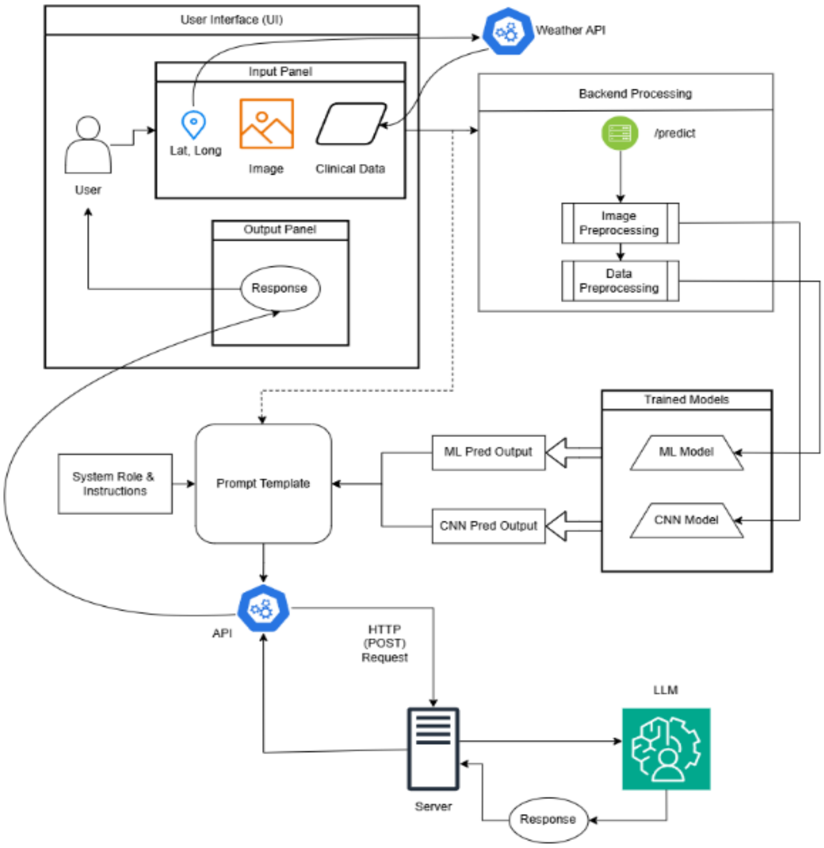

Fig. 1. Architecture Diagram of LSD Prediction.

Fig 1 shows the architecture diagram of LSD prediction. Evaluation of the system appears on the Output Panel, and the clinician can input images, and clinical data into the Input Panel. Backend Processing images are prepared for the CNN using normalization and feature extraction, and the clinical data are similarly prepared for the ML model. AI model Trained ML model to process strucured clincal data and predict risks, CNN to spot patterns or abnormalities in the image data. By initiating a request to the LLM and getting a response back, the API enables communication. Attempting to first shape user input as a prompt to the LLM, and along with it, its response in the user interface, ML/CNN models process the said input. This method not only make use of ML, CNN, LLM, but also integrate them to support the clinicians in the decision-making process.

Lumpy Skin Disease (LSD) is a viral disease affecting cattle; it is caused by the Lumpy Skin Disease Virus (LSDV), which is a member of the Capripox virus genus. To build a complete system or platform to make the process of Lumpy Skin Disease manageable very few blocks are incorporated such as Data collection, Data pre-processing, Feature extraction, Model Training, Evaluation, and performance measures. Fig 2 shows the gradio interface.

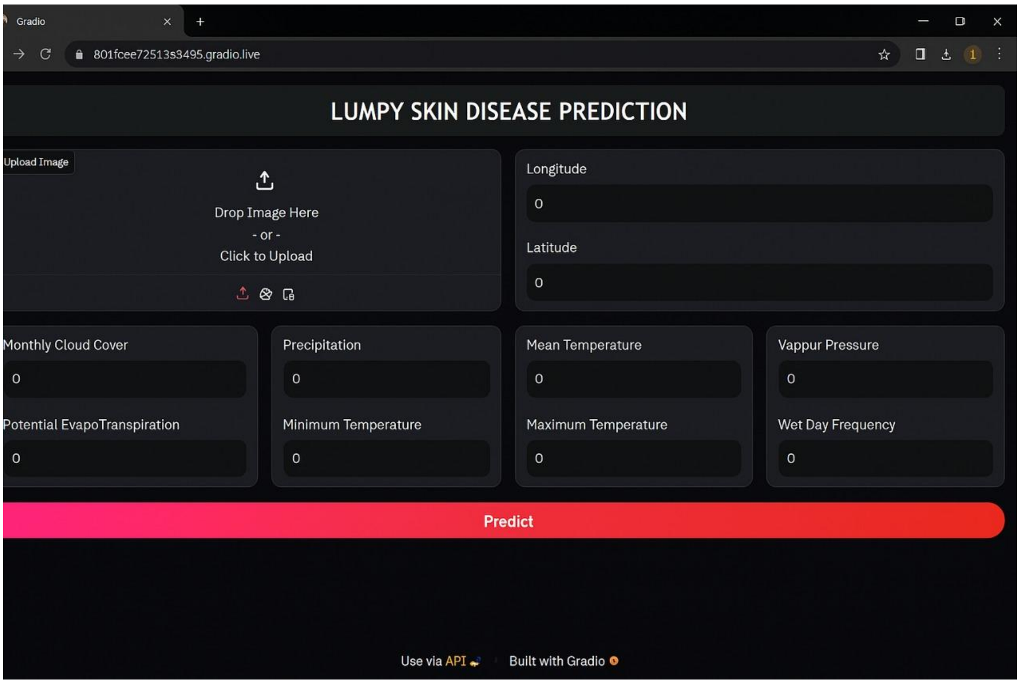

Fig. 2. Gradio – LSD Prediction.

Through these 10 features, the model learns to understand environmental and geographical metrics that are linked to LSD outbreaks and can make accurate and site-specific predictions. This well-defined set of features will help accelerate the identification of important patterns in model, and thus support robust and good diagnostics of disease.

The model training of the system is combined between the use of classical ML models and a CNN for enhanced Lumpy Skin Disease (LSD) diagnostics. The ML models are trained on tabulated clinical and environmental data and the CNN model is trained on images of bovine skin to differentiate between LSD-infected and intact skin.

Advantages

- Enables early detection and intervention to control outbreaks.
- Minimizes economic losses by reducing productivity declines and veterinary costs.
- Improves animal health through timely preventive measures.
- Ensures food security by maintaining livestock product supply.
- Optimizes resource allocation for efficient disease management.

4 Results and Evaluation

A computer-based diagnostic system that uses AI to identify the early stages of Lumpy Skin Disease (LSD) in cattle is a major step in the fight against the only disease that is still an epidemic in Israel and can cause a drop of up to 20% in milk yield. This system utilizing multi-modal AI approach developed in Phase 1 integrates data from medical images, physiological metrics and blood test results to classify the status of vital organs as normal or abnormal, which may help in early detection of signatures of LSD. The AI model had good performance in identifying subtle abnormalities of the organs which are possible early LSDs. Through the combination of information from multiple different sources (e.g., picture data extracted by a convolutional neural network; CNN) and processed structured data information analyzed by other discrimination machine learning models, such as Random Forest, the system obtained good diagnostic reliability. Early detection is important for LSD, as it allows veterinarians to apply quarantine measures and commence treatment before the disease becomes widespread, thereby reducing economic losses and improving control of animal health.

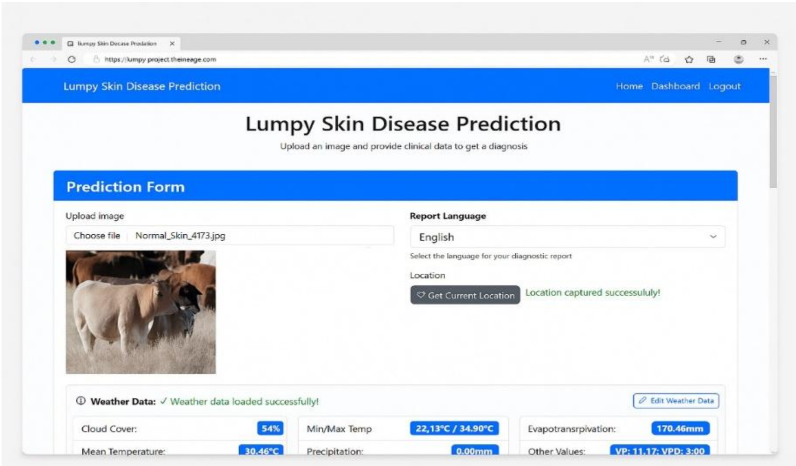

Fig. 3. Result of LSD Prediction.

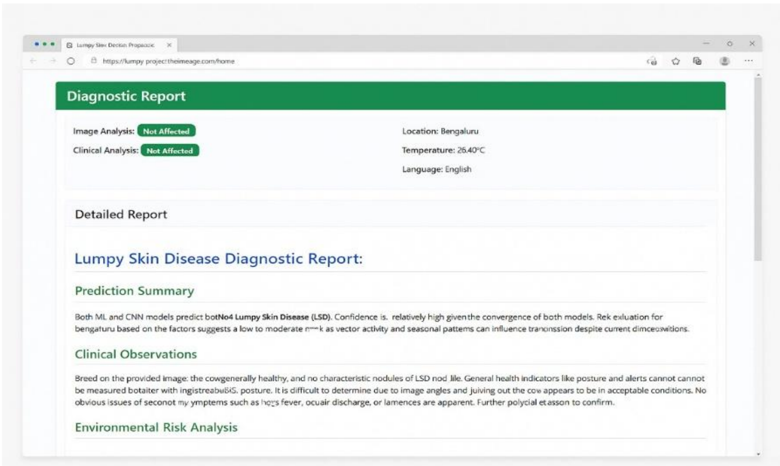

Fig. 4. Predicted and Analysis Disease.

Fig 3 and fig 4 shows the result of LSD prediction and Prediction and analysis disease respectively.

5 Conclusion

The creation of the diagnostic system for Lumpy Skin Disease (LSD) in Cattle is a groundbreaking application of artificial and ML technologies in veterinary medicine. Through incorporating state-of-the-art ML methodologies including Random Forest for structured clinical and environmental data, and Convolutional Neural Networks (CNN) using MobileNetV2 architecture for image processing, the system serves as an effective and accurate tool to detecting LSD in cattle. The system's capability to work with structured clinical data alongside unstructured image data, facilitates a multimodal approach to diagnosis, particularly valuable in a disease such as LSD, where clinical signs might not be immediately apparent visually or appear uniformly amongst animals. The Random Forest model, which used clinical and environmental data as input, was found to have high accuracy to characterize patterns of the disease, while the CNN distinguished healthy animals from animals infected by LSD based on the skin lesions and other visual indicators. In conclusion, this diagnostic system is a big step forward in AI and ML for veterinary diagnosis. It's integrated LSD testing system, along with its simplicity of use, traceable results, and secure databasing, makes it broadly applicable and easily modified to suit different field situations. Introduced on small farms and large-scale industrialized livestock operations, the platform also provides a dependable, easy and fast way to diagnose LSD that supports management of the disease and animal well-being in general.

Although the existing system is a valuable tool to diagnose LSD, an improvement can still be made. Future works may entail to refine the CNN model such as unfreezing specific layers or introducing the latest architectures to enhance the detection result. Use of real-time data from external sources, such as weather and vector activity, would further increase hunt predictions with context information. By scaling the system to mobile devices that can capture images using the IoT, the veterinarians and farmers could receive diagnostics in live, also in the middle of nowhere. Additionally, the addition of generative AI in order to generate in-depth and easy to understand reports would improve user experience, which would make the tool more user-friendly for non-experts. Lastly, the system could be extended to new cattle related diseases which share similar symptoms, further expanding its applicability in cattle health management.

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