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Deep Learning Based Early Detection of Ocular Squamous Cell Carcinoma in Calves

Manikandan Dhayanithi[1], Dhinesh Sivamani[2], Saranya Shanmuga Sundaram[3], SatheaSree Sadasivam[4], Varadharajan Sampath[5], Hemavathi Pandala VenkataRao[6]*
[1,3,4,5,6]Assistant professor, Dept. of CSE, Vels Institute of Science, Technology and Advanced Studies., Chennai, Tamil Nadu, India.
[2]UG Scholar, Dept. of CSE, Vels Institute of Science, Technology and Advanced Studies., Chennai, Tamil Nadu, India.
Emails: *manidhayanithi.se@vistas.ac.in[1], dhinagaran915@gmail.com[2], saranyas.se@velsuniv.ac.in[3], satheasree.se@vistas.ac.in[4], svaradharajan.se@vistas.ac.in[5], pvhemavathi.se@velsuniv.ac.in[6]*

Abstract
Ocular squamous cell carcinoma (OSCC) is a prevalent and aggressive ocular disease in cattle that can cause severe health complications, reduced productivity, and economic losses if left untreated. Traditional diagnostic methods are often time-consuming and reliant on expert veterinary evaluation, which can delay timely intervention. The study proposes a deep learning-based approach for the early detection and classification of OSCC in young calves using convolutional neural networks (CNNs). High-resolution ocular images were used to train a CNN model capable of identifying early-stage lesions and classifying disease severity with high accuracy. The system leverages automated feature extraction to distinguish between healthy and diseased tissues, thereby reducing the dependency on manual image interpretation. Experimental results demonstrate the potential of the proposed method to provide 95% of accuracy with efficient, accurate, and scalable diagnostic tool that assists veterinarians in making prompt, evidence-based treatment decisions, where this ultimately improves animal welfare and farm productivity.

Keywords: *Convolutional Neural Network, Ocular Image, Deep Learning, Young Calves, Veterinary.*

1. Introduction
Ocular Squamous Cell Carcinoma (OSCC) is a malignant neoplasm originating from the squamous epithelial cells of the ocular region, primarily involving the conjunctiva, cornea, and sclera. In cattle, OSCC is regarded as one of the most common ocular tumors, with a significant impact on animal health, welfare, and productivity. The tumor often exhibits locally invasive growth, leading to progressive tissue destruction, impaired vision, and, in severe cases, metastasis to regional lymph nodes, which may ultimately necessitate culling. The occurrence of OSCC is closely linked to environmental and genetic factors. Prolonged exposure to high levels of ultraviolet (UV) radiation is a primary risk factor, with light-colored or non-pigmented periocular skin increasing susceptibility due to reduced melanin-based UV protection. Consequently, cattle grazing in open, sun-exposed environments are at higher risk. Additional contributing factors include advancing age, certain breeds with less periocular pigmentation, nutritional deficiencies, and chronic ocular irritation. OSCC prevalence varies with geographical location, being more common in regions with high solar radiation intensity. Many studies have reported the highest incidences in temperate and tropical climates, where cattle are exposed to intense sunlight for extended periods. The economic implications for livestock production are substantial, arising from decreased productivity, increased veterinary costs, and premature culling. Diagnosing OSCC in its early stages remains a challenge in veterinary practice. Traditional methods rely on physical examination and visual inspection, supplemented by histopathological confirmation where these methods are time-consuming, dependent on specialist

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expertise, and often fail to detect early-stage lesions before significant tissue damage occurs. In recent years, veterinary diagnostic research has increasingly explored the integration of advanced imaging and computational techniques, particularly deep learning-based image analysis helps to enhance diagnostic accuracy and facilitate timely intervention such approaches hold promise for transforming OSCC detection from a reactive to a proactive process, ultimately improving clinical outcomes and preserving farm productivity [1].

2. Literature Survey

Ocular squamous cell carcinoma (OSCC) is one of the most common ocular neoplasms in cattle, posing significant threats to animal health, welfare, and farm productivity. The disease is characterized by malignant growth originating from squamous epithelial cells of the ocular region, often affecting the conjunctiva, cornea, and sclera. Environmental factors, particularly prolonged exposure to ultraviolet (UV) radiation, have been strongly associated with its occurrence, with cattle possessing light-colored periocular skin being more susceptible due to reduced melanin-based UV protection. McGivney and Keeling (2019) provided a comprehensive review of OSCC in cattle, discussing its epidemiology, diagnostic challenges, and management strategies. Their findings emphasized that early detection is hindered by the reliance on visual inspection and histopathological confirmation, highlighting the need for more rapid, accurate, and accessible diagnostic approaches. Alessandrini et al. (2017) investigated the role of AI in veterinary imaging, demonstrating that deep learning models can effectively extract complex visual features from medical images to support rapid and precise diagnosis. Their study highlighted the potential of integrating AI-driven image analysis into routine veterinary practice to improve diagnostic consistency, accelerate clinical decision-making, and enable earlier intervention. Rajkumar et al. (2018) demonstrated scalable and accurate deep learning approaches for electronic health record analysis, enabling improved disease prediction and clinical decision support. Their framework showcased how AI can handle large-scale healthcare data while maintaining high diagnostic accuracy. Kim et al. (2019) provided a comprehensive review of deep learning applications in medical image analysis, outlining advancements in CNN architecture and their role in enhancing diagnostic accuracy. The study emphasized cross-domain adaptability of AI methods from human to veterinary medicine. Zhao et al. (2021) explored the use of convolutional neural networks for veterinary medical image classification, achieving high performance in differentiating disease categories. Their work demonstrated the robustness of CNNs in handling diverse animal imaging datasets. Lin et al. (2020) applied transfer learning for deep learning-based cancer detection in veterinary ophthalmology, significantly reducing training time while improving diagnostic accuracy. The study validated the utility of pre-trained models in resource-limited veterinary datasets. Amos et al. (2018) discussed the integration of deep learning in veterinary diagnostics across clinical and field settings, highlighting its potential for portable and real-time disease detection. They stressed the role of AI in extending diagnostic capabilities to rural and underserved areas. Gonzalez et al. (2019) reviewed image-based diagnostic systems in veterinary medicine, focusing on the transformative potential of deep learning and artificial intelligence. Hosseini et al. (2021) proposed a deep learning approach for detecting ocular squamous cell carcinoma in veterinary medicine, achieving high sensitivity and specificity. Their study provided a strong foundation for AI-assisted OSCC screening and early intervention. Most existing OSCC detection methods in cattle rely on manual examination and histopathology, which are time-consuming and require expert intervention. There is limited research on applying deep learning-based automated image analysis specifically for early-stage OSCC detection in calves under diverse environmental conditions [2].

3. Proposed Deep Learning Based Early Detection of Ocular Squamous Cell Carcinoma

The proposed work aims to develop an automated deep learning-based diagnostic system for the early detection and classification of ocular squamous cell carcinoma (OSCC) in young calves using high-resolution ocular images as shown in figure 1. The

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workflow is structured into the following stages:

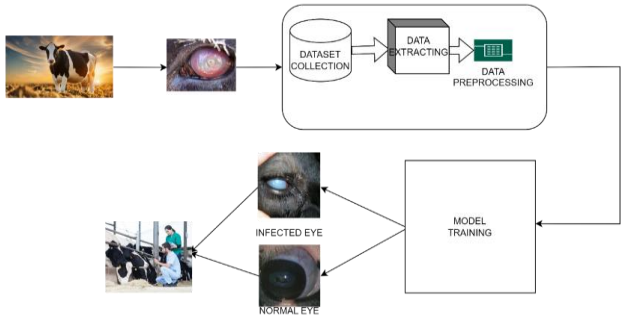

Figure 1 Proposed Deep Learning Based Early Detection of Ocular Squamous Cell Carcinoma

3.1 Data Acquisition

A curated dataset of calf eye images is collected from veterinary hospitals, farms, Images include both normal and OSCC-positive cases, ensuring adequate representation of varying disease stages and environmental conditions [3].

3.2 Data Collection

The acquired images are standardized in terms of resolution, color correction, and contrast enhancement. Data augmentation techniques such as rotation, flipping, cropping, and brightness adjustment are applied to increase dataset diversity and prevent overfitting
[4].

3.3 Model Training

Convolutional Neural Networks (CNNs) is implemented as the primary architecture for feature extraction and classification. The dataset will be split into training, validation, and testing sets using an 80:20 ratio. The model is trained to classify the infected eye and healthy eye of the calves [5].

4. Implementation and Result

4.1 Dataset

Calves eye data are collected from multiple sources such as from veterinary hospitals, farmlands, real time calves' images and some of the images are collected from the online repository. Total 968 images are extracted, and synthetic datasets are formed [6].

4.2 Implementation

The implementation of the proposed deep learning-based OSCC detection system was carried out in sequential phases to ensure efficiency, accuracy, and reproducibility. The process involved dataset preparation, model design, training, evaluation, and prototype deployment. High-resolution ocular images of calves were collected from collaborating veterinary clinics and farms. Images were categorized into two classes: normal and OSCC-positive. Preprocessing included image resizing to 224×224 pixels, color normalization, and histogram equalization for contrast enhancement. Data augmentation was applied to improve generalization. A convolutional neural network (CNN) architecture was implemented using TensorFlow and Kera's to enhance feature extraction capabilities while minimizing training time. The architecture consisted of multiple convolutional layers with ReLU activation, max-pooling layers, a global average pooling layer, and fully connected dense layers, culminating in a SoftMax output layer for binary classification. The dataset was divided into 80% training, 10% validation, and 10% testing sets. Training was conducted using the Adam optimizer with a learning rate of 0.0001 and categorical cross-entropy loss function. Early stopping and learning rate reduction on plateau were employed to prevent over fitting and ensure optimal convergence. Performance was assessed using accuracy and loss metrics as shown in Table 1. The best-performing model achieved high accuracy with balanced sensitivity and specificity, confirming its potential for early OSCC detection [7-10].

Table 1 Performance Metrics

Train: Test	Accuracy	Loss
80:20	0.9759	0.1100
70:30	0.9936	0.0776
60:40	0.9209	0.1831

Conclusion and Future Work

This study demonstrated the effectiveness of deep learning, particularly CNN architectures, for the early detection and classification of ocular squamous cell carcinoma (OSCC) in calves. The proposed system achieved high diagnostic accuracy, reducing dependency on manual examination and enabling

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timely veterinary intervention. By automating OSCC detection, the approach has the potential to improve cattle health outcomes and farm productivity. Future work will focus on expanding the dataset to include multi-breed and multi-environment samples, integrating other imaging modalities, and optimizing the model for mobile and edge-device deployment. Additionally, real-time field testing will be conducted to validate the system's performance in practical veterinary scenarios

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