SCIENTIFIC INNOVATION IN AGRICULTURE: IMAGE PROCESSING FOR LIVESTOCK MANAGEMENT AND EMPOWERING INDIAN YOUTH FOR GLOBAL LEADERSHIP IN VIKSIT BHARAT

Tarun Kumar*, Pranaw Kumar Tripathi
Division of Extension Education and Division of Livestock Production and Management
Indian Veterinary Research Institute, Izzatnagar,
Bareilly-243122, Uttar Pradesh, India
*Corresponding author email: *k.tarunmailme@gmail.com*
DOI: https://doi.org/10.5281/zenodo.14998382

ABSTRACT

Modern livestock management relies heavily on image processing, which allows for advances in body weight prediction, breed recognition, and individual animal identification. It entails transferring visual data to a digital format for analysis, using techniques such as picture thresholding, segmentation, and feature extraction. The technique uses a variety of picture formats, including binary, grayscale, depth, RGB, and infrared. Body condition grading, breed categorization, and early illness diagnosis are among the most important uses. Recent research have shown that 3D cameras and convolutional neural networks (CNNs) can accurately identify breeds and estimate physical condition in animals. While image processing has various advantages, including less labor and improved decision-making, difficulties remain, such as high starting costs, reliance on high-quality photos, and technological complexity. To reach its full potential, further research, training, and scalable solutions are required. By tackling these difficulties, image processing has the potential to significantly enhance sustainable livestock management techniques, resulting in more efficient, data-driven agricultural systems.

Keywords: Image processing, livestock management, breed recognition, body weight prediction, convolutional neural networks, sustainable farming

INTRODUCTION

Image processing is concerned with acquiring and converting a visual input into a digital picture. It may be defined as the study of the process of acquiring a visual signal of the world and changing it into an interpretable form (Fernandes *et al,* 2020). It ranges from the study of image generation, which results from the capture of light signals by specially constructed sensors, to the interpretation of the image as an array of linked values. Digital image processing includes the production, design, development, and improvement of digital imaging algorithms and applications. The term can also refer to the applications or techniques used for digital image manipulation, such as noise reduction, image equalization, image filtering, and other transformations used to prepare images for the next steps in an analysis pipeline or to upgrade images aesthetically.

Digital image analysis, often known as digital imaging, is the process of extracting useful information from photographs. Examples include descriptive statistics such as color and brightness histograms, block statistics from specific locations, and the identification of complicated structures. This collected data is used as input for a variety of image processing techniques, including sharpening, thresholding, smoothing, and edge enhancement, which can be performed prior to analysis. Computer Vision, a science concerned with understanding and rebuilding the world through pictures, employs image processing and analysis techniques to create artificial systems capable of solving visual issues. This field is closely related to Machine Learning and Pattern Recognition since it seeks to define features such as forms, textures, densities, and distances from photographs. In digital image generation, luminous impulses acquired by sensors are coded and saved as numerical values in organized data arrays, which may be altered using computational techniques, allowing computers to interpret pictures as codified light and color information for each location.

TYPES OF IMAGES

I. Binary Images: Binary images are a specific category of raster images that consist solely of two colors, typically black and white. Each pixel in a binary image is represented by a single bit, with one value (usually black) denoting one color and the other value (usually white) representing the second color.
II. Grayscale Images: Grayscale images are a type of raster image that features a range of gray shades, from black to white. Unlike binary images, which are limited to two colors, grayscale images encompass multiple shades, providing enhanced detail and depth.
III. Depth Images: Depth images are specialized images that depict the distance of surfaces from a specific viewpoint, capturing the three-dimensional structure of a scene. Each pixel in a depth image typically contains a value that indicates the distance from the camera to the object at that pixel, rather than conveying color or intensity.
IV. RGB Images: RGB images are a form of color image that utilizes the RGB color model, which stands for Red, Green, and Blue. In this model, colors are produced by blending different intensities of these three primary colors.
V. Infrared Images: Infrared images are obtained using infrared radiation, which lies outside the visible light spectrum. These images provide information that is not perceivable to the human eye, making them useful in various applications.

STEPS INVOLVED IN IMAGE PROCESSING

I. Image Acquisition: Capturing an image using a digital camera or scanner, or importing an existing image.
II. Image Augmentation: Generating new variations of images from an existing dataset to enhance diversity.
III. Image thresholding and binarization: Converting a grayscale or RGB image into a binary image to separate the foreground from the background.
IV. Image Analysis: Processing an image to extract meaningful information, including shape identification, edge detection, noise reduction, object counting, and texture analysis.
V. Image Segmentation: Dividing an image into multiple regions based on pixel characteristics.
VI. Feature Extraction: Transforming raw image data into numerical features while preserving essential information.
VII. Data Analysis: Converting visual information from images into analysable data, involving normalization, model fitting, validation and tuning, and prediction

APPLICATIONS OF IMAGE PROCESSING

I. Body weight & BCS prediction
II. Breed Recognition & Classification
III. Analysis of morphological traits

IV. Individual animal Identification
V. Feed Intake Measurement
VI. Early Lameness Prediction

SOME OF THE STUDIES USING IMAGE PROCESSING

I. **Estimating body weight & body condition score using 3D cameras in cattle (Martins *et al*., Brazil,2020)-**Martins *et al*. from Brazil (2020) investigated the use of 3D cameras to measure body weight (BW) and body condition score (BCS) in Holstein heifers and nursing cows. Over the course of five months, the researchers utilized a Microsoft Kinect 3D camera to record photos from both the lateral and dorsal views of 28 cows and 27 heifers. The study sought to identify the most effective sensor position and evaluate the system's sensitivity over time. The researchers used MATLAB software to analyze the photos and create predictive models for BW and BCS. The BW prediction models demonstrated high correlations, with R^2 values of 0.89 and 0.96 for lateral and dorsal views, respectively. Body weight, height, and volume were among the key measurements. BCS models had R^2 values of 0.63 and 0.61, suggesting potential for improvement. Overall, the findings indicate that 3D cameras have considerable economic potential in livestock management, particularly for calculating body weight, however additional refining is required to appropriately estimate body condition.

II. ***Identifying Similar Dairy Cattle Breeds Using Image Processing and CNNs-*** A recent study by Warhade *et al*. (2024) highlights the importance of accurate breed identification in dairy cattle for better herd management and genetic improvement. The researchers developed a convolutional neural network (CNN) model to distinguish between Sahiwal and Red Sindhi cows, which can look quite similar. To enhance classification accuracy, the team first segmented the cows from their backgrounds using the CNN model. This process created masked images that retained only the cows' pixels. They trained the model on four different views of each cow: front, side, grayscale front, and grayscale side. The segmentation model achieved impressive results, with an intersection-over-union (IoU) of 81.75% and an F1-score of 85.26%, processing images in just 296 milliseconds. For classification, various MobileNet and EfficientNet models were employed. The MobileNet model achieved 80% accuracy for both breeds, while its advanced versions, MobileNetV2 and V3, reached 82%. However, the EfficientNet models outperformed them, achieving accuracy between 84% and 86%, with F1-scores above 83%. These results indicate that CNNs can effectively classify dairy cattle breeds, helping farmers enhance herd productivity.

III. **Identifying Goat Breeds Using CNN Technology-** In a study by Mandal *et al*. (2020), researchers aimed to identify individual goat breeds through image analysis using the Inception v3 convolutional neural network (CNN). They collected over 500 digital images of six purebred goat varieties—Blackbengal, Beetal, Jamunapari, Barbari, Jakhrana, and Sirohi—captured in both controlled and natural environments to minimize stress on the animals. To train and test the model, 10% of the images were set aside for evaluation. The CNN successfully identified the breed of 56 out of 60 test images, achieving an impressive accuracy rate of 93.33%. A probability score of 0.95 or higher was established as the threshold for confirming breed identity, while scores below this indicated uncertainty. The model struggled with images from breeds it had not been trained on, highlighting its specificity. Overall, this technique shows great promise for resolving breed identification challenges in goats, offering farmers a reliable tool for managing their herds more effectively.

WAY FORWARD

Image processing is revolutionizing livestock management, driving us towards a VIKSIT Bharat. Crucial to this is effective feature extraction, a complex yet vital step. With individual identification models achieving accuracies up to ~99%, and the prevalence of CNN models like DenseNet, MobileNet, and EfficientNet, the technological foundation is strong. To progress, we must:

- Invest in R&D: Focus on refining algorithms for diverse conditions and integrating systems.
- Empower Youth: Provide accessible training and resources to foster innovation.
- Address Costs: Explore subsidies and scalable solutions for wider adoption.
- Data Management: Further develop systems that can manage the large amounts of data that are produced by these image processing systems.

By prioritizing these areas, India can harness image processing to achieve global leadership in sustainable livestock practices, contributing to a technologically advanced and prosperous nation.

ADVANTAGES AND DISADVANTAGES OF IMAGE PROCESSING

Advantage	**Disadvantage**
Reduces labor requirements	High Initial Costs
Eases management	Technical Complexity & Data Management Challenges
Eases monitoring	Dependency on good quality images
Reduction of manpower dependency	Dependence on Consistent Environmental Conditions, otherwise error will high
Supporting tool for decision-making	Dependency on Power and Connectivity

REFERENCES

Fernandes, A. F. A., Dórea, J. R. R., & Rosa, G. J. D. M. (2020). Image analysis and computer vision applications in animal sciences: an overview. *Frontiers in Veterinary Science*, *7*, 551269.

Martins, B. M., Mendes, A. L. C., Silva, L. F., Moreira, T. R., Costa, J. H. C., Rotta, P. P., & Marcondes, M. I. (2020). Estimating body weight, body condition score, and type traits in dairy cows using three dimensional cameras and manual body measurements. *Livestock science*, *236*, 104054.

Mandal, S. N., Dan, S., Ghosh, P., Musta, S., Roy, K., Mukherjee, K., ... & Banik, S. (2019). IDENTIFICATION OF GOAT BREEDS BY DIGITAL IMAGE USING CONVOLUTION NEURAL NETWORK. *Reason*, *3*, 42-74

Warhade, R., Devi, I., Singh, N., Arya, S., Dudi, K., Lathwal, S. S., & Tomar, D. S. (2024). Attention module incorporated transfer learning empowered deep learning-based models for classification of phenotypically similar tropical cattle breeds (Bos indicus). *Tropical Animal Health and Production*, *56*(6), 192

Cite this article:

Tarun Kumar*, Pranaw Kumar Tripathi. (2025). Scientific innovation in agriculture: image processing for livestock management and empowering Indian youth for global leadership in Viksit Bharat. Vet Farm Frontier, 02(02), 30–33. https://doi.org/10.5281/zenodo.14998382.