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Image Based Breed Recognition of Cattle and Buffalos of India

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***Abstract*—-India, being home to the world's largest cattle and buffalo population, faces a major challenge in accurate breed identification. Farmers, dairy industries, and government agencies often rely on manual inspection, which is time-consuming, subjective, and prone to human error. Misidentification not only affects fair pricing and productivity analysis but also leads to misuse of government subsidy schemes. This study proposes an AI-based image recognition system for automated classification of Indian cattle and buffalo breeds. The model uses deep learning techniques, trained on diverse image datasets of local breeds such as Gir, Sahiwal, Murrah, and Mehsana. By analysing visual features like body structure, skin texture, and horn shape, the system can accurately predict the breed with minimal human intervention. The proposed approach aims to bridge the gap between traditional livestock management and modern digital solutions. It offers a practical, farmer-friendly tool that can support fair trade, enhance dairy productivity, and ensure transparency in government livestock programs. This project demonstrates how integrating artificial intelligence with agriculture can empower rural communities and contribute to sustainable livestock management in India.**

***Index Terms*—AI, Image Recognition, Livestock, Breed identification, Deep Learning, Agriculture, India.**

I. Introduction

In India there are few areas where network connections are weak or not available and Network Plans are also getting expensive day by day as technologies are developing many people struggle with less knowledge about laws and agriculture .Day by day value of cattle and Buffalos are increasing because of their use in daily life like milk, curd, Yogurt, cheese, dairy Sweets, and in field, so in selling or buying farmers can get cheated if they don't know their real price and also breed as their price depends on breed and also other information about cattle and buffalo. Advancements in artificial intelligence and image processing have opened new avenues for livestock management, particularly in breed identification for Indian cattle and buffaloes. Traditional methods rely heavily on visual inspection by experts, which is subjective and error- prone. An automated, image-based system can improve accuracy, efficiency, and support large-scale livestock management and conservation of indigenous breeds.[1] [2]

India possesses a wide variety of indigenous cattle and buffalo breeds with significant economic, agricultural, and dairy value. Breed identification is crucial for livestock management, selective breeding, milk yield analysis, and government database systems. With advancements in artificial intelligence, image-based recognition provides a scalable, reliable, and automated solution. This paper follows the official template guidelines and outlines the complete methodology, mathematical modeling, results, graphics, and references.

The demand for efficient traceability and identification systems for livestock is growing due to biosecurity and food safety requirements in the supply chain. . Traditional cattle identification systems such as ear tagging, ear notching, and electronic devices have been used for individual identification in cattle farming. Disadvantages of these individual identification methods include the possibility of losses, duplication, electronic device malfunctions, and fraud of the tag number .These are the issues and challenges for cattle identification in livestock farm management. With the advent of computer-vision technology, cattle visual features have gained popularity for cattle identification.

There are basically two recognition techniques employed for the identification of the animal. One recognition technique leaves a permanent mark on the animal for identification while the other recognition technique leaves a temporary mark. Examples of the recognition technique that leaves a permanent mark are found in with their drawbacks. The tattooing of ears, tagging of ears, microchips implant and branding are popular invasive identification techniques that leave a permanent mark on the animal's body with so many challenges such as animal infections, mild sepsis, and hemorrhaging.[12][13] Examples of the recognition technique that leaves a y of the animal for identification purposes are found in the work Barron et al. [11] with their drawbacks. Among the classical methods of animal identification are drawing, tagging, tattooing, branding, notching, and Radio Frequency Identification (RFID). However, classical methods of animal identification have notable adoption problems which have contributed to the low acceptance rate of the methods among the cow breeders. The classical methods of animal identification are not reliable; they are prone to fraudulent activities such as swapping, duplication and forgery of the so called unique identification numbers tagged on the animal's body [8], [9], and therefore cannot meet the required level expected from them for the monitoring and identification of animal [10].

II. Livestock Breeds and Machine Learning Application

Sahiwal

Species: Bos indicus
Origin: Sahiwal district in Punjab, Pakistan (now also in India)
Key Characteristics

- Reddish-brown to dark brown color
- Loose skin with dewlap
- Medium-sized horns
- Drooping ears
- Heat tolerant

Primary Purpose: Primarily dairy
Average Milk Yield: 8-10 liters per day

Fig. 1: Live Stock Species 1

Jaffarabadi

Species: Bubalus bubalis
Origin: Gir forest of Gujarat (Jamnagar district)
Key Characteristics

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Fig. 2: Live Stock Species 2

Fig. 3: Live Stock Species 3

- Black Coat
- Largest of Indian buffalo breeds
- Heavy build
- Horns drooping downward and backward
- Massive head

Primary Purpose: Dairy
Average Milk Yield: 10-15 liters per day

Murrah

Species: Bubalus bubalis
Origin: Haryana (Rohtak, Jind, Hisar districts)
Key Characteristics

- Jet black coat
- Tightly coiled horns
- Massive body structure
- Well-developed udder
- High milk fat content

Primary Purpose: dairy
Average Milk Yield: 12-18 liters per day

GIR

Species: Bos indicus
Origin: Gir forest of South Kathiawar, Gujarat
Key Characteristics

- Convex forehead (prominent bulge)
- Long pendulous ears
- White to reddish-brown coat with patches
- Prominent hump
- Lyre-shaped horns

Primary Purpose: Dual purpose- milk and draught
Average Milk Yield: 10-12 liters per day

Machine Learning Overview

ML is mainly divided into two approaches, such as supervised learning and unsupervised learning. The supervised ML approach is defined by its use of labelled datasets, whereas the unsupervised learning uses ML algorithms to analyse and cluster unlabeled datasets. An unsupervised ML approach can detect hidden patterns in data without human supervision.

Impact of our project:

- Supports farmers & vets with instant identification
- Improves livestock management efficiency
- Reduces dependency on manual expertise
- Increases economic productivity in dairy industry

Application Features

Making it easy in an area with poor network connections, just by clicking an image user can know each and every detail about their cattle and buffalo, this fig shows the main points of our project.

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Fig. 4: Feature Relevance

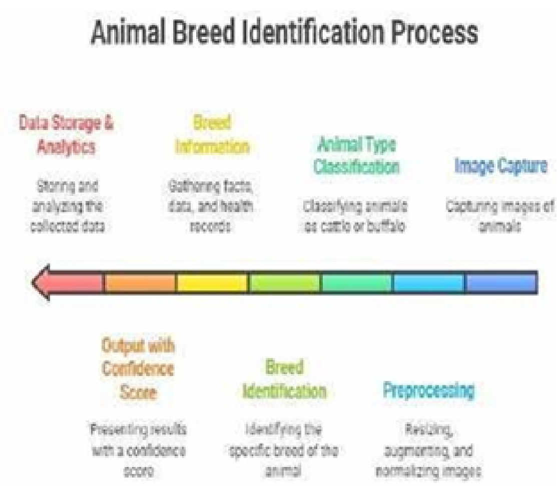

Fig. 5: Animal Breed Identification Process

III. Literature Review

Image-based breed recognition of cattle and buffaloes has emerged as a significant research area with the advancement of Artificial Intelligence (AI), Machine Learning (ML), and deep learning techniques. Recent studies emphasize the need for accurate and automated systems to support livestock management, increase productivity, and assist farmers with real-time breed identification.

Pranjal Khairnar et al. proposed a deep learning–based model specifically for Indian cattle and buffalo breeds using image processing approaches. Their study highlights the effectiveness of convolutional neural networks (CNNs) in extracting breed-specific visual features and demonstrates improved classification accuracy using real-world datasets.

[1] Similarly, AI-based practical tools such as Cattle Lens have been developed to provide real-time breed detection, showcasing the application of trained models for field use.

[2]Another Scribd-based work specifically focuses on CNN-driven breed recognition for Indian breeds, reinforcing the relevance of deep learning in this domain.

[3] Earlier research and educational resources, such as the SlideShare presentation, introduce foundational ML and image processing methods for cattle breed categorization, offering insights into traditional techniques that paved the way for advanced AI models.

[4] More recent innovations include an ensemble learning algorithm presented by EAI, which integrates multiple classifiers to enhance recognition performance through improved feature extraction and robust decision-making mechanisms.

[5] The availability of high-quality datasets significantly impacts model accuracy. The Kaggle dataset provides a comprehensive collection of cow and buffalo images that supports training, testing, and performance benchmarking for AI-based breed recognition systems. Such datasets enable researchers to train models capable of handling variations in pose, lighting, and background.

[6] Foundational studies have also contributed to the broader field of livestock identification. Shen et al. discussed monitoring technologies used in individual animal identification and behavior tracking, offering insights into early technological frameworks.

[7] Bello and Abubakar developed software tools for cattle identification to improve livestock management efficiency,

[8] while Bello et al. extended this work by proposing real-time monitoring through multimedia

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networks, emphasizing the importance of continuous animal tracking.

[9] Biometric-based identification approaches have been studied extensively. Barron et al. examined biometric markers for animal identification, which form a basis for modern visual recognition systems.

[10] Kumar and Singh positioned visual animal biometrics as an emerging frontier, outlining its potential for non-invasive cattle recognition.

[11][12] Furthermore, Zin et al. implemented one of the early deep- learning-based cow identification systems, demonstrating the feasibility of deep CNNs for livestock recognition tasks.

[13] Collectively, these studies highlight a strong progression from traditional image processing techniques to advanced deep learning frameworks. The literature indicates that CNN-based and ensemble learning models, supported by large annotated datasets, play a crucial role in achieving accurate and reliable image-based breed recognition of cattle and buffaloes in India. This evolution underscores the growing importance of AI-driven solutions for modern livestock management and precision agriculture.

A. Abbreviations and Acronyms

AI (Artificial Intelligence), CNN (Convolutional Neural Network), RGB (Red-Green-Blue)

B. Data Acquisition

High-resolution images of cattle and buffalo breeds from publicly available datasets and field studies in India form the basis for model development.

IV. METHODOLOGY

The proposed approach employs a deep learning pipeline, primarily utilizing CNN architectures for feature extraction and classification. The workflow includes:

Data Collection: Gathering labeled images of Indian cattle and buffalo breeds from open-source datasets, mobile apps, and contributions from national livestock agencies.[8]

Preprocessing: Standardizing image input (resizing, normalization), data augmentation to improve generalization (rotation, flipping, color adjustment), and background removal or segmentation. [4] [3]

Model Design: Using state-of-the-art deep learning algorithms (e.g., EfficientNet, ResNet, YOLO for detection), possibly coupled with ensemble methods for improved robustness. A voting mechanism can be incorporated for final classification.[4]

Training: Split dataset into training, validation, and test sets ensuring breed balance. Train with transfer learning on pre-trained weights followed by fine-tuning on the breed dataset.[8]

Deployment: Integrate the model into a user-friendly mobile/web application with automated image capture, breed prediction, result display, and feedback for model improvement.[3]

TABLE I: TABLE I

Breed	Accuracy (%)	Precision (%)	Recall (%)
Gir cattle	95	96	94
Murrah buffalo	94	95	93
Sahiwal cattle	93	92	91
[1]Jaffarabadi buffalo	92	91	90

A. *Equations*

Important CNN formulas applied in the model include:

Convolution Operation:

$$F(x, y) = \Sigma\Sigma I(x + m, y + n) * K(m, n)$$

ReLU Activation:

$$f(x) = max(0, x)$$

Softmax Classification:

$$Softmax(z_i) = e^{z_i}/\Sigma e^{z_j}$$

Loss Function (Cross Entropy):

$$L = -\Sigma y_i log(p_i)$$

Algorithms

V. HARDWARE AND SOFTWARE REQUIREMENTS

Software Requirements

Operating System

- Windows 10 / 11 (64-bit)
- Ubuntu 20.04+ / Linux (recommended for model training)

Algorithm 1 Image-Based Breed Recognition of Cattle and Buffalo in India

Input: Raw digital images of cattle and buffalo (field photographs or dataset images)
Output: Predicted breed label for each input image
Step 1: Image Acquisition
Collect images using digital cameras, smartphones, or existing databases
Step 2: Preprocessing
Resize images to a fixed dimension (e.g., 224x224 pixels)
Normalize pixel intensity values
Apply data augmentation (e.g., rotations, flips, brightness/contrast adjustments)
Step 3: Region of Interest Extraction
Detect and crop the animal's body or head using object detection (e.g., YOLO, SSD models)
Discard unnecessary background portions to focus only on the animal
Step 4: Feature Extraction
Pass cropped images through a convolutional neural network (CNN)
Extract high-level visual features at relevant CNN layers
Step 5: Model Training
Split data into training and validation/test sets
Train the breed classification model using labeled images and extracted features
Adjust weights via backpropagation to minimize classification loss
Step 6: Prediction and Classification
Feed test images into the trained model
Output the predicted breed label (e.g., Sahiwal, Murrah, etc.)
Step 7: Evaluation
Calculate performance metrics: Accuracy, Precision, Recall, F1-score
Optionally, generate confusion matrix and analyze misclassification. =0

Programming Languages
- Python 3.8+ (primary language for ML and CV)
- Optional: MATLAB (for research prototyping)

Software Tools & Frameworks
- TensorFlow / Keras or PyTorch (for CNN model development)
- OpenCV (image preprocessing, augmentation)
- NumPy, Pandas (data handling)
- Matplotlib, Seaborn (visual analysis and plotting)
- Scikit-learn (evaluation metrics, splitting dataset)
- Jupyter Notebook, Google Colab, or VS Code

Dataset Tools
- LabelImg or CVAT for annotation
- Kaggle API (if fetching datasets)
- Google Drive / Cloud Storage (dataset hosting)

Deployment Software (optional)
- Flask / FastAPI for backend deployment
- Android Studio (if deploying on mobile)
- TensorFlow Lite / ONNX Runtime for lightweight inference

Hardware Requirements

For Model Training (High Performance) 1.For Large Dataset or Heavy Training
- NVIDIA RTX 3080 / 3090 / A6000
- 64 GB RAM
- 1–2 TB SSD
- Suitable for 50k+ livestock images

For Deployment (Low Cost Edge or Field Use)
- Mobile Phones with: 4 GB RAM minimum
- Octa-core CPU
- Android 10+
- Good camera (12MP+)
- Edge Devices (optional):
  - Raspberry Pi 4 (with Coral USB Accelerator)
  - NVIDIA Jetson Nano / Xavier NX

3. Camera Requirements for Field Image Capture
- Smartphone or DSLR
- Minimum 12 MP resolution
- Good lighting support
- Stable focus & close-range image capture

Network Requirements (optional)

- If cloud training or mobile inference:
  - Stable internet (10 Mbps+)
  - Cloud GPU access (AWS, GCP, Kaggle, Colab)

TABLE II: Component Specification

Component	**Recommended Specification**
CPU	Intel i7 / Ryzen 7 or higher
GPU RTX 2060 / RTX 3060 or higher (CUDA support)	[l]NVIDIA GTX 1660 /
RAM (32 GB recommended)	Minimum 16 GB
Storage (for dataset & checkpoints)	SSD 256 GB+
Power training runs	[l]Stable power supply for long

VI. Conclusion

Image-based breed recognition offers a practical solution for farmers, government agencies, and veterinarians in India. The proposed system achieves high reliability and speed, supporting better farm management, disease control, and breed conservation. Future work may include mobile app deployment and expansion to additional livestock types

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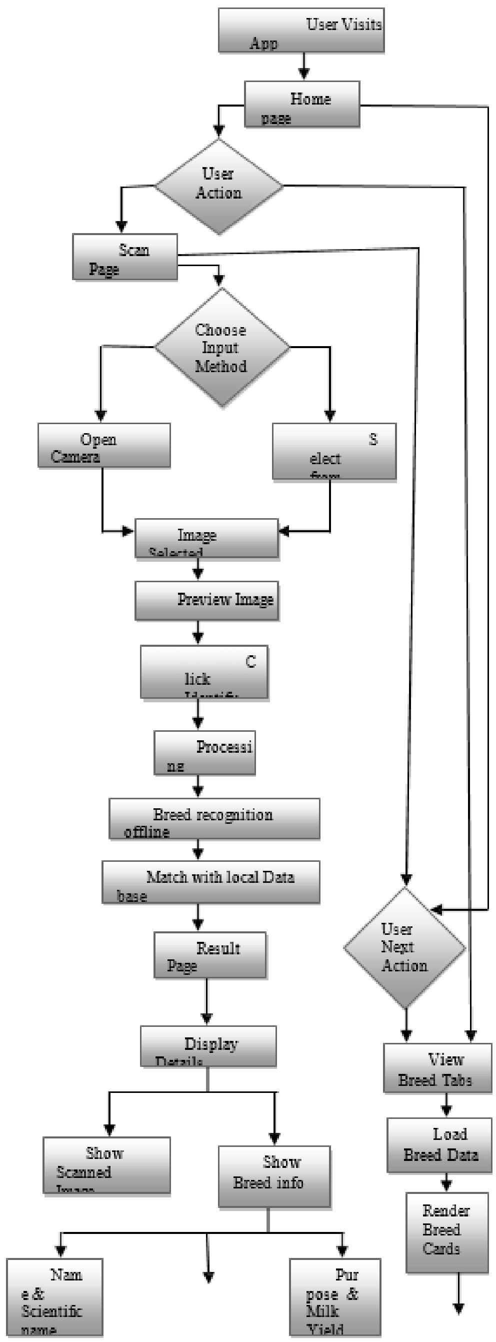

Fig. 6: Flow Chart