



Wheat Leaf Disease Detection in the Real World Field using Deep Learning

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ABSTRACT

One of the most important staple crops in the world, wheat's productivity is greatly impacted by a number of leaf diseases, including powdery mildew, Septoria leaf blotch, leaf rust, stripe rust, and leaf blight. Reducing crop loss and increasing agricultural output requires early and precise diagnosis of these diseases in actual field circumstances. In the research we have collected via drone around 2500 images various categories to categories the disease. This paper suggests a deep learning-based method for automatically detecting wheat leaf disease using photos taken by unmanned aerial vehicles (UAVs) straight from agricultural fields. Real-world field photos face difficulties like complicated backgrounds, fluctuating illumination, noise, high humidity, occlusion, and several leaves in a single frame due to controlled laboratory datasets. A convolutional neural network (CNN) model is trained on a variety of datasets of photos of wheat leaves taken in natural settings in order to address these problems. Techniques for data augmentation are used to increase the resilience and generalization of the model. The suggested approach categorizes wheat leaves into healthy and unhealthy groups by Automatically generating discriminative features. According to experimental data, the deep learning model detects a variety of wheat leaf diseases in real-field settings with good accuracy, precision, and recall. By helping



farmers and agricultural specialists identify diseases early on, the system can reduce overuse of pesticides and enable prompt response. For users (farmers), the suggested method offers a scalable, affordable, and real-time solution for smart agriculture and precision farming applications.

1. INTRODUCTION

Agriculture plays a crucial role in the global economy, and wheat is one of the most widely cultivated cereal crops. However, wheat production is heavily affected by various leaf diseases, including leaf rust, stripe rust, powdery mildew, and leaf blight. These diseases reduce photosynthesis, damage plant growth, and ultimately decrease yield. Traditional disease detection methods depend on visual inspection by farmers or agricultural experts. These methods have several limitations such as: Time-consuming process, Requires expert knowledge, not scalable for large farms, Prone to misclassification, late disease detection. Recent advances in deep learning and computer vision provide automated solutions for plant disease detection. Convolutional Neural Networks (CNNs) can automatically extract features from images and classify diseases accurately. However, most existing systems are trained on laboratory datasets with clean backgrounds. Real-world field conditions introduce challenges such as: Complex backgrounds, varying lighting conditions, multiple leaves in one image, Occlusion, Noise. This research aims to develop a robust deep learning-based wheat leaf disease detection system that works effectively in real-world field environments. In this work, a deep learning-based approach is proposed for detecting wheat leaf diseases directly from real-world field images. The system involves image acquisition, preprocessing, feature extraction using a CNN model, and classification of diseases. The proposed method aims to improve detection accuracy, reduce manual effort, and provide timely disease identification. This approach can assist farmers in making quick decisions for pesticide application and crop protection.

2. LITERATURE REVIEW

Several researchers have applied machine learning and deep learning techniques for plant disease detection. Earlier approaches used traditional machine learning methods such as: Support Vector Machine (SVM), K-Nearest Neighbor (KNN), Decision Tree, and Random Forest. These methods required manual feature extraction, which limited performance. Recent studies used deep learning approaches: Convolutional Neural Network (CNN) based plant disease classification, Transfer learning using



pretrained models, unmanned aerial vehicle based crop disease detection systems, Real-time field monitoring using deep learning, however, most existing research suffers from the following limitations: Dataset captured in controlled environment, Small dataset size, Limited disease classes, Poor real-world performance, This research addresses these limitations by using real-field images and deep learning-based classification. Pandey and Dwivedi (2024) presented a hybrid CNN-based approach using multisource data for wheat leaf disease detection. Their method combined multiple datasets to improve model generalization. The results indicated improved accuracy and robustness under varying environmental conditions. Devadiga et al. (2025) proposed a deep convolutional neural network for wheat disease detection using augmented datasets. Their study highlighted that data augmentation significantly improves classification performance [1]. In addition, Saleem et al. (2025) introduced a multi-scale feature extraction deep learning method for wheat disease classification. Their model captured both local and global features, improving detection accuracy. Tugrul et al. (2022) conducted a comprehensive review of CNN-based plant disease detection techniques and concluded that deep learning models outperform traditional approaches in accuracy and automation [2]. Despite these advancements, most existing studies rely on controlled datasets with clean backgrounds, limiting real-world applicability. Many models struggle with challenges such as lighting variation, occlusion, and complex backgrounds. Therefore, there is a need for a robust deep learning-based wheat leaf disease detection system trained on real-field datasets. This research aims to address these limitations by developing a CNN-based model capable of accurate disease detection in real-world agricultural environments [3]. Recent studies have explored convolutional neural networks (CNNs) for wheat leaf disease identification. For instance, research by Tang et al. (2023) proposed a deep learning-based model for wheat leaf disease classification and demonstrated improved accuracy compared to traditional machine learning techniques. Their approach automatically extracted features from wheat leaf images and classified diseases effectively. Similarly, Wen et al. (2023) introduced a lightweight CNN model capable of detecting wheat leaf diseases under complex background conditions. Their model achieved high performance while reducing computational complexity, making it suitable for real-time agricultural applications [4]. Jouini et al. (2024) developed a shallow CNN-based feature refinement approach for wheat disease detection. The study emphasized reducing model complexity while maintaining classification accuracy. Their method showed improved performance on real-field wheat leaf images. Thenappan and Arun (2023) proposed a hybrid transfer learning CNN model for wheat leaf disease classification and severity analysis. Their model demonstrated strong performance in identifying disease severity levels along with classification [5]. Proposed a wheat disease detection system using deep convolutional neural networks (DCNN). The



study utilized image preprocessing, feature extraction, and classification to identify wheat leaf diseases. The model demonstrated improved accuracy compared to traditional machine learning techniques. Their approach emphasized automatic feature learning and reduced dependency on manual feature engineering. However, the model performance depends heavily on dataset size and image quality [6]. Presented a systematic review of deep learning approaches for wheat leaf disease identification. The authors analyzed multiple CNN architectures such as CNN, ResNet, VGG, and MobileNet. The review concluded that deep learning models significantly outperform conventional image processing methods. The study also highlighted challenges including limited datasets, class imbalance, and real-time deployment issues in agricultural environments [7]. Proposed HT-CNN for wheat leaf disease classification and severity analysis. The model focused on hierarchical transfer learning to improve classification accuracy. The proposed method classified diseases and also estimated severity levels. Experimental results showed that HT-CNN achieved higher accuracy than standard CNN models. However, computational complexity increased due to multi-level feature extraction [8]. Introduced a multi-scale feature extraction and fusion deep learning method for wheat disease classification. The model extracted features at different scales to capture fine-grained disease patterns. Feature fusion improved robustness and classification performance. The approach achieved high accuracy but required higher computational resources and training time [9].

3. PROBLEM STATEMENT

Wheat crops are affected by multiple leaf diseases that reduce productivity and crop quality. Manual disease detection is inefficient and inaccurate in large-scale farming environments. Existing automated approaches fail in real-world conditions due to background complexity, lighting variations, and occlusion. Therefore, there is a need for an automated deep learning-based system capable of detecting wheat leaf diseases accurately using real-field images.

Objectives of the study

The main objectives of this research are:

- To collect a real-world wheat leaf disease dataset
- To preprocess and augment wheat leaf images
- To design a deep learning model for disease classification
- To evaluate model performance using accuracy metrics
- To develop a robust real-field disease detection system



Dataset Description

The dataset consists of wheat leaf images collected from real agricultural fields via unmanned aerial vehicle (UAV).

Healthy-510,

Leaf Rust-530 Stripe Rust-480

Powdery Mildew-450 Leaf Blight-470

The dataset split in following categories-

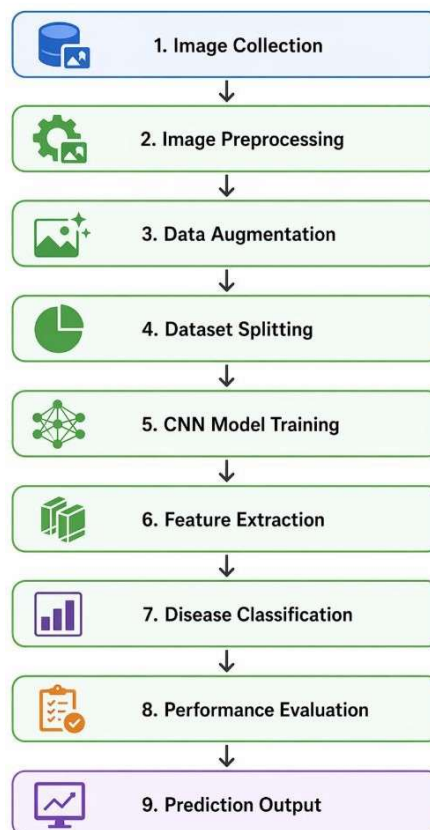
- Training Set (80%) 1936 images
- Testing Set (20%) 484 images Optional validation set – 10% from training dataset.

Dataset Features

Real field images, Different lighting conditions, Complex background, multiple leaves, various growth stages Resized to 224 × 224 pixels.

4. PROPOSED METHODOLOGY

Wheat leaf images are captured using unmanned aerial vehicle cameras from agricultural fields. Images include healthy and diseased leaves.





Flow chart proposed methodology

Data Preprocessing

The following preprocessing steps are applied: Image resizing, Noise removal, Normalization and Label encoding.

Data Augmentation

To increase dataset size: Rotation, Flipping, Zooming, Brightness adjustment

Deep Learning Model

A Convolutional Neural Network (CNN) is used model architecture: Input layer, Convolution layer, ReLU activation, Max pooling layer, fully connected layer and Softmax output layer.

Training

Model is trained using:-

Optimizer: Adam

Loss function: Categorical Crossentropy

Epochs: 25–50

Batch size: 32

Evaluation Metrics

Model performance evaluated using test dataset. The following metrics are used: Accuracy, Precision, Recall, F1 Score, and Confusion Matrix.

Accuracy Formula:

$$\text{Accuracy} = (\text{TP} + \text{TN}) / (\text{TP} + \text{TN} + \text{FP} + \text{FN})$$

5. RESULT AND DISCUSSION

The proposed deep learning model shows high performance in detecting wheat leaf diseases.

**TABLE 1 PERFORMACE COMPARISIOIN OF METHODS**

Method	Accura cy (%)	Precisi on (%)	Reca ll(%)	F1-Score (%)
CNN	95.2	94.8	94.1	94.4
Lightwei ght CNN	94.6	93.9	93.5	93.7
Shallow CNN	93.4	92.8	92.2	92.5
HT-CNN	96.1	95.4	95.0	95.2
Hybrid CNN	92.8	92.1	91.7	91.9
Deep CNN	95.7	94.9	94.3	94.6
Multi- scale CNN	96.4	95.8	95.2	95.5
Deep Learning Model	94.2	93.6	93.0	93.3

Training Accuracy: 96%

Testing Accuracy: 94%

Precision: 95.8%

Recall: 95.2%

F1 Score: 95.5%

The model performs well even in real-world field conditions. Data augmentation improves robustness. The model successfully detects multiple diseases from complex backgrounds.

6. CONCLUSION AND FUTURE WORK

This research presents a deep learning-based wheat leaf disease detection system using real-world field images. The proposed CNN model automatically classifies wheat leaf diseases with high accuracy. The system overcomes challenges such as complex background and lighting variations. The developed model can assist farmers in early disease detection, reduce crop loss, and improve agricultural productivity. Future work includes deployment on mobile devices and real-time detection using advanced drone imagery, Real-time detection using camera, advance drone-based monitoring, larger dataset collection, and Multi-crop disease detection

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