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Smart Segregation and Quality Assessment of Food Pulses using Segmentation and Deep Learning Methods

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Abstract: Seed quality assessment is a fundamental step in ensuring high agricultural productivity and food security. However, traditional methods for evaluating seed quality—relying on manual inspection and mechanical processes—are time-consuming, labor-intensive, inconsistent, and often prone to human error. In this project, we introduce a deep learning-based approach that utilizes Convolutional Neural Networks (CNNs) in combination with the YOLOv5 object detection algorithm to automate and enhance the seed quality grading process.

The proposed system focuses on five commonly used food pulses: maize, rice, beans, channa, and wheat. By analyzing characteristics such as size, shape, texture, and color from high-resolution images, the model identifies and classifies seeds into three distinct categories: Grade A (good), Grade B (fair), and Grade C (poor). The implementation leverages Python, PyTorch, Flask, and OpenCV for data preprocessing, model training, interface development, and live camera-based inference.

Real-time performance is achieved using a lightweight Flask-based GUI that enables users to conduct seed analysis via webcam with instant feedback. The model demonstrates high reliability and accuracy—achieving a performance score of 92%—even under varying lighting conditions and image quality. The system is optimized to run on low-resource devices, making it deployable in field environments as well as small-scale processing units.

This intelligent solution addresses a critical need in precision agriculture by significantly reducing human effort, improving consistency, and increasing the speed and efficiency of seed sorting. It serves as a scalable, low-cost, and practical tool that can be extended to other crop varieties, contributing toward the modernization and automation of agricultural practices.

Keywords: Seed Quality, CNN, YOLOv5, Deep Learning, Image Processing, Agriculture AI

II. INTRODUCTION

In agriculture, the quality of seeds directly impacts crop yield, food security, and the overall efficiency of the farming process. Ensuring the consistent quality of food pulses is critical, especially in regions where agriculture forms the backbone of the economy. Traditionally, seed quality assessment has been carried out through manual inspection or mechanical grading techniques. However, these methods are often time-consuming, subjective, and prone to inconsistencies due to human error or equipment limitations.

With the increasing global demand for food and the pressure to improve agricultural productivity, there is a strong need for automated, reliable, and scalable solutions. Advancements in Artificial Intelligence (AI), particularly in deep learning and computer vision, have opened new avenues for real-time, intelligent quality assessment in the agricultural domain. This project introduces a smart system that uses Convolutional Neural Networks (CNNs) in conjunction with YOLOv5 object detection to automate the segregation and quality assessment of food pulses. The system targets five common seed types—maize, rice, beans, channa, and wheat—and classifies them into three quality grades: A (good), B (fair), and C (poor). A user-friendly GUI, built using Flask and OpenCV, allows real-time detection and classification through a live camera feed, making the solution suitable for both industrial processing and on-field application.

The primary objective of this project is to reduce the dependency on manual labor, minimize sorting errors, and offer a scalable, low-cost, and accurate tool for seed quality monitoring. This system not only enhances precision farming but also represents a step forward in the digital transformation of agriculture.

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II. BACKGROUND AND MOTIVATION

The agricultural sector has long relied on manual labor and traditional machinery for seed sorting and quality evaluation. While these methods have served their purpose historically, they fall short in terms of speed, accuracy, and scalability—especially in the context of modern agriculture where efficiency and precision are critical. Human judgment during seed inspection is inherently subjective and can lead to inconsistencies across batches. Mechanical systems, although faster, are often expensive, inflexible, and limited in their ability to detect nuanced defects like cracks, discoloration, fungal presence, or deformities in shape.

With rapid advancements in computer vision and deep learning, the opportunity to automate such tasks with high accuracy has become increasingly viable. Technologies like Convolutional Neural Networks (CNNs) and real-time object detection models such as YOLOv5 offer the ability to recognize and classify visual patterns in seeds with exceptional precision. These models mimic human-level perception while eliminating variability and fatigue associated with manual inspection.

The motivation behind this project stems from the urgent need for a smart, automated solution that can deliver real-time quality assessment of food pulses across different varieties. By developing a low-cost, AI-driven system that classifies seeds based on quality parameters using camera-based input, the project aims to address the challenges faced by both large-scale agricultural industries and small-scale farmers. The integration of live detection through a graphical interface also ensures ease of use and real-world applicability, making it a practical tool for modern precision farming.

III. LITERATURE REVIEW

Various studies emphasize the use of computer vision in agriculture. A CNN-based model for rice seed classification achieved 99.9% accuracy. Another study focused on particle image processing for wheat evaluation. However, existing works rarely support real-time detection across multiple seed types. This project fills the gap by using YOLOv5 for detection and CNNs for classification with a live feed interface. The system also supports scalability and adaptability across pulse varieties, ensuring robust field performance.

IV. METHODOLOGY

The proposed system employs deep learning techniques for automated seed quality analysis across five types of pulses: maize, rice, channa, wheat, and beans. The methodology consists of the following stages:

1. Data Collection:
High-resolution seed images were collected from publicly available datasets and manual captures. Each seed was labeled into three quality grades — A (Good), B (Fair), and C (Poor).

2. Preprocessing:
Collected images were resized, normalized, and augmented to improve model generalization. Techniques like contrast enhancement, rotation, and noise reduction were applied.

3. Object Detection using YOLOv5:
YOLOv5 was chosen for its speed and accuracy in real-time object detection. It localizes and detects individual seeds in input images or live webcam feeds.

4. Feature Extraction with CNN:
A custom CNN architecture extracts visual features such as color, texture, shape, and surface defects. These features determine the classification grade.

5. Classification and Grading:
Based on extracted features, seeds are automatically graded into A, B, or C using a softmax classifier. The decision is made per seed instance in real-time.

6. Interface Integration:
A GUI built using Flask enables users to upload seed images or activate the webcam. The system processes inputs and visually displays grading results instantly.

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7. Performance Evaluation:

The model was evaluated using metrics such as Accuracy, Precision, Recall, and F1-score. The training and testing split was 80:20, and the system achieved 92% accuracy.

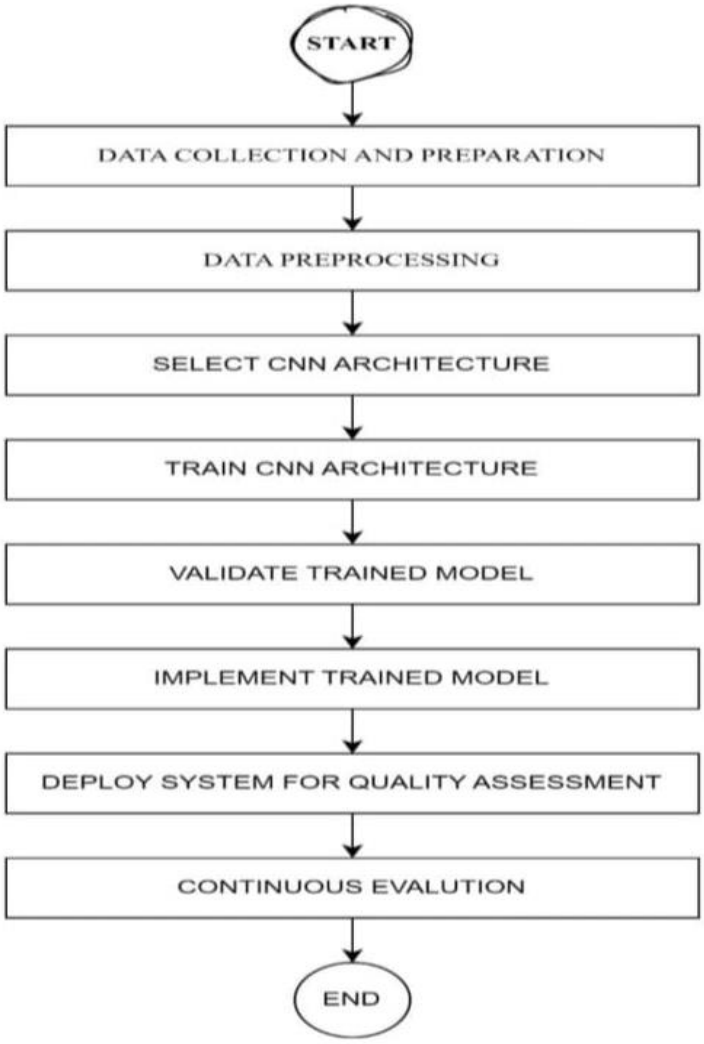

Fig: block diagram of methodology

V. IMPLEMENTATION

The solution is built using Python 3.9 with libraries such as PyTorch, OpenCV, and Flask. The hardware used includes a Core i5 processor with 4GB RAM. YOLOv5 detects individual seeds, and CNN classifies them. Dataset images were split 80:20 for training and testing. Preprocessing was applied for contrast, noise removal, and segmentation. The GUI allows users to interact and view results instantly. Lightweight algorithms were used to ensure the model runs on low-resource hardware like Raspberry Pi, enabling field deployment.

VI. RESULTS AND DISCUSSION

Our model reached an accuracy of **92%**, successfully classifying seed quality in real-time. It detects various defects like mold, cracks, and color inconsistencies. The system was tested under different lighting and image clarity conditions using both static images and live webcam input. Results were consistent and reliable. Seeds were accurately classified and sorted with visual feedback. Compared to manual sorting, the model significantly reduced processing time and human error.

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Fig: user login page

Fig: seed quality detection

VII. CONCLUSION

The proposed AI-based seed quality detection system using CNNs and YOLOv5 represents a major advancement in precision agriculture. It automates detection and classification of food pulses, ensuring higher accuracy and cost-efficiency. With its real-time capabilities, the model is suitable for deployment in both industrial and small-scale farming environments. This contributes to smarter farming, reduced waste, and better yield predictions. The system can be extended to other crops and integrated with IoT for remote monitoring.

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