

Rice Quality Inspector Using AI/ML & IOT

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Abstract

The research project "Rice Quality Inspector using AI/ML and IoT" aims to develop an intelligent and automated system for accurate assessment of rice grain quality using artificial intelligence, machine learning, and the Internet of Things. Traditional methods of rice quality inspection are manual, time-consuming, and prone to human error, leading to inconsistent grading. The proposed system uses a YOLOv8-based image processing model to detect rice grains, identify defects, and classify impurities with high accuracy. IoT sensors such as DHT22, MQ135, and soil moisture sensors are used to monitor environmental parameters like temperature, humidity, and gas concentration to maintain optimal storage conditions. The system also provides AI-based suggestions for improving rice quality. This approach reduces manual effort, increases accuracy, and supports smart and sustainable agricultural practices.

Keywords: Internet of Things (IoT), YOLOv8, Rice Quality Inspection, Image Processing, Artificial Intelligence, Machine Learning, Grain Defect Detection, Smart Agriculture, IoT Sensors, Sustainable Farming

1. INTRODUCTION

Rice is one of the most consumed staple foods throughout the world and is of major agricultural importance, especially in Asian countries. Quality determines market value, consumer satisfaction, and export potential. Traditional rice quality assessment relies on manual inspection procedures where trained personnel are supposed to evaluate parameters concerning grain size, color, and texture and also control impurities. However, this usually represents a very time-consuming process that is subjective and inconsistent, resulting in a lot of inaccuracies in grading and generally reducing industrial process efficiency.

Due to the rapid development in the field of Artificial Intelligence, Machine Learning, and the Internet of Things, rice quality evaluation might become faster and more efficient. Integrating these technologies means the creation of intelligent systems that will be capable of carrying out simultaneous image-based defect detection and environmental monitoring to provide a comprehensive view in real time of rice quality. The project entitled "Rice Quali-

-ty Inspector Using AI/ML & IoT" focuses on designing a smart system to analyze rice quality using visual inspection and analysis of data from sensors.

A visual defect diagnosis in rice samples is made possible by utilizing the YOLOv8 deep learning model for the detection of broken grains, half grains, stones, foreign objects, and pest contamination. Simultaneously, IoT-based sensors are used, including DHT22 for temperature and humidity, MQ135 for gas concentration, and a Soil Moisture sensor to capture the environmental data affecting rice freshness and storage conditions.

All the collected data are processed through a Flask-based web application, which showcases the live sensor readings, AI detection results, and computes an overall quality score. The final output classifies the rice as Excellent, Good, Moderate, or Poor on a weighted AI logic basis that combines visual and environmental parameters. In a technical sense, there is a powerful combination of Computer Vision, IoT, and AI-driven analytics in this project. Tools such as Python, OpenCV, Ultralytics YOLOv8, and Arduino are playing the lead role in real-time performance and precision.

2.Body of Paper

2.1 Literature Review / Related Work

Recent advancements in smart agriculture and precision farming have shown significant progress through the integration of artificial intelligence (AI) and Internet of Things (IoT) technologies. Many research works have utilized image processing and deep learning techniques such as Convolution Neural Networks (CNN) for crop and grain quality analysis, achieving high accuracy under controlled conditions. In the domain of rice quality inspection, YOLO-based models have been widely adopted for grain detection, classification, and defect identification, improving efficiency and reducing human error.

Additionally, several IoT-based systems have been developed to monitor environmental parameters such as temperature, humidity, and gas concentration to maintain optimal storage conditions for agricultural

products. These systems enhance quality preservation but often lack integration with intelligent visual inspection methods. Some studies also focus on automated grading and classification of rice grains using machine learning; however, they do not incorporate real-time environmental monitoring. Most existing systems are either focused solely on image-based quality detection or only on environmental monitoring, without combining both aspects into a single platform

1.2 Problem Statement

Rice quality assessment plays a crucial role in determining market value and ensuring food safety. However, traditional methods of rice inspection are manual, time-consuming, and highly dependent on human expertise, leading to inconsistent and error-prone results. Detecting defects such as broken grains, discoloration, and impurities becomes difficult, especially when dealing with large quantities of rice. In addition, improper storage conditions like fluctuations in temperature, humidity, and gas levels can degrade rice quality over time, but continuous monitoring of these parameters is challenging. There is also a lack of real-time, data-driven systems that can assist in accurate grading and quality evaluation. Therefore, there is a need for an automated, intelligent, and efficient system that can perform precise rice quality inspection along with environmental monitoring.

1.3 Objectives

- To design and develop an intelligent rice quality inspection system using artificial intelligence and machine learning techniques.
- To capture images of rice grains and analyze them for defects, impurities, and quality parameters.
- To classify rice grains based on quality metrics such as size, shape, and presence of broken or discolored grains.
- To monitor environmental conditions such as temperature, humidity, and gas concentration using IoT sensors.
- To provide accurate analysis and AI-based recommendations for improving rice quality and storage conditions.
- To reduce manual effort and increase efficiency in rice quality inspection.

1.4 Methodology

The proposed *Rice Quality Inspector using AI/ML and IoT* follows a structured methodology to ensure accurate and automated rice quality assessment along with environmental monitoring.

Initially, images of rice grains are captured using a camera module. These images are processed using a YOLOv8-based AI model to detect grains identify

defects such as broken, discolored, or impure grains, and classify them accordingly. The image processing stage includes the following steps:

1. Image acquisition
2. Image preprocessing (noise reduction and enhancement)
3. Feature extraction (shape, size, and color analysis)
4. AI model-based classification

Simultaneously, IoT sensors such as DHT22, MQ135, and soil moisture sensors continuously monitor environmental parameters like temperature, humidity, and gas concentration to ensure proper storage conditions. The collected data is processed by a micro-controller and can be transmitted to a cloud-based platform for real-time monitoring. The system integrates both visual inspection and environmental analysis to provide accurate quality evaluation. Additionally, AI-based insights and recommendations are generated to improve storage conditions and maintain rice quality. This approach results in an efficient, automated, and intelligent rice quality monitoring system.

1.5 Implementation

The proposed *Rice Quality Inspector using AI/ML and IoT* system is implemented using a combination of hardware and software components working together to achieve accurate rice quality assessment and monitoring.

1. Camera Module

The camera module captures high-quality images of rice grains. These images are used for processing through AI/ML models to detect defects such as broken grains, discoloration, and impurities. It plays a key role in automated visual inspection.

2. Micro-controller (ESP32 / Raspberry Pi)

The micro-controller acts as the central unit of the system. It collects data from sensors, processes inputs, controls the system operations, and communicates with the AI model and cloud platform.

3. Temperature and Humidity Sensor (DHT22)

This sensor monitors environmental conditions such as temperature and humidity, which are critical for maintaining rice quality during storage.

4. Gas Sensor (MQ135)

The MQ135 sensor detects harmful gases and air quality levels in the storage environment, helping to prevent spoilage and maintain grain quality.

5. Soil Moisture Sensor

Although mainly used in agriculture, this sensor can be utilized to monitor moisture levels in storage or surrounding environments to avoid excess humidity that may damage rice grains.

6. IoT Communication Module (Wi-Fi)

The IoT module enables real-time data transmission to a cloud platform or application.

This allows users to monitor rice quality parameters and environmental conditions remotely. Together, these components create an efficient, automated, and intelligent system for rice quality inspection and monitoring.

2.6 Results and Discussion

Rice Grain Detection :

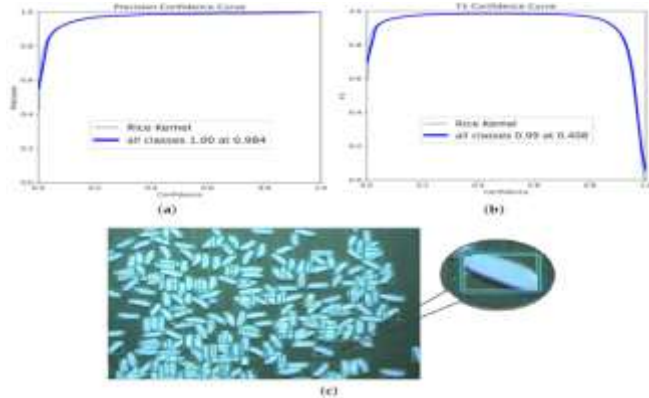


Fig 1: Rice Grain Detection

The proposed Rice Quality Inspector system was tested using a YOLOv8-based model for detecting and classifying rice grains. The model successfully identified different types of grains, including normal, broken, discolored, and impure grains. The detection results showed high accuracy with minimal miss classification. The bounding box outputs clearly highlighted each grain, making the classification process reliable and efficient.

Model Training Performance:

The model was trained on a dataset of rice grain images, and performance metrics such as precision, recall, and accuracy were evaluated. The results indicated high precision and recall values, confirming the robustness of the model. The confusion matrix showed very low error rates, proving that the system can effectively differentiate between various grain categories.

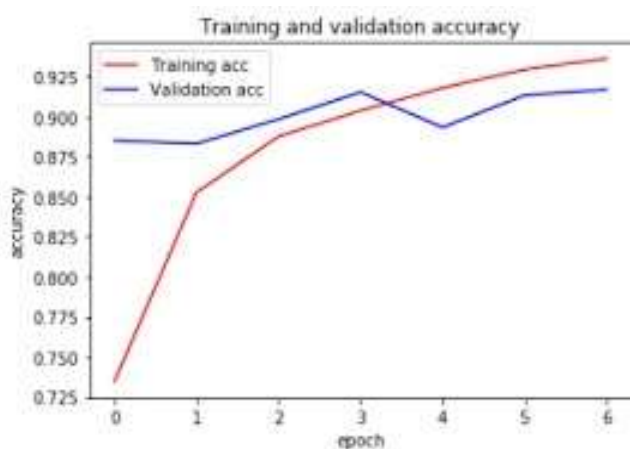


Fig.2 Model Training Results

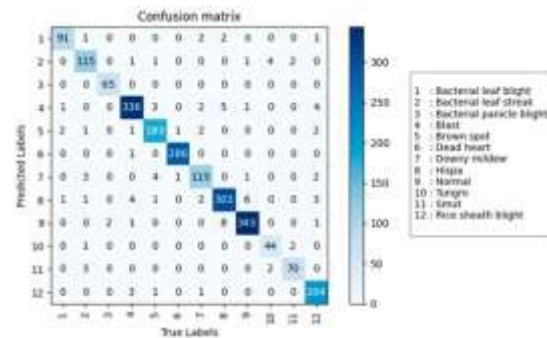


Fig 3 Confusion Matrix

Image Processing Results:

The system performed image preprocessing techniques such as noise reduction and image enhancement to improve detection quality. Feature extraction methods analyzed grain size, shape, and color for accurate classification. The processed images showed clear improvement over raw images, enabling better detection performance.

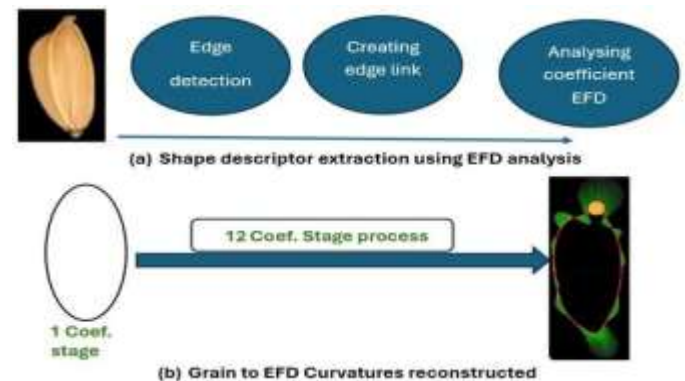


Fig.4 Raw Image and Processed Image Comparison

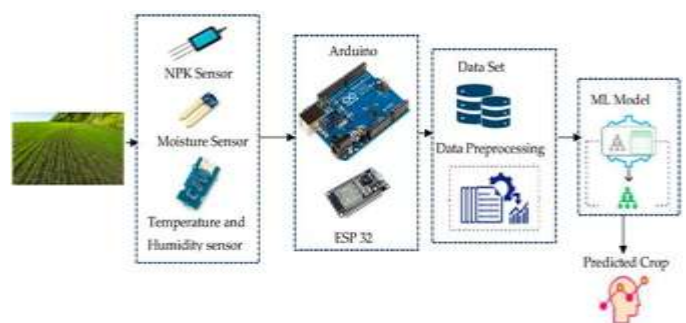


Fig.5 Sensor Output (Temperature, Humidity, Gas Levels)

2.7 System Architecture

2.7 SYSTEM ARCHITECTURE

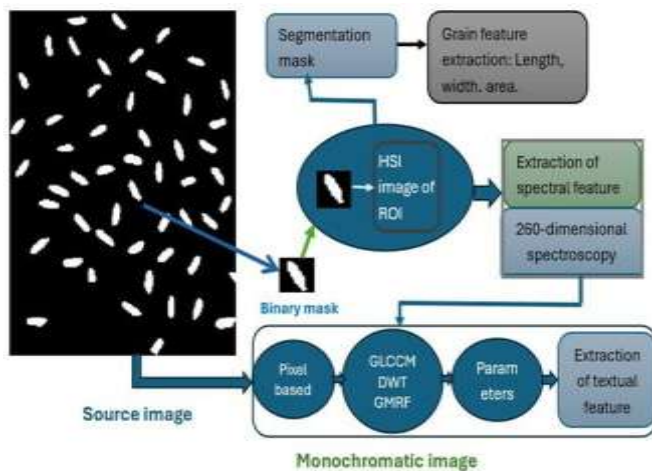


Fig -2: Architecture

2.8 Limitation

- Continuous internet connectivity is required for real-time monitoring and cloud integration.
- High processing power is needed for efficient AI/ML model execution.

2.9 Future Scope

The proposed *Rice Quality Inspector using AI/ML and IoT* provides a strong foundation for advanced smart agriculture and industrial quality inspection systems. Future enhancements may include:

- 1.Improving detection accuracy by using advanced deep learning models such as CNN and optimized YOLO architectures.
- 2.Integration of cloud-based analytics for large-scale data storage and real-time monitoring.
- 3.Development of a portable and cost-effective device for field and industrial usage.
- 4.Expansion to classify multiple grain types and quality grades automatically.
- 5.Implementation of edge computing for faster on-device processing and reduced latency.
- 6.Integration with mobile or web applications for better user interaction and remote control.
- 7.Deployment at industrial scale with centralized monitoring systems to improve efficiency, consistency, and sustainability in rice quality management.

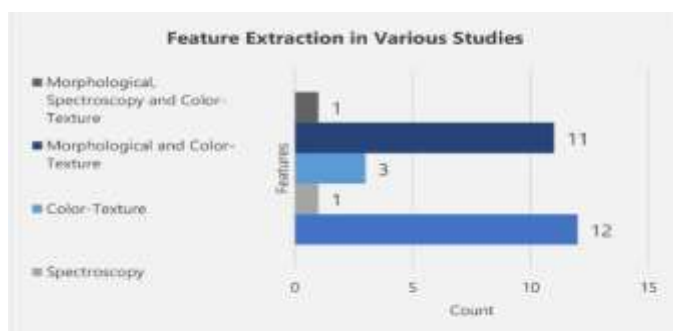


Fig.7 Future Scope

2.CONCLUSIONS

The Rice Quality Inspector (Grain Insight) project provides an intelligent, automated, and reliable method for assessing the quality of rice grains using a combination of YOLOv8-based image processing and IoT sensor integration. The system monitors essential environmental parameters such as temperature, humidity, and gas concentration through sensors like DHT22, MQ135, and the soil moisture sensor, ensuring that the storage conditions are ideal for maintaining rice quality. Meanwhile, the YOLOv8 model performs accurate grain detection and impurity identification, reducing manual inspection errors and improving consistency in grading and evaluation.

Furthermore, the inclusion of AI-driven suggestions for improvement adds a predictive and analytical layer to the system, helping users make better decisions in real time.

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4. REFERENCES

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