Grain Quality Analysis Using CNN And Iot Based Strategic Safeguarding

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Abstract: More than half of the global population consumes rice daily, making it a staple that fulfills over 21% of the world's caloric needs—more than any other food. The demand for rice is highest when its quality is optimal. Traditionally, the type and quality of rice are assessed visually by human inspectors. However, this method is labor-intensive, time-consuming, relies on human expertise, and is subject to inconsistencies due to the inspector's physical condition.
To overcome these limitations, this work proposes an automated system that leverages digital image processing techniques for the identification and classification of rice grains. Image processing offers a non-contact, efficient, and reliable alternative by capturing images of the grains for analysis. Using MATLAB, the system preprocesses the images, segments the rice grains, and extracts relevant features. The endpoints of each grain are identified to calculate their length and breadth, which are key parameters in determining grain quality.
Additionally, the rice grains are stored in containers equipped with DHT sensors that continuously monitor and record temperature and moisture levels to ensure proper preservation conditions.

Keywords: Morphological operations, IoT, CNN , Rice Grain quality.

1. Introduction

Quality is generally defined as the combination of features and characteristics of a product or service that meets stated or implied needs. In the case of rice, grain quality is determined by several factors, including aroma, size, color, nutritional content, and the proportion of whole grains. In the rice trade—particularly in import and export—quality is a crucial consideration [1].
Rice samples often contain various foreign materials such as paddy husks, chaff, broken or damaged grains, weed seeds, and stones, all of which affect the overall quality. One of the key aspects of assessing rice grain quality is analyzing its shape, which involves measuring the grain's length, width, and their ratio. Currently, this process is performed manually by inspectors using tools like rulers or micrometers. This traditional approach requires the examiner to extract a few grains from a sample, place them individually in a one-grain tray, and measure each seed one by one. This method is not only labor-intensive but also time-consuming and inefficient.
To address these limitations, the proposed method introduces an image processing-based solution for rice quality assessment. This approach significantly reduces the time, cost, and effort involved in traditional inspection methods. Image processing and machine vision technologies have advanced rapidly, supported by the availability of powerful computing systems and more affordable hardware and

software for digital imaging. These technologies have become widely used in agricultural and biological research.

Several studies have successfully applied machine vision techniques for evaluating the visual quality of rice grains [3]. The primary aim of this research is to offer an efficient, accurate, and cost-effective alternative for rice quality analysis through image processing technology.

2. Existing Method

Rice grain analysis using human graders is a method that involves sorting rice grains based on their physical properties such as size, shape, and color. The grading is done by trained personnel who visually inspect and manually sort rice grains into different categories based on their quality. The grading process typically involves the following steps:

1. Sampling: A representative sample of rice grains is collected from a larger batch of rice, typically using a grain sampler.
2. Preparation: The rice grains are cleaned and sorted to remove any debris or foreign materials.
3. Grading: The rice grains are then visually inspected and sorted by the human grader into different categories based on their physical properties. The categories can include broken grains, whole grains, and grains of different sizes, colors, and shapes [4].
4. Quality assessment**:** Once the rice grains are sorted, the human grader can assess the overall quality of the rice based on the percentage of broken grains, the presence of foreign materials, and other factors [5].

Rice grain analysis using human graders is a method that involves sorting rice grains based on their physical properties such as size, shape, and color [6]. The grading is done by trained personnel who visually inspect and manually sort rice grains into different categories based on their quality. The human grading method has some limitations. It is subjective and can be influenced by the personal biases of the graders, which may lead to inconsistencies in the grading process. Additionally, it is time-consuming and labor-intensive, which can be a bottleneck in large-scale rice processing operations [7]. Despite these limitations, human graders are still used in some parts of the world, particularly in small-scale rice processing operations where the use of automated equipment may not be feasible due to cost or availability. In these cases, trained personnel can still provide accurate grading of rice grains, especially if the grading standards and procedures are well-established and consistent.

Overall, while human grading of rice grains can provide accurate results, the use of image processing techniques is becoming more prevalent due to their speed, objectivity, and non-destructive nature.

3. Proposed Method

Defining rice quality can be challenging, as it varies depending on consumer preferences and the intended end use of the grain. However, all consumers generally seek the highest quality rice within their budget. As countries achieve self-sufficiency in rice production, consumer demand for higher-quality rice has significantly increased.

To meet this demand, image processing techniques are employed to assess rice quality by measuring key physical attributes such as length, breadth, and the length-to-breadth ratio. These measurements are used to count and classify rice grains based on their dimensions.

The process begins with image pre-processing, which includes image registration and noise removal using filtering techniques to enhance image clarity. In the next step, a shrinkage algorithm is applied to segment touching or overlapping rice kernels for accurate individual analysis. Following segmentation, edge detection is performed to identify and outline the boundaries of each grain. Finally, the system measures the length, breadth, and calculates the length-to-breadth ratio of each rice grain, providing a reliable and automated method for evaluating grain quality. In the fifth step of the algorithm, Quality of rice is analyzed according to its size and shape which is the last step. The following steps are carried out to achieve the desired results. The flow chart of the proposed method is shown in Fig.1 and block diagram of the proposed method for quality analysis is shown Fig.2

1. Image Pre-processing
2. Morphological Operations
3. Edge Detection
4. Object Measurement

5. Quality Analysis

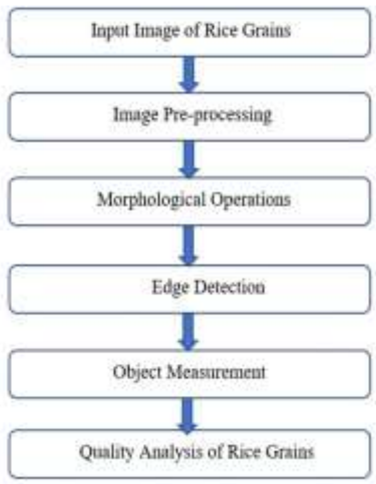


Fig.1: Flow chart of the Proposed System

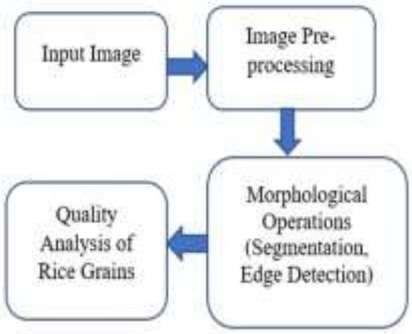


Fig.2: Block Diagram of the Proposed System

4. Data Collection

Image Pre-processing:
The image of the rice grains is captured using a color camera and stored in the RGB color space. To enhance image quality, a filter is applied to reduce noise introduced during image acquisition and to sharpen the image. A thresholding algorithm is then used to segment the rice grains from the black background, effectively isolating them for further analysis.

Morphological Operations:
Morphological operations such as erosion and dilation are applied to refine the segmented image. Erosion removes pixels along the edges of objects, helping to separate touching rice grains while preserving the core structure of each grain. Dilation is then used to restore the eroded grains to their original shape without reconnecting them, ensuring accurate individual grain analysis.

Edge Detection:
Edge detection is performed to identify the boundaries of each rice grain by detecting changes in image intensity. The Canny edge detection algorithm is used for this purpose, as it effectively delineates the edges and separates the rice grains from the background.

Object Measurement:
After edge detection, the system proceeds to count the number of rice grains. The algorithm identifies the endpoints of each grain, and a virtual caliper is used to connect these points and measure the length and breadth of each grain. With these measurements, the length-to-breadth ratio is calculated for each individual grain.

Quality Analysis:

The quality of the rice grains is evaluated based on their measured physical characteristics—specifically, the length, breadth, and the length-to-breadth ratio. These parameters are key indicators used to classify and assess the overall quality of the rice.

5. Software

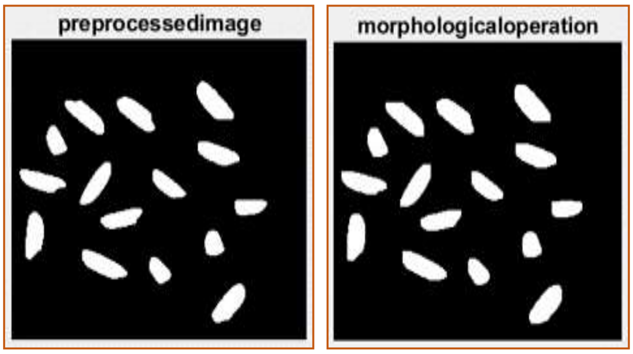
In this work, MATLAB 2013 is used to implement the proposed method. MATLAB is a powerful programming platform specifically developed for engineers and scientists to analyze data, design systems, and build applications that impact a wide range of industries. At its core is the MATLAB language—a high-level, matrix-based language that enables intuitive and efficient expression of computational mathematics.

Widely adopted across both academia and industry, MATLAB is used for diverse applications including signal processing, image and video processing, control systems, test and measurement, computational finance, and computational biology. Its versatility and robust functionality make it an ideal choice for complex technical tasks.

Designed to align with the way engineers and scientists think and work, MATLAB is accessible to users of all skill levels—from beginners to experts. Comprehensive support is readily available through the MATLAB Help Center, which offers detailed documentation, community forums, and instructional videos to assist users at every stage.

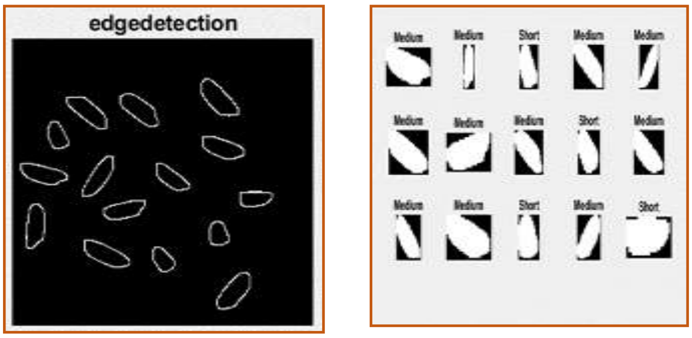
6. Results

Fig.3: Input Image of the Rice Grains



(a) (b)

Fig.4:(a) Preprocessed Image (b)Morphological Image



(a) (b)

Fig.5: (a)Edge Detection (b)Analysis of each grain

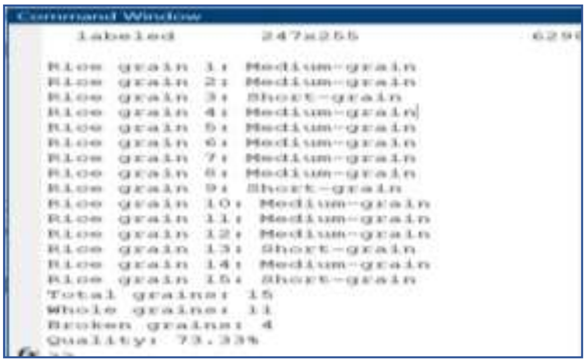


Fig.6: Result of the Rice Grain Analysis

After grain analysis, IoT-enabled moisture sensors DHT 11 are deployed for safeguarding the grain within storage facilities and during transportation to continuously monitor the moisture content of grains. Conditions of storage exert a significant impact on grain quality. IoT can assist in preserving the proper humidity and temperature levels guaranteeing that grains are stored in the best feasible conditions without spoiling. Various communication modules [9] can be deployed based on convenience to send the information to the concern person.

Algorithm

```
initialize_dht11_sensor()
while True:
    temp, humd = read_dht11_data()
        if (temp < LOWER_TEMP_THRESHOLD or temp > UPPER_TEMP_THRESHOLD) or \
       (humd < LOWER_HUMIDITY_THRESHOLD or humd >
UPPER_HUMIDITY_THRESHOLD):
       elif temp < LOWER_TEMP_THRESHOLD or humd < LOWER_HUMIDITY_THRESHOLD:
           activate_heating_or_humidifier()
        send_alert(temperature, humidity)
        if temp > UPPER_TEMP_THRESHOLD or humd > UPPER_HUMIDITY_THRESHOLD:
           activate_cooling_or_ventilation()
```

7. Conclusion

In this project, the rice grain samples are classified into different categories, and their quality is analyzed based on the length-to-breadth ratio. Unlike existing methods that primarily focus on detecting or counting rice grains in a sample, our approach goes further by providing a detailed quality assessment of each grain. Due to this distinct focus, direct comparison with previous work is not applicable. Our method offers a near 100% accuracy in evaluating grain quality—an analysis that would otherwise be highly time-consuming and labor-intensive if done manually. This automated system significantly reduces the need for human effort while ensuring consistent and reliable results. Additionally, the process includes a preservation stage that protects the rice grains from environmental and climatic changes, helping maintain their quality over time.

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