Rice Quality Analysis: A Comprehensive Review of Image Processing and Machine Learning

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***Abstract*—Rice quality assessment can be defined as the task of determining the physical, chemical, and biological attributes of rice kernels. Several variables affect the quality of rice kernels and therefore must be evaluated to ensure proper production, storage, and utilization of this grain. Traditional methods of rice quality analysis rely mostly on destructive testing which makes the process costly, time-consuming, and prone to subjective results. Modern technology allows developing new, non-destructive techniques that require minimal human interaction and provide precise results in shorter time periods. This paper focuses on the development of different types of quality assessment systems and their application for the evaluation of rice. Modern techniques can be divided into two categories based on the type of parameters to be determined. One category involves the analysis of physical characteristics of rice such as size, weight, shape, color, presence of cracks, and chalkiness level. This kind of assessment is conducted using computer vision systems based on advanced image processing and machine learning algorithms. Another category of modern rice quality assessment techniques includes non-destructive spectroscopic measurements for determination of chemical characteristics of rice kernels. This approach allows analyzing the internal structure of grains to obtain grains are collected from different resources.**

***Index Terms*—Rice Quality, Digital Image Processing, Machine Learning, Deep Learning, Spectroscopy, Hyperspectral Imaging, Non-Destructive Testing.**

I. INTRODUCTION

Rice (Oryza sativa) is the primary source of food for more than half of the world's population, thereby making rice quality an attribute of great international significance. It should be noted that rice quality is a multifactorial and interrelated index, which falls into four broad categories [1]:

- Milling Quality – Based on the Head Rice Yield (HRY) or percentage of sound kernel.
- Appearance Quality – Determined by appearance characteristics like grain size, dimensions (length to width ratio), uniformity, color, and chalkiness.
- Cooking and Eating Quality – Predominantly determined by physio-chemical nature of starch in terms of Amylose Content (AC), Gelatinization Temperature (GT), and Gel Consistency (GC).

Nutrient Content: In terms of proteins, fats, and minerals.
The method of evaluating the visual characteristics and milling quality of rice exported internationally through naked-eye inspection by experts has been a longstanding practice. Nevertheless, while being quite accurate, analyzing the internal quality of rice like AC and GT using chemical methods has never been a rapid process and is even destructive. With the rapid increase in rice production across the globe in recent times, there is an absolute need for a more efficient alternative way of assessing the quality of rice which is both accurate and rapid [2].

II. LITERATURE REVIEW

Several tests have been done to test the quality of the rice grains using the technologies mentioned above. In the beginning, the research studies considered the processes of extracting features using morphology and textures of the pictures and then classifying them using SVM and KNN algorithms. For example, the authors of the work done by S. Patel et al. suggested an algorithm that classifies rice grains using the morphological characteristics of the object with the support vector machine algorithm

[1]. In the context of the development of deep learning, the use of CNNs became widespread in addressing issues of image recognition and classification. As it is suggested by K. He et al., the authors suggested ResNet architecture aimed at enhancing the recognition accuracy through the solution of the vanishing gradient problem

[2]. Further, the authors of the paper by M. Tan and Q. Le designed EfficientNet architecture with optimized scaling and reduced parameter utilization rates during classification

[3]. The utilization of transfer learning from CNN models helps significantly increase the precision of the results and speed up the training process. In this case, CNN will be utilized in the project

III. METHODOLOGY

1.Data Collection:
The images of rice res the accuracy and precision of the model. These are classified based on the types such as Basmati, Jasmine, Arborio, Ipsala, and Karacadag. The dataset consists of labeled images that will be used for training and testing purpose.

2.Data Preprocessing:
The preprocessing of images includes processes like resizing, normalizing, and flipping which improve the efficiency of machine learning models.

3.Feature Extraction:
Instead of manual feature extraction process, it is performed automatically by utilizing the Convolutional Neural Network model which extracts information about shapes, texture, grains, and more.

4.Model Training and Selection:
Here the existing CNN model such as EfficientNet and ResNet are used by implementing the transfer learning concept.
Selection of an appropriate model depends upon its performance accuracy and minimum loss.

5.Model Evaluation:
For testing the efficiency of the proposed model, it is evaluated using the validation set and misinformation about amylose, protein, and gelatinization temperatures of rice.
Thus, both types of modern systems are equally important because they determine all the major parameters needed for characterization of rice quality. Both techniques demonstrate excellent accuracy with values surpassing 98%.

This demonstrates the potential of combining machine learning and advanced sensors in agricultural applications.

6.Deployment:
In this final stage, the created model is incorporated into an already existing web application using the Flask framework.
Classification of rice grains is done instantly.

IV. SYSTEM ARCHITECTURE

Image Acquisition
This is achieved by uploading the image of the rice grains through the user interface of the web-based application.

Data Preprocessing
The preprocessed image is achieved using data preprocessing techniques such as resizing, normalization, and augmentation to fit the machine learning model applied.

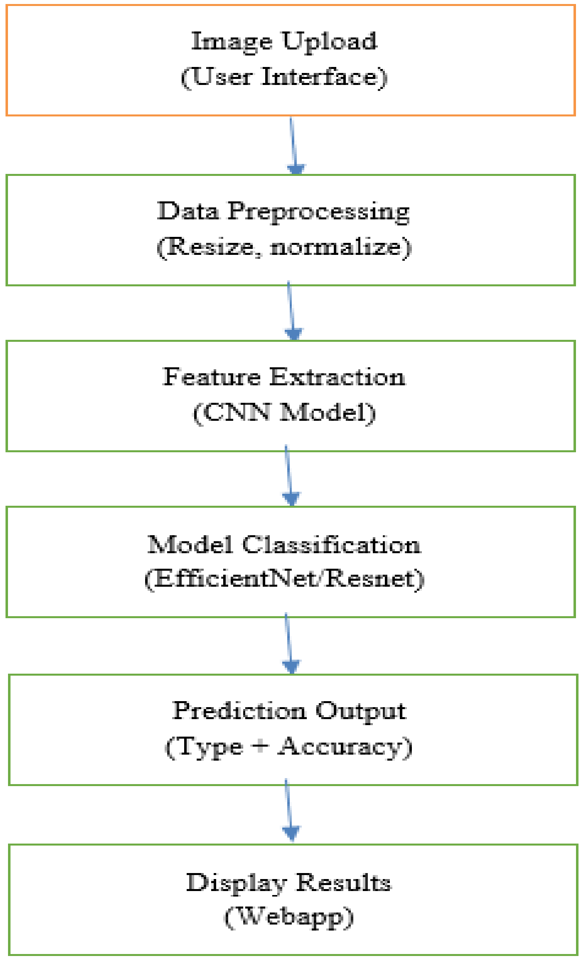
Feature Extraction
The preprocessed image is then introduced to the Convolutional Neural Network (CNN), which applies feature extraction process automatically on features like size and texture of the rice grains.

Model Processing (Classification)
The feature extraction is further used by the pre-trained deep learning model (EfficientNet/ResNet) for the classification process.

Prediction
Prediction is made based on the rice class together with its probabilities.

Results

Results of the classification process are delivered back to the user through the interface of the web-based application.



V. MODEL TRAINING

Training Data Set:

It consists of images of different types of rice grains belonging to Basmati, Jasmine, Arborio, Ipsala, and Karacadag classes.

It is labeled and is used in training and validating purpose.

Data set is divided into two sets, namely training and testing sets to facilitate evaluation.

Classification Algorithm Used:

CNN algorithm has been adopted for classifications.

EfficientNet or ResNet architecture is employed for classifying objects based on their features.

Their function is to extract important features and improve accuracy.

Vectorization:

Represent image in numeric form.

This process can be done with the help of CNN algorithm by converting images into vectors.

Feature vector represents important characteristics, such as object texture and shape.

Accuracy:

Model possesses high accuracy levels depending upon how well-trained the model is (above 90 percent).

It is defined with respect to validation data and provides means for evaluating performance in terms of recognition accuracy.

Robustness:

It is a very robust model as both preprocessing and data augmentation have been applied.

It is consistent regardless of any circumstances.

VI. USER STUDY

Experimental evaluations of usability and performance were conducted for the assessment of usability and performance of the software developed.

The sample consisted of both students and people who feel confident using technology products. They were asked to take photos of rice using the web-based application and get the outcome of the experiment.

Based on criteria such as usability, performance, and precision, the application being studied was assessed.

On the whole, the subjects found the user interface of the application convenient and user-friendly, while the information processing speed was relatively fast. One should note that based on comments made by the subjects, it can be assumed that the software saves users unnecessary efforts and classifies rice accurately. Moreover, the respondents suggested introducing features like mobile phone compatibility and smartphone camera usage. The findings of the experiment confirmed the usability and effectiveness of the application.

VII. CONCLUSION

One of the most prominent technological revolutions concerns the field of evaluating the qualities of rice. There is no need to mention how great advances have been made in the sphere of technology, starting from rudimentary practices based exclusively on manual evaluations to advanced technologies using automated solutions. Computer vision algorithms, especially those that use principles of deep learning, enable fast analyses of physical properties and millability of rice. Meanwhile, spectroscopy allows performing fast chemical analyses that determine the sensory qualities of rice. What is particularly important about these two technologies is that they mark the beginning of a whole new epoch in this sphere of technology because they are able to perform the evaluation of the qualities of rice at once.

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REFERENCES

[1] Y. Li *et al.*, "Comprehensive Evaluation of 17 Qualities of 84 Types of Rice Based on Principal Component Analysis," *Int. J. Environ. Res. Public Health*, vol. 18, no. 23, 2021.

[2] M. K. Khan et al., "A Review Paper on Rice Quality Analysis Using Image Processing Technique," Int. J. Res. Appl. Sci. Eng. Technol. (IJRASET), vol. 10, no. 5, 2022.

[3] S. A. Ghasemi, S. T. M. Alahakoon, and W. H. Wijesekera, "Review of Rice Quality Under Various Growth and Storage Conditions and Its Evaluation Using Spectroscopic Technology," Appl. Spectrosc. Rev., vol. 56, no. 6, 2021.

[4] A. K. Bhoi and S. K. Nayak, "Rice Grain Classification Using Image Processing Techniques," in Proc. IEEE Int. Conf. Communication and Signal Processing, 2019.

[5] S. S. Nandhini and R. S. Kumar, "Quality Evaluation of Rice Grains Using Machine Learning Models," in Proc. IEEE Int. Conf. Intelligent Computing and Control Systems (ICICCS), 2020.

[6] H. Y. Tran, T. D. Nguyen, and P. D. Nguyen, "Rice Variety Identification Using Convolutional Neural Networks," IEEE Trans. Instrum. Meas., 2021.

[7] D. K. Simhadri and S. Kondaveeti, "Rice Quality Analysis Using Morphological Techniques," in Proc. Int. Conf. Communication, Computing and Internet of Things (IC3IoT), 2022, pp. 289–293.

[8] C. C. Chen et al., "A Hybrid Method for Cereal Grain Identification Using Morphological and Color Features," Pattern Recognit. Lett., vol. 34, no. 5, pp. 581–589, 2013.

[9] S. S. Roy et al., "Automated Classification of Rice Kernels Based on Geometric Features and Chalkiness Using Computer Vision," Comput. Electron. Agric., vol. 165, Art. no. 104961, 2019.

[10] T. L. Liu et al., "Quality Assessment of Rice Using Convolutional Neural Networks and Other Machine Learning Techniques: A Comparative Study," Curr. Agric. Res. J., vol. 12, no. 2, 2024.

[11] P. K. Jha et al., "Rice Quality Analysis Using Image Processing," Int. J. Adv. Res. Sci. Commun. Technol. (IJARSCT), vol. 2, no. 2, 2022.

[12] H. H. Tuan et al., "Rapid Testing System for Rice Quality Control Through Comprehensive Feature and Kernel-Type Detection," Foods, vol. 11, no. 19, 2022.

[13] S. D. Al-Ansi et al., "Rice Variety Classification Using Machine Vision and Deep Learning Techniques," J. Food Sci. Technol., vol. 59, no. 7, pp. 2707–2719, 2022.

[14] K. J. P. P. D. A. Silva et al., "Transfer Learning with Pre-Trained CNN Models for Rice Leaf Disease Classification," Comput. Electron. Agric., vol. 163, Art. no. 104845, 2019.

[15] R. U. Islam et al., "A Hybrid Vision Transformer and ResNet18 Based Model for Biotic Rice Leaf Disease Detection," Front. Plant Sci., vol. 16, 2025.

[16] B. P. H. T. H. Sun et al., "Review on the Application of Hyperspectral Imaging in Rice Quality Inspection," J. Food Eng., vol. 285, Art. no. 110099, 2020.

[17] M. H. F. S. Sultana et al., "Rice Grain Quality Parameters and Determination Tools: A Review on the Current Developments and Future Prospects," Int. J. Food Prop., vol. 25, no. 1, pp. 1063–1078, 2022.

[18] Y. Zhang et al., "Evaluation of Cooked Rice for Eating Quality and Its Components in Geng Rice," Foods, vol. 12, no. 17, 2023.