Deep Learning Based Approach for Rice Classification

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I. Abstract

The majority of importers rely on the producer for the quality and category of rice which may be unreliable. Rice production is a risky business involving unpredictable circumstances, high competition, lower margins and more which creates strong greed in the market for profits. Currently non-destructive rice classification methods have been developed using CNN, which uses hyperspectral imaging, but the classification algorithms are not optimized to distinguish different rice varieties effectively. They do not meet the rice industry standards which includes the use of multiple samples and multiple algorithms. They have not used the latest industry technologies to capture data and hence improving the data quality for better classification. We researched the major types of rice breeds and based on the top majority based on export quantity and revenue generated, we have developed an optimized algorithm using the latest VGG network which is a deeper CNN with multiple layers. Previous researchers were able to segregate rice, while we have achieved highly improved accuracy scores. Our algorithm, using VGG has been able to remarkably distinguish between major rice varieties with an accuracy above 99%. These rice varieties are the top contributors in the world import-export markets. This algorithm can be implemented by integrating it with the latest hardware and can be a breakthrough in the multi-billion-dollar industry.

II. Introduction

The global rice market is estimated to be valued at about 300 billion dollars. Major exporters include China, India, Bangladesh, and majorly south-east Asian countries. The world trade by rice is $26.8 billion dollar business (source). In 2020, the top exporter of rice was India standing at exports of $8.21 billion, followed by Thailand at $3.88 billion, Vietnam at $2.74 billion, Pakistan at $2.14 billion and the United States at $1.92 billion. Top importers being China, Saudi Arabia, the United States, Philippines and Iran. While rice is such a basic commodity all around the world, it is consumed by all nations. Rice ranks in the 1001st position in the Product Complexity Index (PCI). The Product Complexity Index indicates the product know-how and various factors involved with the production of the product. The higher the Product Complexity Index, the more complex it is to produce a product and fewer countries can do so. This industry, despite having enormous revenue, is not sufficiently regulated with norms in regard to regular consistency checks. Rice is classified mostly based on the shape, colour, and size of the grain. People used to execute this process manually, but it is no longer appropriate in the digital era because it is time consuming and costly. Furthermore, because manual approaches are limited to the experience of the evaluation experts, the result may differ. When handling a large-scale assessment, quick decision-making using manual approaches can be difficult as well. There have been classification algorithms for grain categorization but it is not reaching the most accurate results, therefore, we conducting an improved one with VGG architectures, which can dive deeper to multiple layers and hence be able to return the highest percentage of correctness in classifying

III. Literature Review

1. General papers

1.1. A novel deep learning-based approach for seed image classification and retrieval

This paper studies two plant seed datasets and classifies their family through deep learning techniques. The accuracy for both the seeds analyzed is 95.65% and 97.47%.

Image analysis plays a huge role in the field of life sciences, it is essential for understanding medical characteristics or performing significant quantitative measurements of image objects. The use of technology in agricultural work started at the beginning of the 20th century. Technological advances helped in the collection of big data that makes up the environment of current information technology. Deep learning is a modern technique for image processing and data analysis. It offers promising results and has great potential. A lot of works in this literature focus on identification and classification of obstacles, concentrating on issues such as weed detection and soil analysis. There is no paper which uses deep learning approaches to classify single seeds

The research focuses on plant seeds from two points of views: classification and retrieval. Both have been performed with CNN and compared with deep learning or traditional approaches. Their contribution is i) proposing SeedNet, a brand-new CNN to perform classification and retrieval of seed images, ii) extensively comparing proposal with ten state-of-the-art CNNs; iii) comparing our CNN with four classical machine learning approaches, trained with handcrafted (HC) features; iv) propose two brand new seed datasets of single crops, obtained with a concrete pre-processing step.

In this paper a new CNN architecture SeedNet was introduced. In addition to it, the performances of different CNNs were studied and compared SeedNet for both tasks by using two very different datasets. The aim was to evaluate the possibility to find the architecture of the best performing model and the best training options for these issues. We also compare deep against traditional machine

2. Rice classification related Paper

2.1. Review of Rice Crop Identification and Classification using HyperSpectral Image Processing System

This paper works on a neural network for classification of rice varieties. A total of 9 datasets were used in the study. Algorithms were developed using six color features and fifteen texture features from color images of individual seed samples. The identification of rice seeds is very important when classifying rice. The grade and price of rice is determined by these factors. With the power and memory of machines they can be used for inspection of agricultural products.

250 grams of grain samples from 9 rice varieties were selected as experimental seed materials. The image acquisition was done using a Sony DSC-W270 digital camera. Neural network models were designed and developed using Matlab toolbox. Initially individual neural network models were created for each feature set (color, morphology and texture) separately. Then a combination of feature set model was implemented. In order to reduce the dimensions of the input feature set, principal component analysis was applied.

The MLP model had a classification accuracy of 33%. The optimal feature model increased it to 44%. Colored Model of MLP produced a classification of 51%. In the combined model with all three sets had an accuracy of 92%. The paper presents classifications of rice seeds using improved classification accuracies were obtained when the network trained with the optimal data set.

2.2. Rice Classification Using Hyperspectral Imaging and Deep Convolutional Neural Network

Rice has been one of the most important foods that contribute to human food. Many rice varieties have been cultivated, imported, and exported worldwide. Rice impurities could spoil the trust between exporters and importers, causing a need to develop a rice variety inspection. The data from rice seeds is acquired using an optical imaging system. There are two types of features that are used for these methods: spatial features and spectral features. Common spatial features that describe the visual appearance of a rice seed include shape, morphological, and textural features. Using a hyperspectral imaging camera can be used to get information from a wider range of electromagnetic spectrum. The purpose of this paper was to develop a technique to improve the accuracy of rice dataset classification. A Spatio-Spectral Deep Convolutional Neural Network has been used. A residual network has been modified and extended with bottleneck building blocks to enable spatio-spectral data classification. Two datasets, of processed rice and paddy rice, were acquired from the hyperspectral imaging system and used to assess the performances of the classification methods. The training split used was 85% training and 15% for testing. A deep CNN that automatically performed spatio-spectral feature extractions without any predefined data processing steps was used to classify the rice variety of each rice seed. Using two types of rice datasets, the method yielded higher classification accuracies than the most commonly used classification methods based on SVM. The proposed method achieved 91.09% mean classification accuracy for the paddy rice dataset, which consisted of the rice varieties that have been frequently mistaken for the others, compared to 79.23% obtained from SVM with both spatial and spectral information

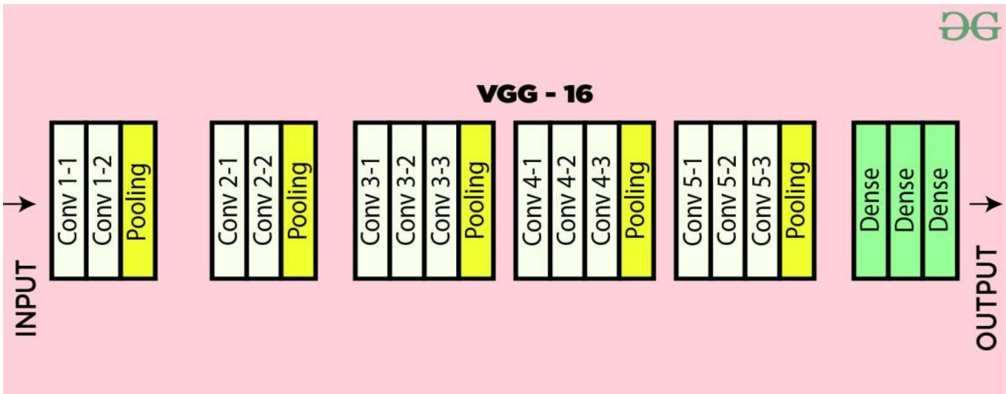
2.3. Review of Rice Crop Identification and Classification using HyperSpectral Image Processing System

Multispectral data is not a great dimensionally data, and so it is not able to detect materials accurately. A material may display distinct spectral properties over a particular narrow wavelength range, making it distinguishable from other materials only in images recorded over that wavelength range. A Multispectral scanner may not cover this spectral range, particularly if the range is outside the range for detection of the principal materials known to be present at the scene. To make them differentiable few spectral bands are not sufficient i.e. multispectral data is not sufficient to differentiate the two different objects with different properties in the limited (same) numbers of bands or using same wavelength. Therefore more bands are needed to increase the object distinguishing.

IV. Approach Description

We conducted a Visual Geometry Group (VGG) whose layers use a very small receptive field (3x3, the smallest possible size that still captures left/right and up/down), this is simply a Convolutional Neural Network (CNN) with multiple layers. Since the normal CNN cannot help us classify the grain with the best probability of correctness, we decided to use Simplified VGG and VGG16

VGG16 is a CNN architecture that is considered to be one of the best vision model architectures made till today. VGGNet-16 supports 16 layers and can classify images into 1000 object categories, including keyboard, animals, pencil, mouse, etc.



VII. Experimental Testing

We built the architectures based on the Rice Image Dataset, which was released in the year 2021 and is taken from 5 different classes namely Basmati, Arborio, Jasmine, Ipsala, Karacadag. These are five different varieties of rice often grown in Turkey. The dataset itself contains 75,000 grain pictures with 15,000 from each of these types.

In the first model, we created Simplified VGG architecture. technically, this has 4 Convolutional layers using 3x3 kernel filters, 2 Max Pooling layers, 2 Dense layers and 1 Fully Connected layer. Being conducted on Google Colab boosted by Google's free GPU, it has successfully executed 45 minutes and stops early at epoch 13th since there was no improvement during 3 continuous epochs (epoch 11, 12, 13). Eventually, it returns an amazing number of 99.22% accuracy with optimizer Adam.

Statistical results based on Simplified VGG architecture

	precision	recall	f1-score	support
Arborio	0.986259	0.988889	0.987572	2250.000000
Basmati	0.996864	0.988889	0.992860	2250.000000
Ipsala	1.000000	0.997333	0.998665	2250.000000
Jasmine	0.986356	0.996000	0.991154	2250.000000
Karacadag	0.991541	0.989778	0.990658	2250.000000
accuracy	0.992178	0.992178	0.992178	0.992178
macro avg	0.992204	0.992178	0.992182	11250.000000
weighted avg	0.992204	0.992178	0.992182	11250.000000

Move the second one, VGG16 in this case, it has 13 Convolutional layers using 3x3 kernel filter, 5 Max Pooling layers and 3 Dense layers. For this one, it uses 2 layers set in total with 16 weight layers. Similarly, this VGG16 architecture runs with Adam optimizer and on Google Colab equipped with GPU, and the total run time was around 40 minutes while early stopping at the eleventh epoch. The accuracy was slightly higher

Statistical results based on VGG16 architecture

	precision	recall	f1-score	support
Arborio	0.986259	0.988889	0.987572	2250.000000
Basmati	0.996864	0.988889	0.992860	2250.000000
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Karacadag	0.991541	0.989778	0.990658	2250.000000
accuracy	0.992178	0.992178	0.992178	0.992178
macro avg	0.992204	0.992178	0.992182	11250.000000
weighted avg	0.992204	0.992178	0.992182	11250.000000

Comparable results: Our model's error rate is less than 1%, indicating that it is feasible. In comparison to previous models, which achieve just 99% or nearly 98% accuracy, this model performs better with higher accuracy, and the runtime with GPU is not too long for training, lasting no more than 45 minutes.

IV. Conclusion and Future Work

In this work, we developed two Convolutional neural network models which are Simplified VGG which contain 7 weighted layers, and VGG16 with 16 layers. The two models all bring out the practical results which are higher than 99% and low runtime. In the model we overcome the 2D dataset with just 75,000 pictures for 5 types of grain and bring out very good results. Using a deep CNN that autonomously retrieved spatio-spectral characteristics without the requirement for any specified data processing techniques, the classification of the rice variety of each rice seed was accomplished. The Simplified VGG brings out the result of 99.22% accuracy when the VGG16 with a deeper architecture has 99.39% accuracy but the runtime of two models with early stopping callback.

Our research is not complete and still has some limitations that could be transformed into future work. These would be conducting more different types of algorithms such as RNN and ANN to compare the effectiveness of them to CNN architectures, we can also identify the paddy grain quality just by physical appearance, which is wonderful. Another limitation is that we have not tested on diverse type of rice, in the later work, we can do research on Sushi rice or similar grain.

V. Reference

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