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Classification of Lemon Quality Using the Residual Convolutional Neural Network Deep Learning Model

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Abstract **–** Determining lemon quality is an important post-harvest process. Lemon producers want the lemon quality classification process to be done correctly. In this way, the monetary return they will receive will be right for them. In this study, lemons with good quality and bad quality images were classified. 951 images for bad lemons and 1125 good quality images were used in the dataset. Convolutional Neural Networks (ResCNN) deep learning model and 5-fold cross validation process were performed in lemon classification process. As a result of the statistical measurements, the highest accuracy value was obtained as 0.8848 for both lemon varieties as the average value. While the highest sensitivity value was obtained from good quality lemon as 0.9013, the highest specificity value was obtained as 0.9013 from bad quality lemon variety.

Keywords – Lemon Varieties, Deep Learning, Rescnn, Classification, Deep Learning

I. INTRODUCTION

Today, the use of deep learning models in every field has expanded significantly. It is possible to see similar applications and automations in the field of agriculture. There are many studies on classification in the literature. Boumaraf et al. carried out their experimental studies on the BreakHis dataset using the ResNet-18 network transfer learning method, and their evaluation results achieved 98.2% test accuracy in binary classification [1]. Saini and Susan proposed a model with pre-trained layers of the VGG16 network trained on the ImageNet object classification dataset [2]. Vinay Kukreja et al. In their study, classification was made with an AlexNet-based CNN on the citrus plant. Classification was made in 2 categories as healthy and diseased. They trained a CNN model with these data and reached 89.1% accuracy as a result [3]. Ravikumar Chakali et al. in their study, a study was conducted on the detection of leaf disease in pomegranate plants. It reached 90% accuracy by training the CNN model with 54306 images and classifying it for 38 classes [4]. Islam et al. conducted an image classification-based machine learning study for the detection of diseases in the papaya plant and the authors got the best results when they used CNN with 98.4% [5]. Marcum et al. in their work, they worked with high resolution images on large areas of the earth's surface. With the ResNet-101 network, an average accuracy of 98.2% was obtained [6]. Bakhshi et al. proposed a genetic algorithm that could potentially discover suitable architectures and optimize hyperparameters for a given image processing task [7]. Becker et al. in their study, pre-trained deep learning models provided better accuracy compared to other models tested with 12 image magnification, with an accuracy rate of 70.4% [8]. Foamy et al. in their study, they proposed a new method to achieve better performance and reported that they increased it by 5.14%, 5.85%, and 2.29%, respectively, by testing it on different datasets [9].

The aim of this study is to classify good and bad quality lemons using ResCNN deep learning models. In this way, it helps to determine the real

monetary values of lemons according to the quality of the lemons.

II. Materials and Method

Residual networks as ResNet; It is a CNN-based deep learning model that contains the building blocks of more than one residual learning depending on the number of layers [10]. The ResNet block structure is shown in Figure 1. [11].

In the figure, x is the solid-line residual link that carries the layer input to the aggregation process. Shortcut links are those that bypass one or more layers. With residual blocks, inputs can propagate more quickly over links remaining between layers.
There are 2 different lemon types in the dataset used in this study. The images of bad quality and good quality lemon varieties are shown in Figure 2. and Figure 3. Experimental studies were conducted with a total of 2076 images [12].

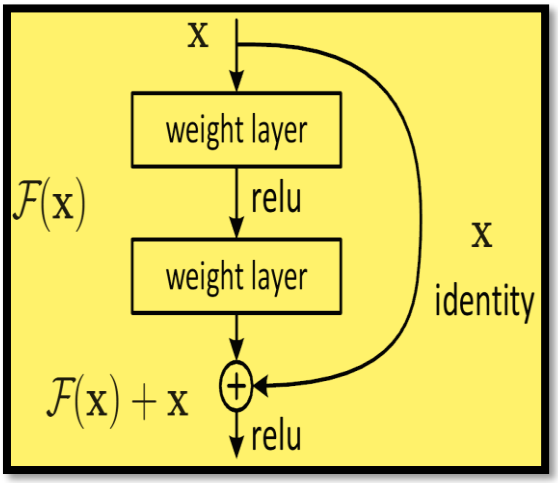


Figure 1. Structure of the Residual Block.

Figure 2. Bad quality lemon images

III. Experimental Results and Discussions

In order to evaluate the classification performance of artificial intelligence techniques, the error matrix (CM) is used in almost every study, where the predictions and actual values are compared. In this study, experimental studies on the database were tested statistically.
CM results and ROC curves obtained from Fold 1 to Fold 5 using ResCNN are shown in Table 1 to Table 5 respectively.

Figure 3. Good quality lemon images

Table 1. 1. Fold results

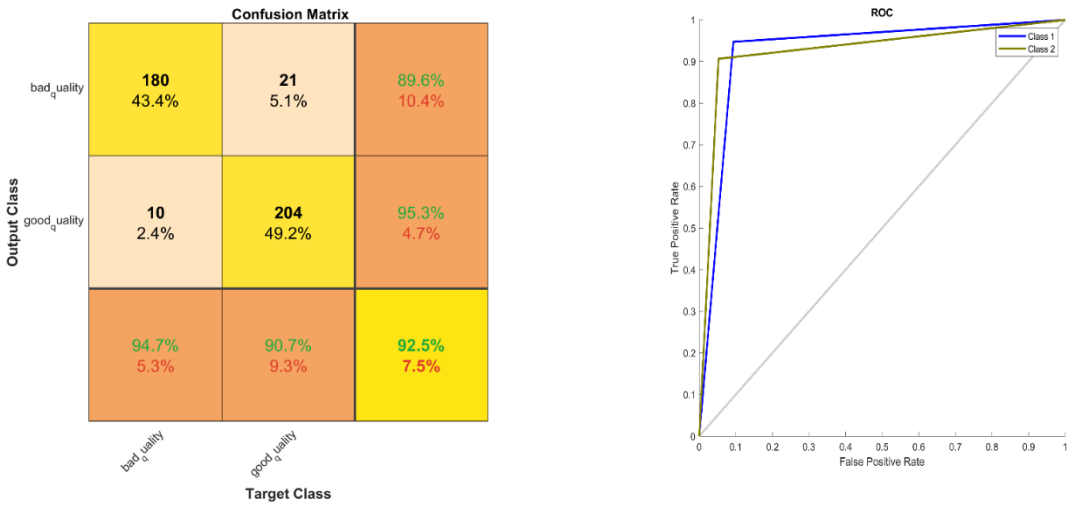


Table 2. 2. Fold results

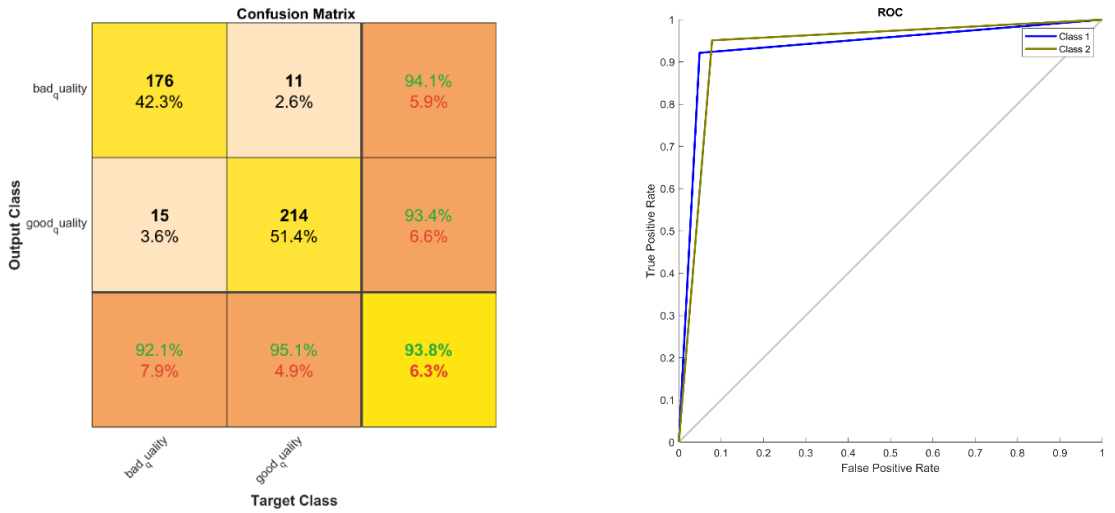


Table 3. 3. Fold results

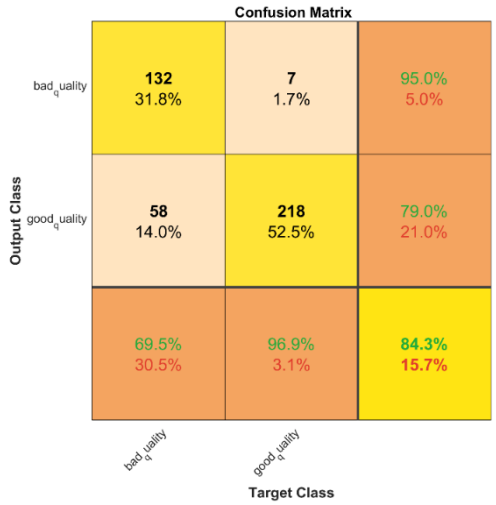
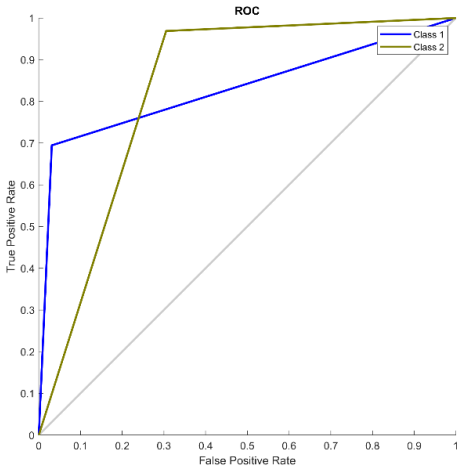
	

Table 4. 4. Fold results

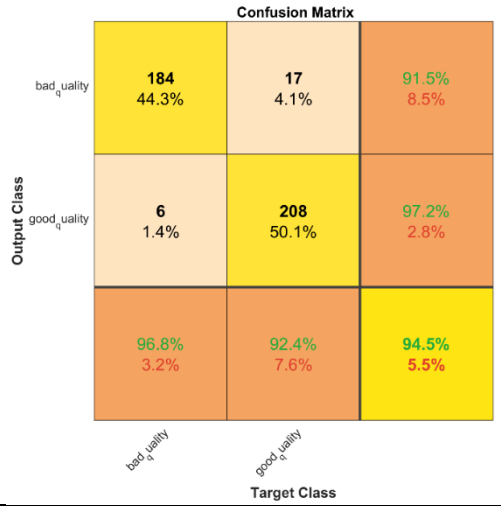
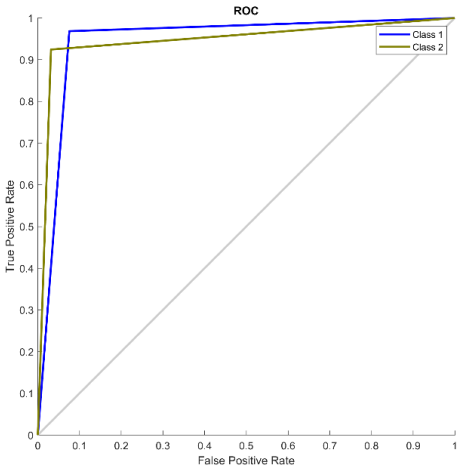
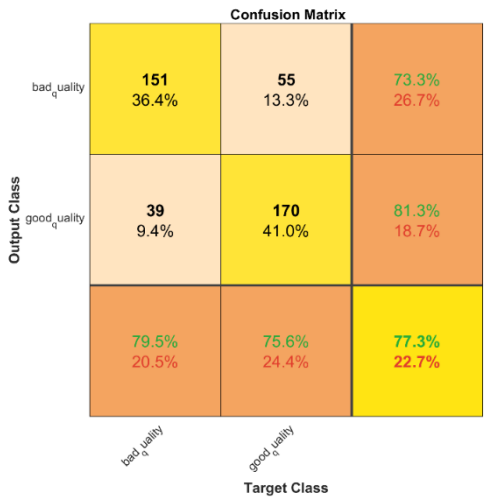
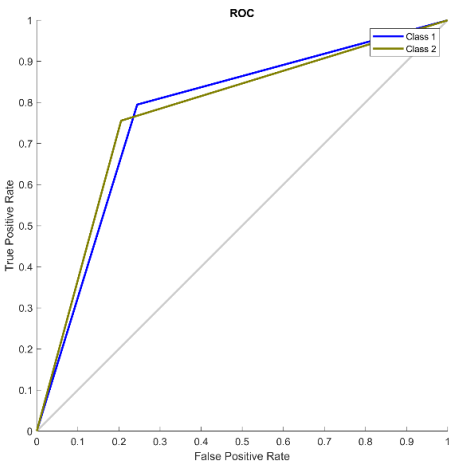
	

Table 5. 5. Fold results

The 5-fold average of the CM results obtained from ResCNN is shown in Table 6..

Table 6. Average of Fold values

	Bad_quality	Good_quality
precision	0.886954	0.892597
sensitivity	0.865346	0.901333
specificity	0.901333	0.865346
accuracy	0.884849	0.884849
F-measure	0.871633	0.894679

When we examine Table 6, it is seen that the highest average accuracy value for 5 folds is obtained from the good quality lemon variety as 0.901333. It is seen that the highest F-measure value was also obtained from the good quality lemon variety as 0.894679.

IV. Conclusions and Future Work

Marketing of agricultural products is of great importance for both the producer and the consumer. It is very important that the products are correctly separated into certain classes after they are harvested. In this study, a lemon quality control dataset consisting of a total of 2076 images and a size of 300x300 was used. ResCNN, a deep learning model, was used for classification of 2 different lemon varieties in the data set. In the classification process, the sensitivity value was 0.99799 for the bad quality lemon variety, while the precision value was 0.8925 for the good quality lemon variety. In future studies, hybrid models can be developed by using different models.

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