Indonesian Journal of Electrical Engineering and Computer Science
Vol. 37, No. 3, March 2025, pp. 1682~1691
ISSN: 2502-4752, DOI: 10.11591/ijeecs.v37.i3.pp1682-1691

Classification of traditional Joha rice using deep neural network

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Article Info

Article history:

Received Jun 19, 2024
Revised Sep 15, 2024
Accepted Oct 7, 2024

Keywords:

Convolution neural network
Dataset
Flatten
MATLAB
Optimizer

ABSTRACT

Rice is the major food for the most of the people in the world. It is grown comfortably in a rain fed area. Rice is called a kharif crop in India. According to the International Rice Research Institute (IRRI) classification rice is classified as Ahu, Sali, Boro and Hill rice. In north eastern India the Joha rice is mainly cultivated in the state of Assam. There are many varieties of Joha rice like Kunkuni, Rampal, Manipuri, Tulshi, and Keteki. But it is quite complex for the farmers as well as the common people to differentiate these type of Joha rice due to their morphological structure. Initially this type of classification done by naked eyes or used some laboratory experiments. But due to the tiredness and some external factors it is not fruitful. Some of the image classification technologies are used in classification as well identification of rice in different research work using MATLAB. At present deep learning plays a tremendous role in image analysis in agricultural domain. Here in this paper we take two verities of Joha rice which are closer in morphological structure and cannot be separated by our naked eyes. Using deep neural network, binary classification is done in these Joha rice.

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1. INTRODUCTION

In agricultural domain, different problems are occurs in classification as well as identification of rice. These problems are solved sequentially using some image analysis techniques. The prominent and accurate results in classification of rice will give effective information for the farmers and the common people. At the initial state if rice is not classified properly it is not possible to get better results in terms production which will directly affect the market value of the rice. In northeast regions in India particularly in the state of Assam Joha rice is cultivated in different regions. It is scented rice under the Sali rice. According to the application of Assam Agricultural University Geographical Tag (GI) tag has registered to “JOHA RICE OF ASSAM”. There are different varieties of Joha rice cultivated in different district of Assam. But still there is a massive gap between the famers as well as the customers in terms of identification and classification of these types of Joha rice.

Different Joha rice has different characteristics like their superfine kernel, unique aroma, and better cooking properties. So, farmers as well as customer always confused whether they have selected the proper variety what they want. Because any mixing up seeds will give poor result in terms of production and their nutritious value. Some of the varieties of Joha rice have a microscopic difference in physical structure as well as in colours and these differences are not possible to identify them from naked eyes. So, main aim of our work is to facilitate the farmers as well as customer for identifying these varieties by using their own mobile phones.

In the related research works most of the classification and identification done on MATLAB. For collecting the samples some researcher used random sampling procedure [1]. After collecting the images some of the researchers have used hand handled mobile phone for taking the images. Some of the researchers took their images in black background and used kernel whiteness [2] and binarization [3] process for reducing the noise. After image acquisition, filtering techniques were used by some of the researchers. In most of the work, the filtering techniques were implemented by using the Gaussian filter and median filtering [4], [5] to enhance the quality of the images. In some of research works, morphological operation like morphological opening [6], morphological closing [7] and thresholding [8] techniques were used for the image enhancement purpose. Next depends on the size and shapes of the images the dilation and the erosion method were used for enhanced the quality of the images. Some researcher used Otsu's method [9], [10], canny edge detection [11] and random transform [12] for segmenting the images. For classification purpose, some researcher classified rice seeds by combining RGB and hyperspectral images [13] and extracting fourier feature [14] from grain images. The different classifiers used by different researchers and their accuracies are shown in Table 1.

Table 1. The accuracy obtained by different researchers

References	Class	Classifier	Accuracy (%)
[15]	7	SVM prediction using ICA based feature selection	95.14
[16]	6	Back propagation neural network	95.00
[17]	9	MLP	92
[18]	3	Multi-layer feed forward neural network	97
[19]	5	ANN	98.8
[20]	5	MLP and Neuro-Fuzzy Network	98
[21]	5	Fuzzy Inference System	89.8
[22]	4	Weka Machine Learning software	95.2
[23]	2	ANN	76.7
[24]	2	CNN	99.31
[25]	3	AlexNet	91.23
[26]	3	KNN	100
[27]	3	Multi-class SVM	92.22
[28]	4	A Neuro-fuzzy cascade network	96.75
[29]	14	SVM	83.9
		DNN	95.14
[30]	5	ANN	99.87
		DNN	99.95
		CNN	100
[31]	8	DNN	89.4
[32]	5	RF	99
		DT	99

By comparing the results obtained by the different researchers from Table 1, the best result was achieved by using the convolution neural network (CNN) model. So, achieving a prominent and accurate result we have trained InceptionV3 model by our own dataset.

2. METHOD

We have collected five varieties Joha rice namely Kunkuni Joha, Keteki Joha, Manipuri Joha, Rampal Joha and Soru Joha for the classification purpose. Among these varieties Keteki and Manipuri Joha are almost same in their physical structure and colour. So, we take these two varieties for binary classification. We have completed our work in three steps. Figure 1 shows all the steps for completing our work. The steps from the Figure 1 can be explained as follows:

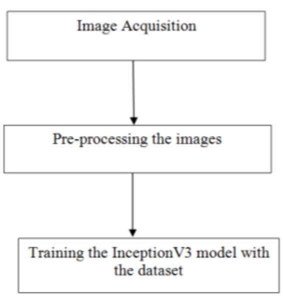


Figure 1. Steps for the proposed work

2.1. Image acquisition

For binary classification of Joha rice we take 640 images of Keteki Joha and 660 images of Manipuri Joha cultivated in different parts in Assam, India. The image acquisition is carried out with OPPO A96 android mobile where the camera has the following properties: main camera: 50MP, f/1.8, FOV 77°, 5P lens, AF. The images of the samples of rice are taken at same distance from the surface. For reducing the noise a black surface is used as a background.

2.2. Pre-processing the images

Before processing the images, we have stored the images with proper labelling. The images are stored as in the Figures 2 and 3.

Figure 2. The stored images of Manipuri Joha

Figure 3. The stored images of Keteki Joha

Each image has the following properties:
Dimensions: 3072×4080
Width: 3072 pixels
Height: 4080 pixels
Horizontal resolution: 96 dpi
Vertical resolution: 96 dpi
Bit depth that is the number of bits used to define each pixel is 24.

For morphological structure we use the vernier caliper for measuring the length and width of the sample of rice. We take 10 samples for measuring the length and the breath of Manipuri Joha is shown in the Table 2. From the Table 2 the average length and breadth of Manipuri Joha are 7.84 mm and 1.04 mm. Similarly the length and the breadth of 10 samples of Keteki Joha are shown in the Table 3. From the Table 3 the average length and breadth of Keteki Joha are 8.06 mm and 0.99 mm.

Table 2. The lengths and breadths of Manipuri Joha

Length (mm)	Breadth (mm)
7.76	1.03
7.78	1.01
7.65	1.07
7.86	1.05
7.74	1.00
7.81	1.03
7.73	1.05
8.05	1.08
8.17	1.06
7.84	1.02

Table 3. The lengths and breadths of Keteki Joha

Length (mm)	Breadth (mm)
7.48	0.99
8.25	0.98
8.28	1.00
8.06	0.95
8.05	0.98
8.15	1.12
7.99	0.99
8.16	0.98
8.21	0.99
8.01	1.01

2.3. Training the model with our own dataset

For binary classification we take 1,000 images for the training and 300 samples for testing the model. There are different types CNN model available like InceptionV3, ResNet, and VGG16. for image identification and classification. The InceptionV3 model has several advantages for food image classification. It has been successfully implemented in various research works, achieving high accuracy. So, for Training our dataset we use the InceptionV3 pre trained model. The libraries for building the model are shown in the Figure 4.

```
import numpy as np
import matplotlib.pyplot as plt
import pandas as pd
from keras.layers import Dense, Flatten
from keras.models import Model
from keras.applications.inception_v3 import InceptionV3,preprocess_input
from keras.preprocessing.image import ImageDataGenerator
import keras
```

Figure 4. The libraries used for the model

In our work NumPy is used working with arrays and Pandas is used for working with the dataset. Before training the model, images are processed using ImageDataGenerator according to the requirement of the IncepionV3 model. The model is shown in the Figure 5. Here the output of the base model add to the flatten layer which converts the multi-dimensional array into flattened one dimensional array. The code shown in Figure 6 for compiling and displaying the summary of the model.

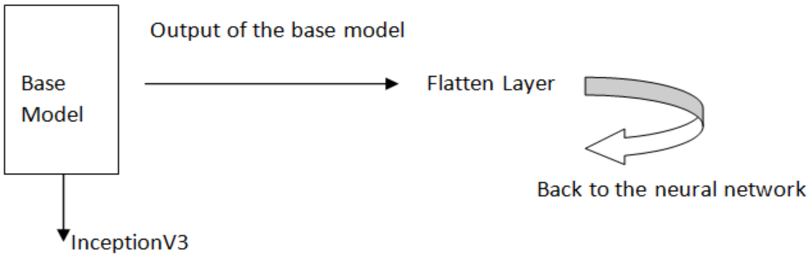


Figure 5. Final model

```
X = Flatten () (base_model.output)
X = Dense (units=2, activation='sigmoid') (X)
model = Model (base_model.input,X)
model.compile(optimizer='adam',
loss=keras.losses.binary_crossentropy,metrics=['accuracy'])
model.summary()
```

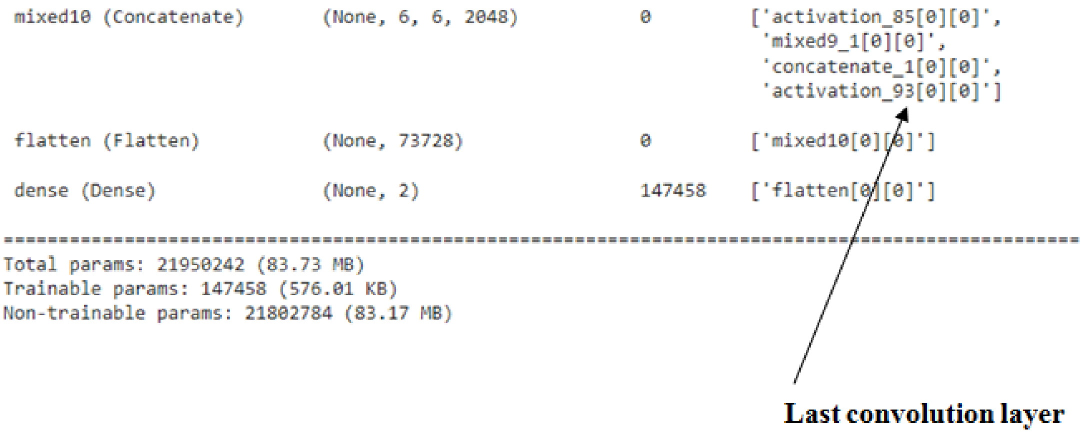
Figure 6. Code for displaying the summary of the model

For activation purpose we have used the Sigmoid function as we are working on binary classification. The sigmoid function is calculated as (1).

$$S(x) = \frac{1}{1+e^{-x}} \quad (1)$$

Where x is the input to the sigmoid function.

The Adam optimizer is used for the optimization purpose. In our experiment the Adam optimizer minimize the loss function during the training of the model. The last convolution layer from the summary of the model is shown in the Figure 7.



```
mixed10 (Concatenate)     (None, 6, 6, 2048)    0        ['activation_85[0][0]',
                                                          'mixed9_1[0][0]',
                                                          'concatenate_1[0][0]',
                                                          'activation_93[0][0]']

flatten (Flatten)         (None, 73728)         0        ['mixed10[0][0]']

dense (Dense)             (None, 2)             147458   ['flatten[0][0]']

==================================================================================
Total params: 21950242 (83.73 MB)
Trainable params: 147458 (576.01 KB)
Non-trainable params: 21802784 (83.17 MB)
```


Figure 7. Last convolution layer of the model

3. RESULTS AND DISCUSSION

When training the model we set number of epoch is 10. After the first epoch the loss versus accuracy is 5.9939 and 0.4400. As we use the Adam optimizer the loss function is gradually decrease and after the 7 epoch the accuracy is improved and achieved highest accuracy 96%. The loss and accuracy graph is shown in the Figure 8. In Figure 8 the blue colour line shows the accuracy line.

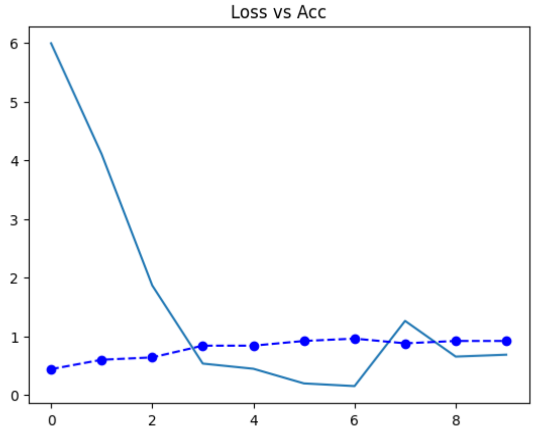


Figure 8. The loss and accuracy graph

After training the model we have to validate our model. For validating purpose, we take any random image sample from the testing dataset. If we take a random image sample of Keteki Joha, the validation process is shown in the Figure 9. Again, if we take any random sample of Manipuri Joha the validation process is shown in the Figure 10.

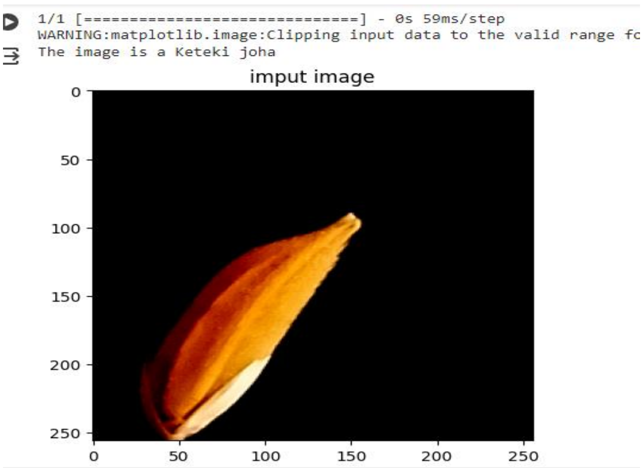


Figure 9. Validation of the model with Keteki Joha

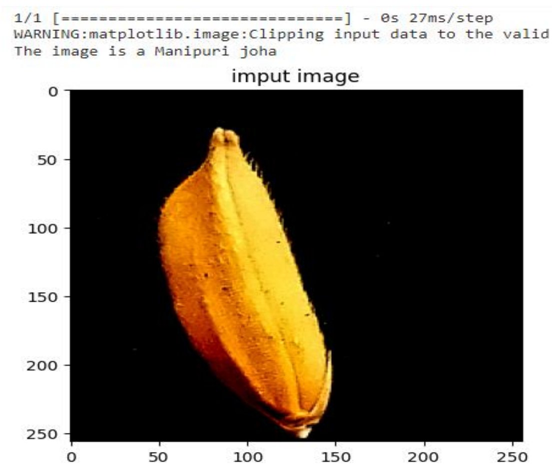


Figure 10. Validation of the model with Manipuri Joha

After validation of the model, we try to visualize the features that make the image of Keteki Joha separate from the image of Manipuri Joha. For this purpose we have used the gradient class activation map (GRAD-CAM) method. In this method we first create an image with RGB colorized heatmap of the original image of Keteki Joha. The heatmap image of Keteki Joha is shown in Figure 11. Now the heat-map image is super-imposed on original image. The superimposed heatmap image of Keteki Joha is shown in Figure 12.

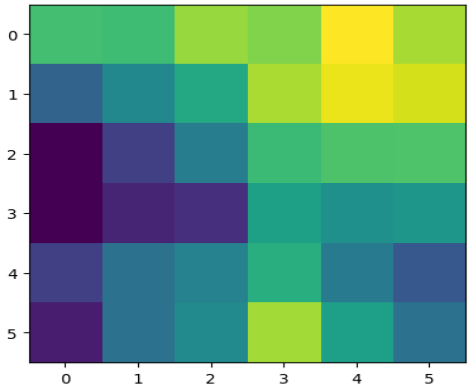


Figure 11. The heatmap image of Keteki Joha

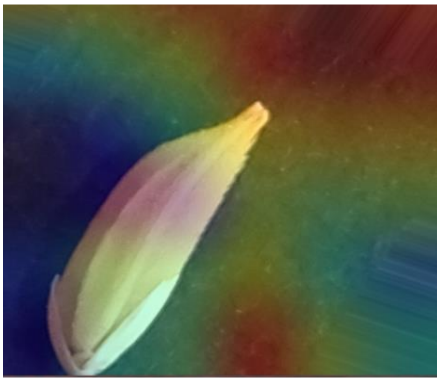


Figure 12. Image with heatmap representing region of interest of Keteki Joha

When we try to map the original image to the heatmap image, the Grad-CAM method will take the top portion of the Keteki Joha rice as an important region for separating it from Manipuri Joha. In the similar way we get the colorized heatmap image of the Manipuri Joha which is shown in Figure 13. Now the heat-map image is super-imposed on original image. The superimposed heatmap image of Manipuri Joha is shown in Figure 14.

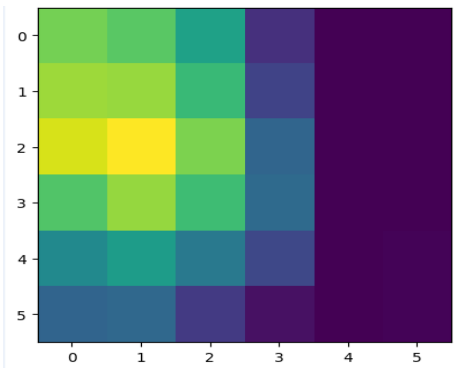


Figure 13. The heatmap image of Manipuri Joha

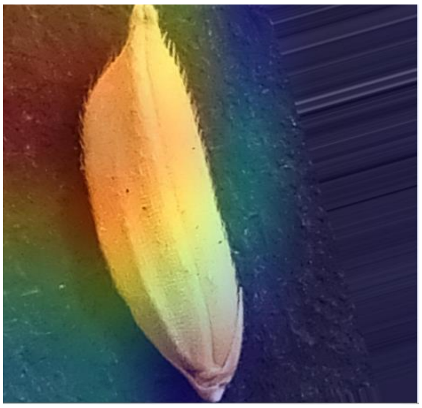


Figure 14. Image with heatmap representing region of interest of Manipuri Joha

When we try to map the original image to the heatmap image, the Grad-CAM method will take the top and middle part of the Manipuri Joha as an important region for separating it from Keteki Joha. The functions for implementing GRAD-CAM method is shown in the Figure 15.

In our case the prediction gradcam_heatmap is defined by as follows

```
def make_gradcam_heatmap(img_arr , model , last_conv_layer_name , pred_index = None):
 grad_model = tf.keras.models.Model(
 [model.input] , [model.get_layer(last_conv_layer_name).output , model.output]
 )
```

For saving and displaying purpose we have used the following functions

```
def save_and_display_gradcam(img_path , heatmap , cam_path = "cam.jpg", alpha = 0.4):
```

For image visualization purpose we have used the following codes

```
def image_prediction_and_visualization(path , last_conv_layer_name = "conv2d_93" , model = model):
```

Last convolution layer

Figure 15. Functions of GRAD-CAM method

4. CONCLUSION

The overall accuracy depends upon how images are captured in different situations. Initially we have collected the images and stored in the different folders. The length and breadth of the different varieties of Joha rice are measured with the help of vernier calliper. Some of the verities of Joha rice are almost identical in terms of length, breadth and colour. It is not possible to identify a particular type of Joha rice among their different varieties. We take two varieties Keteki Joha and Manipuri Joha which is almost same in terms of the morphological structure. The images of these two types are taken from the same distance. At the initial state, we are not aware the background of the images resulting extra noises added in the images. After that for every single image we have taken black background. In black ground the noises are reduces in comparison of the other background. In the previous research works, best result was found using the CNN model. Here in our research work we choose pre trained InceptionV3 model. In this model the output of the base model is feed into the flatten layer. We have got best result using this model and reached the highest accuracy. After validation of our model, we have implemented the GRAD-CAM method for understanding that how machine will take regions of the images for separating one image from the other. Here we have done binary classification with 1,000 images. There are other CNN model like VGG16, and ResNet. which can also be trained with our dataset with more images. In future, these models can be trained for multiple classification of Joha rice using vast dataset according to the requirement of the rice industries.

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