IMAGE ENHANCEMENT AND CLASSIFICATION OF CIFAR-10 USING CONVOLUTIONAL NEURAL NETWORKS

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***Abstract*— A new architecture for enhancement of image and image classification is developed based on the image processing techniques and Convolutional Neural Multi class Networking Algorithm. Classification and enhancement of images deals with the combination of two different concepts, image enhancement and image classification techniques by identifying useful information from the given input images. This method works on image quality assessment and improving the images for identifying the image class from the dataset. The enhanced image is classified to identify the class of input image from the CIFAR-10 dataset. CIFAR-10 dataset is used to train Convolutional neural network model with the enhanced image for classification. This dataset consists of ten classes like airplane, automobiles, cat, dog, frog, horse, ship, bird, truck in colored images. This dataset is used for training and testing of our model. CNN algorithm acts as a mid-way between the image processing and image classification in the network and it is a systematic hierarchy of analyzing the images and image operations on 32*32 images.**

***KEYWORDS*: Image Classification, Image Enhancement, Deep Neural Networks, Convolution Neural Network, Misclassified Images, Image Prediction.**

I. INTRODUCTION

Image Enhancement is a process of improving the quality and converting the object of the image more identical and clearer than the original image. The converted images are more likely used for problem solving. Enhancement of images is performed by certain different techniques based on the size, format and mode. The main Enhancement techniques are coloring, contrasting, brightening, and sharpening of images. Color Enhancement focus on improving the RGB color composition of images. Contrast Enhancement adjusts the structure of images in the visible differences. Brightness Enhancement concentrates on display quality improvement. Sharpness Enhancement / Edge Enhancement used for edge contrasting [20].

Convolutional-Neural-Network (CNN) is one of the Deep-Learning methodologies used for classification. Convolutional neural network is also called as space invariant artificial neural network. Convolutional-Neural-Network [19], [21] is used for classification to execute complex algorithms and complex data to emulate human recognition. It is most popularly used for image recognition in computer vision tasks based on pixels size of images in the network. CNN consists of 3 layers in the network like input layer were the input given is considered, hidden layer where the non-linear activation functionalities are performed and the output layer. All the layers are interconnected in the feed forward neural network.

Convolutional neural network consists of two main operations called feature-extraction operation and classification with three different layers as shown in Fig 1. The Convolutional Layer acts as the heart of the CNN to perform the dot product between two kernel matrices. Convolution layer using kernel spatial produces an activation map which gives a position of each and every spatial position of image. Max-pooling layer is used to reduce image spatial dimensions with respect to the convolution layer by decreasing the weights and computational size of images. Fully connected layer is used to represent the map between the input and output.

Convolutional-Neural-Networks [19], [21] are used for analyzing and classification of images sensibly in Deep Convolutional Layered Networks. Image Enhancement and classification paper gives a clear insight in dealing with all the possible image enhancement techniques to predict the actual animal's name in the Convolutional Network. This paper is a combination of two different techniques like Image Enhancement which is used for increasing the quality of the input images and image classification to predict the object in the enhanced image. The present existing paper related to these studies deals either classification or image processing. In this paper we aimed to develop a new architecture by giving input as the image and extracting the output in the text format using deep learning methodologies and enhancement techniques. This architecture is implemented with the CIFAR-10 dataset of animal images for identification and prediction of output for the given input image.

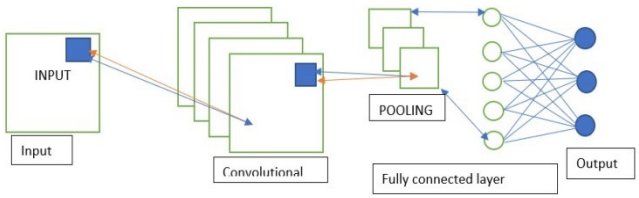

Fig.1. Convolutional Neural Network Architecture

II. LITERATURE SURVEY

The literature survey of this implementation deals with concept of Deep Learning which was discussed in different papers. Survey reveals the different concepts how the authors had handled various datasets using deep learning concepts. Convolutional-Neural-Network is one of the most important concepts in deep-learning to classify images, recognitions of objects, hand written digits in the real word. Convolution neural network with different operations the high accuracy is obtained when applied in problem solving.

Deepika Jaswal et al. applied Convolutional Neural Network to different dataset. They have tested the standard datasets with the deep learning concepts to measure the

accuracy and performance of the model [1]. How they are varying form one dataset to another datasets. The datasets used for testing the performance are remote sensing of aerial image data for analyzing different aerial images using CNN, SUN dataset image performance analyzing [1]. The authors of this paper performed some experiments by utilizing some of the quality metrics of datasets with deep learning algorithms and graphical representation of the analyzed dataset performance after testing [1] the datasets.

Manoj Krishna et al. [2] had discussed about the implementation of image classification in deep learning by considering the test and training images. In the test images the authors [2] had selected 4 images. The selected images from different areas were cropped according to the experiment requirements and the cropped images from the ImageNet and Alex Net datasets [2] are used for classification purpose. The results of this experiment were effective and predicted the correct classification in the 4 test images on which the experiment is performed.

Haris Ackar et al. [3] had discussed about the improving visual appearance of the images by applying various image processing technologies to obtain better results. Algorithm used in computer vision to improve the image quality [3] like color enhancement, in fared and gray scaling. In this paper the authors had revealed the drawbacks of image enhancement on medical images, underwater images, defogging of images, image infrared, visualization and contrast images. Their results states that Encapsulation image is effective when performed with different image algorithms [3].

Farhana Sultana et al. [4] had discussed about different components used in CNN. The advancement from LeNet-5 to SENet CNN models training and testing details [4] were compared. Image Classification with LeNET-5 to SENet are compared and analyzed based on the computer vision problems. In the fully connected layer the datasets like LeNET- 5(1998), AlexNet-2012, ZFNet, VGGNet, GoogleNet, RestNet, DenseNet and CapsNet [4] are compared with respect to the CNN conventional model for feature classification of images.

Riccardo La Grassa et al. [5] had discussed about the multi class classification problems for optimizing [5] the loss function on class hierarchy problems using tradition CNN classification approaches on text. The optimization of loss function architecture developed [5] by the authors had revealed the relationship between the local hierarchy and global hierarchy information when implemented on computer vision tasks with datasets. The results of this paper [5] give the high accurate predictions and flexibility in reducing the misclassified models with the datasets.

Agnieszka Mikalajczyk and Michal Grochowski [6] had discussed about the various problems faced by the computer vision tasks when implemented with the deep learning/machine learning [6]. In their paper the authors had compared data augmentation on image styles for analyzing the machine learning in multiple methods. In this they had transformed the images based on their own data augmentation methodology. The new methodology [6] is used for improving the training data by comparing various challenges. The results of this paper after merging and analyzing their model with the previous works [6] out-turned the high potential in deep learning and machine learning algorithms.

Raveen Doon et al. [7] had discussed about the deep learning classification model performance on cifar10 dataset. In this paper they have used regularization and optimization techniques for image classification [7].The accuracy obtained after training the model was a benchmark outcome [7] with deep learning concepts.

Li Taoetal [8] had discussed about the image enhancement on the low light images. The authors had developed a new multi scale feature to get around gradient vanishing problems when implemented with deep learning [8]. They have used SSIM model to train the images by increasing the light of the image by enhancing contrast of image. In SSIM model [8] the authors had 4 classes like bird, house, girl, town and pepper. The results obtained by the model LLCNN had improved the performance by the experimental procedure of enhancement of brightness and contrast [8].

Vignesh Thakkar and Suman Tewary [9] had discussed about various activation functions to analyses the key features of batch normalization in model training. In their paper they had improved the performance of CNN when compared to the other network model using batch normalization [9]. They had improved by adding multiple Batch Normalization layers using Convolutional layer, activation layers to train the model. They had compared both the operations with Batch Normalization and without Batch Normalization to analyze the results and to improve the accuracy using batch normalization process using cifar-10 dataset [9].

Rasim caner calik and M. Fatih demiric [10] had discussed about the experiment in which authors had performed image classification using CNN on embedded system to store in data in the memory. As deep learning required large amount of training data using this experiment the authors stored their entire framework within 2GB memory. Their model showed a better performance on the embedded system architecture [10].

Shuying liu and Weihong Deng [11] had discussed about how the CNN are able to train large amount of dataset and how small datasets are advantageous to train the model using CNN [11]. Their research work reveals that if the model is strongly fit the large dataset, then that model can also fit the small dataset [11]. In their paper they proposed a modified VGG-16 model to redesign the network to classify images of large dataset. Their work reveals that using strong drop out layers and batch normalization with fast convergence the accuracy can be increased in deep learning image classification problems [11].

Kuntal Kumar Pal and Sudeep K.S [12] had discussed about the pre-processing data in the model by changing the layers of the CNN network model. In their paper they have shown 3 different techniques to pre-process the data for image classification using CNN [12]. Their work reveals that Zero-Component-Analysis, Mean Normalization and Standardization techniques form image classification pre-processing with CNN [12]. They had conducted the pre-processing using the raw data of images with Zero-Component-Analysis, the results reveal that using these pre-processing techniques the performance of the model can be enhanced in Convolutional layers [12].

Yanan sun et al. [13] had discussed about their architecture for classifying their own images using CNN architecture design with genetic algorithm to perform the

classification [13]. In their proposed architecture the authors had validated image classification using CNN with automatic and manual tuning. They had compared their model with 5 automatic CNN architecture design algorithm. The CNN architecture used to develop the accuracy of the model, parameter number with summed computational model resources by consuming the computation resources [13]. In this model the experiments results reveal that CNN-GA performance when it is performed manually and using automation procedure using the computational resources for tuning the model to evolution offitness CNN model to solve optimization problems using the genetic algorithm [13].

Kavi B. Obaid et al. [14] had discussed about latest models of deep learning implementation by comparing the accuracy of the model when tested with two differentdatasetslikecifar10and cifar100 [14]. In their paper they had focused on the feature learning in traditional methods and feature expression to identify images in large dataset using deep learning concepts. In this paper the authors had done a survey on the deep learning model which is used for image classification to compare the accuracy of the various models [14].

Benjamin Recht et al. [15] had discussed about the improvement of the major task performed by the deep learning on the cifar-10 dataset [15]. In this paper the authors had developed method to increase the accuracy of the model by creating a new test dataset of unseen images to increase the accuracy of the model using deep learning image classification. The authors of this paper by considering the Overfitting problem in training the data and testing the data their experiment reveals this it is able to attend 100% training accuracy for image classification [15]. The test accuracy of this model focuses on fitting the model with a high accurate performance [15].

Krizhevsky et al. [16] had discussed about the two-layer deep Convolutional belief network (DBN). The authors of this paper had trained the model by considering the small image dataset [16]. They had considered the edge pixels for filtering the output by fitting the data to the Convolutional filter in DBN [16]. To reduce the Overfitting problem the authors of this paper had considered the local and global connections of the network to perform image classification using cifar-10 dataset [16]. The authors had considered the padding operation in the model to deal with edge pixels [16]. Using this DBN model the authors achieved in improving the test set accuracy of the model by connecting the hidden layers using dine tuning image classification [16].

Dr. P. Karuppusamy [17] had discussed about their new architecture which was developed to enhance the CNN application using two [17] different approaches. Author also addressed many issues related to CNN which were mostly noticed in remote-sensing-application area [17].

Dr. J. Manoharan [18] provide a detailed information on variants of ELM for different classification tasks and also future extension of ELM for applications based on function approximation [18]. Comparisons and results of ELM are discussed and explained the procedure to improve and optimize the variants of ELM by using neural network with novel feed forward algorithm. At last concluded with the research points used to continue research in neural networks specialization [18].

III. METHODOLOGY

The proposed new architecture in combination with Image Enhancement and Image Classification. The main motive behind the combination of these two different techniques is to improve the prediction accuracy of the CNN [19], [21] model when implemented on the CIFAR-10 dataset. The proposed method is given as algorithm 1 and algorithm 2. To implement these algorithms using python, TensorFlow and Keraslibraries.

Algorithm 1: IMAGE ENHANCEMENT

Input: Misclassified images from CNN image classification.
Output: Enhanced image

1. Selecting the Misclassified images which are identified using CNN images classification.
2. Applying image magnification techniques on the selected misclassified image.
3. Enhancing the color of the input image to desired value.
4. Enhancing the contrast of the input image to desired value.
5. Enhancing the brightness of the input image to desired value.
6. Enhancing the sharpness of the input image to desired value.

For-example:
Inputimage4=ImageEnhance.Sharpness(image_color_enhan).enhance(1.5)

As the enhanced value changes the image magnification also changes.

In this model the first step of implementation is to collect the misclassified images in CIFAR-10 dataset when deep learning conceptualization is applied. The misclassified images are enhanced to increase the performance of the model by applying some image magnification techniques like increasing brightness, color, contrast and sharpness. The intensified images are used for classification for predicting the correct aggregate of the model. We had considered the misclassified images. The intensified images using the image enhancement operations like increasing the brightness, contracting the image, enhancing the color and sharpness of the image are considered for enhancement. This model uses the enhanced image after performing the image with respect to the size of the images as per the size in the dataset to predict the image. By enhancing the intensified images and enhanced the images were given as the input to the trained model to increase the accuracy by this model and to predict the correct image label using CNN model.

Algorithm 2: IMAGE CLASSIFICATION

Input: Enhanced image
Output: Predicting the correct classification using CNN model.

1. Importing the dataset using tensorflow and keras.
2. Defining the Labels from the imported dataset.
3. Training the labels from the dataset.
4. Plotting the axes objects using the flatten of 15*15 matrix into 225arrays.

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5. Developing the CNN model

Convolutional layer
Pooling layer
Drop out layer
Batch normalization with the relu activation, filters and padding.
Dense layer is used with softmax activation function.
Metrics like accuracy, precision and recall are used for measuring the performance of the model.

6. Epochs 100 are used to increase the model evaluation accuracy.
7. Graph of loss function evolution, Accuracy, precision and recall are plotted using the formulas.
8. Model is evaluated using the test accuracy.
   evaluation = model.evaluate(X_test, y_cat_test)
   print(f'TestAccuracy:{evaluation[1]*100:.2f}%')
9. Testing the model to predict the correct classification by giving the enhanced images for testing.
10. Predicting the correct label index of theenhanced image after testing with themodel.

In this model the second step of implementation is to CNN classification where the first step output is considered to perform the image classification to predict the upshot. In this model the probability functions are consider on the dataset for forecasting the outcomes. In this model we load the dataset using TensorFlow and Keras for performing data visualization, model building, data augmentation, model evaluation and testing the images. Fig. 2 is the complete description of the model architecture. In this model we use the deep learning library TensorFlow and Keras for building our model with multiple Convolutional layers, dropout layers and flatten layer. The batch normalization operation we used for performing the operations of the CNN model. We use data generator operation for setting up the batch size for training the dataset with respect the model which we build in CNN. Using the iteration procedure in the epoch we train the model to minimize the error function and increase the accuracy. As the model accuracy is increasing the error function gets decreases as the model gets trained. The trained model issued for predicting the image from the dataset.

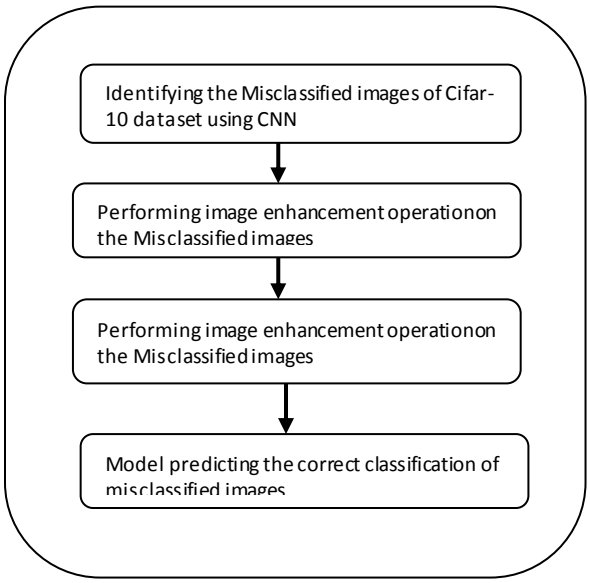


Fig. 2.Model Architecture

IV. EXPERIMENTATION

In this implementation CIFAR-10 data is used for training and testing the model. The dataset consists of the 10 different animal classes to compute the classification of images. The picture elements are 32*32 RGB 60,000 images with 6000 photographs in each. The dataset consists of 10 labels of different categories as in the Fig. 3 representation. The dataset is split into two categories of training dataset where the images are used for training the model; the second division is testing dataset where model uses the images for testing and predicting. In the training dataset model uses 50000 images for training the data and 10000 images with equal divisions in each class label of the dataset.

Fig. 3. Cifar-10 dataset

In this approach, the misclassified images are collected from the cifar-10 dataset. The enhancement techniques like contract, improving brightness and sharpness of the photograph is performed and saved the outcome. In this model, different dimensions for enhancing the images are implemented using the Python code.

This model developed to implement the CNN image classification by using the open-source end to end machine learning platforms for importing the dataset. In the initial stage all the required libraries are imported using the Python code. Dataset consist of both the training and test set with the specified magnitude of images. As shown in the Fig.4 the image dataset is labeled.

Pre-processing of data accomplished to recompute the depiction. Model is build using the open- source machine learning platforms to perform the CNN operations on the model sequential. Using the kernel sizes and activation Relu-operation, Max pooling-operation and Convolutional-operations are performed on the Batch Normalization. The flatten, dropouts and dense layer are performed with the SoftMax-activation function. A data augmentation is used for predicting the batch-processing size of data generator in the training set. Epochs are executed to test the metrics like accuracy, precision, recall and loss function. The model is tested and evaluated to get the effective accurate outcome.

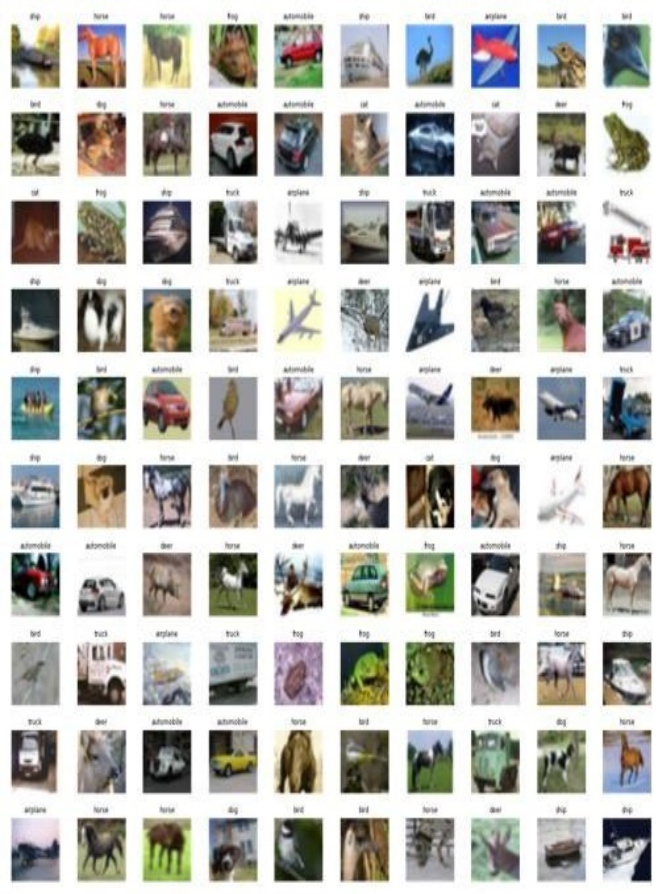


Fig. 4. Implementation of data visualization

V. RESULTS

The experimental results are obtained after training the model and giving the misclassified images to enhance and classify using CNN. These misclassified images are classified correctly and an effective outcome had obtained. Fig 5 represents the result analysis in the graphical representation of the model. Fig 6 represents the test accuracy outcomes after evaluating the model.

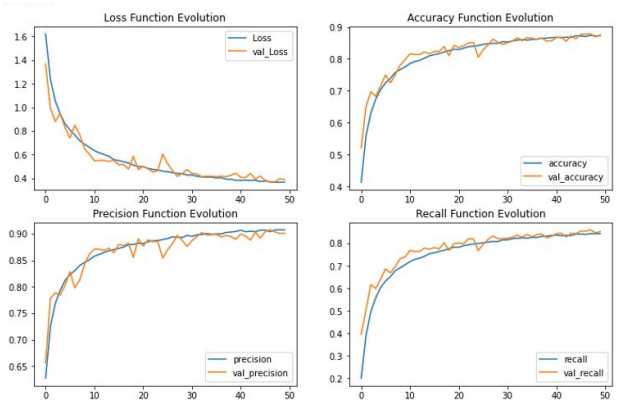


Fig. 5. Result Analysis

```
[18] evaluation = model.evaluate(X_test, y_cat_test)
     print(f'Test Accuracy : {evaluation[1] * 100:.2f}%')

313/313 [==============================] - 3s 9ms/step - loss: 0.3492 - accuracy: 0.8890 - precision: 0.9119 - recall: 0.8723
Test Accuracy : 88.90%
```

Fig. 6. Model Evaluation Accuracy

Using CNN classification, the accuracy of model is increased to evaluate the correct image prediction of images. Fig.7 is the complete representation of the image prediction from wrong to correct prediction. In the Fig. 7 the first representation is the misclassified image where the horse is predicted as dog and using our model, we are trying to predict the image correctly and obtainedindex7as output. For the image the index 7 is used for representation of the class 7 in the dataset array.

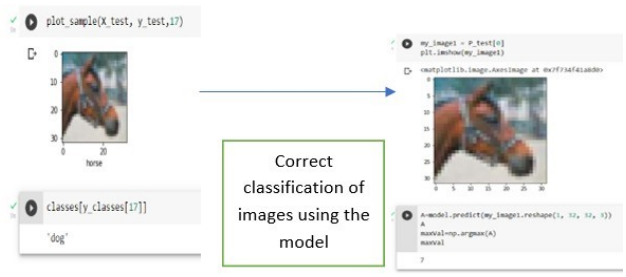
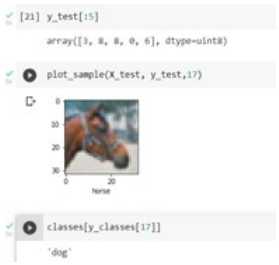
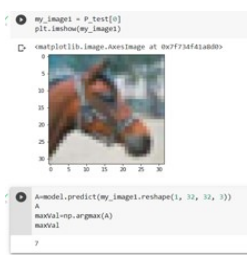
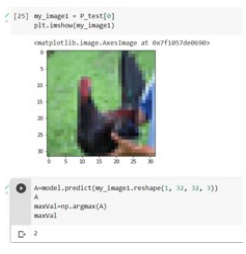
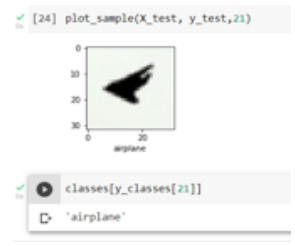
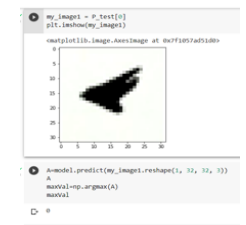
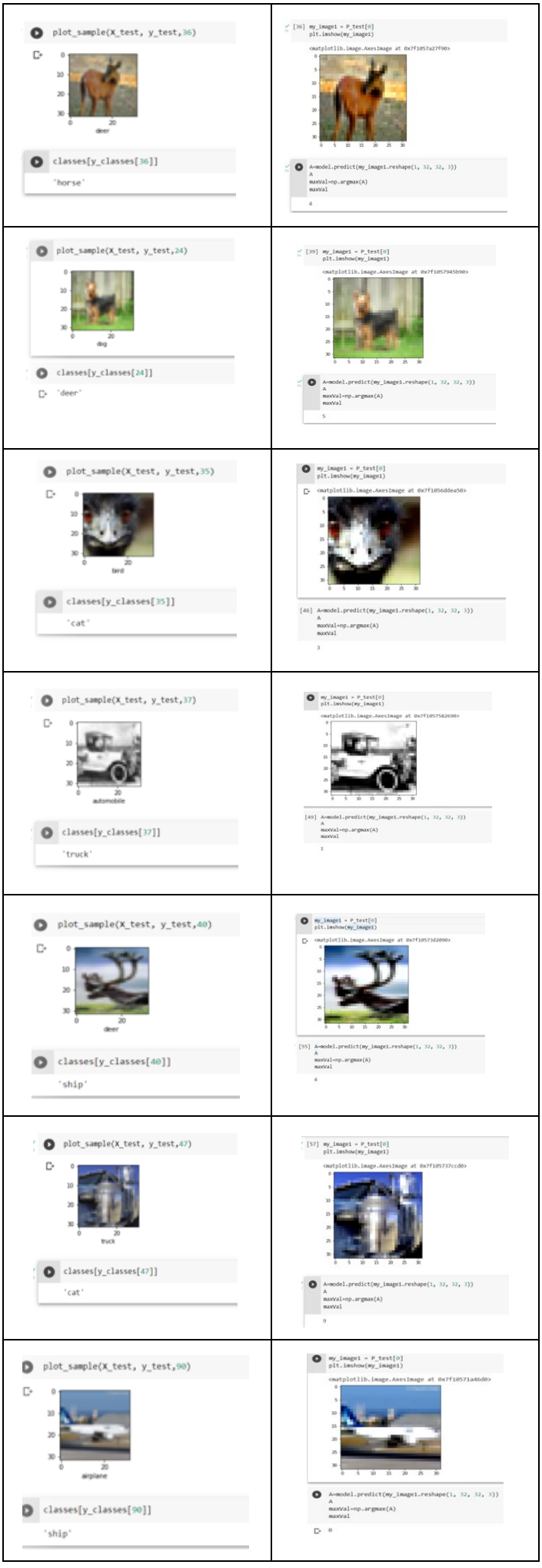
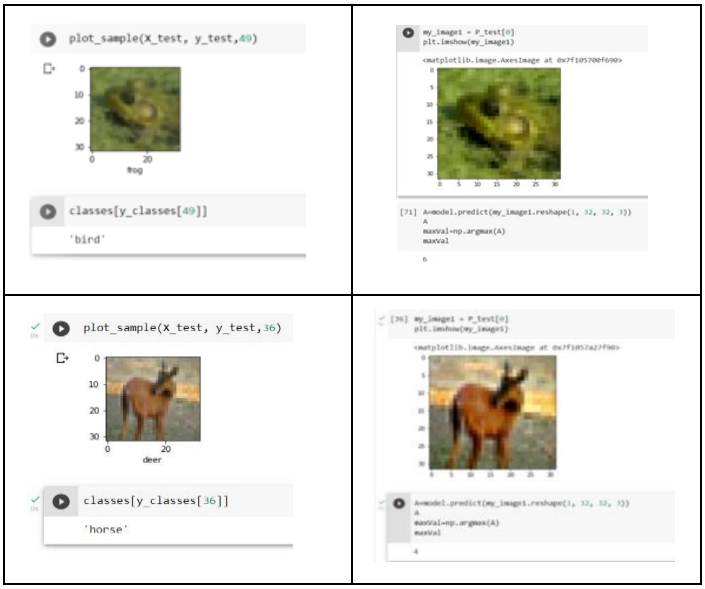


Fig. 7. Model prediction of misclassified image to correct classification

TABLE I. Model image prediction using CNN image classification

Lables : 0-Airplane , 1-Automobile , 2-Bird , 3-Cat, 4- Deer , 5- Dog, 6- Frog, 7- Horse, 8- Ship, 9- Truck	
Misclassified images using CNN (Wrong_prediction)	Correct classification of images using new model (Correct_prediction)
	
	
	
	





Randomly 15 images are considered out of which 12 images are correctly predicted as shown in the Table1. In Table1 the label index 0,1,2,3,4,5,6,7,8,9 represents the classes in the cifar-10 dataset. In this model after taking the enhanced image as the input, predicts the image using the CNN architecture with respect to the label index of the class.

VI. CONCLUSION

A new architecture of enhancement of image and image identification are developed based on the image processing techniques and Convolutional neural multi class networking algorithm. Classification and enhancement of images deals with the combination of two different concepts i.e., image enhancement and image classification techniques by identifying useful information from the given input images. Our method works on image quality assessment and improving the images for identifying the image class from the dataset. The enhanced image is classified to identify the class of input image from the CIFAR-10 dataset. The model accuracy obtained after evaluating the experiment is 88.55%.

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