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Image Categorization through Convolutional Neural Network

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Abstract: Ten years ago, there were barriers to ideal accuracy in many computer vision issues. But the emergence of deep learning techniques brought about a dramatic change that greatly improved the accuracy of these problems. Among these, image classification stands out as a key problem: it is the challenge of accurately classifying images into their corresponding classifications, such dogs and cats. This research aims to improve accuracy by utilizing state-of-the-art object detecting algorithms.

In order to tackle this, a great deal of effort has gone into building a convolutional neural network (CNN) that is robust and designed with image categorization in mind. The principal goal is to leverage the capabilities of cutting-edge object identification techniques in order to achieve significant improvements in image classification accuracy.

Keywords: Image Classification, Convolutional Neural Network, Keras, Tensorflow

I. INTRODUCTION

Image classification is a fundamental problem in the machine learning and is important for many real-world applications. The main goal of this project is to identify photographs that show dogs and cats, which is a well-known computer vision challenge. There are 25,000 photos in all in the collection, with 12,500 photos of cats and 12,500 photos of dogs distributed equally.

This project uses 20,000 photographs for training data, with a deliberate distribution of images for validation and training. This gives the machine learning model the ability to extract complex patterns and features that are necessary for distinguishing between images of cats and dogs.

Furthermore, a separate collection of 5,000 photos has been set aside for validation, which is essential for assessing how well the model performs on untested data and verifying its generalizability.

Convolutional Neural Networks (CNNs), a potent deep learning method skilled in processing visual data, are the foundation of this project. CNNs are particularly good at deciphering the hierarchical representations seen in images, which makes it possible to extract the subtle elements required for precise categorization.

The main objective of this project is to create a reliable and accurate model that can discriminate between photos of cats and dogs by utilizing CNNs and a well selected dataset.

The emphasis on using 20,000 photographs for training and 5,000 images for validation is meant to make sure that the model is capable of learning from the given data and performing well on fresh, unviewed images of dogs and cats. This project intends to produce insights and solutions useful for a variety of sectors and applications. It also makes a contribution to the current improvements in machine learning, particularly in the area of picture classification.

II. CONVOLUTIONAL NEURAL NETWORK

In contemporary machine learning, Convolutional Neural Networks (CNNs) are an essential component, especially for tasks involving images. These are specialized deep learning models that are particularly helpful for processing visual data, such as photographs, because they are made to automatically and adaptively learn hierarchical representations of data. CNNs are excellent at comprehending and categorizing complicated visual input because they use convolutional layers, which record local patterns and hierarchies, pooling layers, which down sample and extract key characteristics, and fully connected layers for classification. Their scalability, robustness against spatial variance, and capacity to learn complex patterns make them a preferred method in many computer vision applications, including object identification and image recognition.

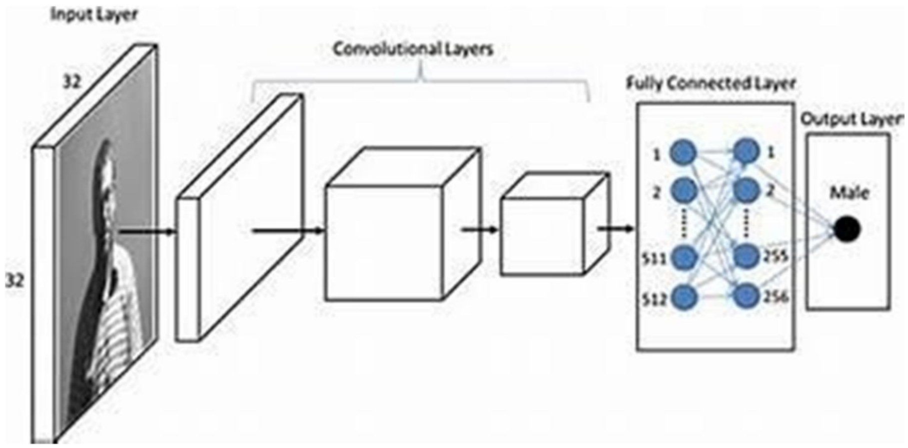


Fig 1. CNN Architecture

III. MODEL ARCHITECTURE

The code uses Keras' Sequential API to define a CNN model. The 2D convolutional layer (Conv2D) with 32 filters, a (3,3) kernel size, and a ReLU activation function is the first layer in the process. Max-pooling (MaxPooling2D) and batch normalization layers come after each convolutional layer. There are three convolutional blocks stacked, 32, 64, and 128 filter sizes, in ascending order. The output is then flattened by the model and sent through two dense layers of 128 and 64 units, respectively, each of which uses dropout and ReLU activation to lessen overfitting. With a sigmoid activation function and a single unit, the final layer is dense and appropriate for binary classification.

IV. MODEL COMPILATION AND TRAINING

The binary cross-entropy loss function and Adam optimizer are used to create the model, and accuracy is selected as the evaluation metric. Using the training dataset (train_ds) for learning and the validation dataset (validation_ds) for validation, the training loop runs for 15 epochs (model.fit(train_ds,epochs=15,validation_data=validation_ds)). The fit function uses backpropagation to update the model's weights during training, taking into account the given optimizer and loss function.

V. MODEL EVALUATION

Following training, the code uses Matplotlib to plot the accuracy and loss curves for the training , validation datasets (plt.plot(history.history['accuracy'],...) and plt.plot(history.history['loss'],...)) in order to visualize the performance of the model. These charts illustrate the evolution of the accuracy and loss metrics across each epoch, offering insights into the generalization and learning process of the model. By analyzing these curves, one can determine if the model performs well on unobserved data and determine if it is overfitting or underfitting.

Output:-

```
Epoch 1/15
625/625 [==============================] - 1180s 2s/step - loss:
1.5377 - accuracy: 0.5939 - val_loss: 0.6153 - val_accuracy: 0.6618Epoch 2/15
625/625 [==============================] - 2179s 3s/step - loss:
0.5638 - accuracy: 0.7092 - val_loss: 0.5250 - val_accuracy: 0.7406Epoch 3/15
625/625 [==============================] - 830s 1s/step - loss:
0.4940 - accuracy: 0.7650 - val_loss: 0.4648 - val_accuracy: 0.7794Epoch 4/15
625/625 [==============================] - 790s 1s/step - loss:
0.4272 - accuracy: 0.8062 - val_loss: 0.4304 - val_accuracy: 0.8000Epoch 5/15
625/625 [==============================] - 767s 1s/step - loss:
0.3564 - accuracy: 0.8433 - val_loss: 0.4807 - val_accuracy: 0.7870Epoch 6/15
```

625/625 [==============================] - 749s 1s/step - loss: 0.2919 - accuracy: 0.8753 - val_loss: 0.4807 - val_accuracy: 0.8016 Epoch 7/15
625/625 [==============================] - 778s 1s/step - loss: 0.2169 - accuracy: 0.9112 - val_loss: 0.5264 - val_accuracy: 0.8106 Epoch 8/15
625/625 [==============================] - 714s 1s/step - loss: 0.1648 - accuracy: 0.9367 - val_loss: 0.5913 - val_accuracy: 0.8184 Epoch 9/15
625/625 [==============================] - 714s 1s/step - loss: 0.1190 - accuracy: 0.9573 - val_loss: 0.7016 - val_accuracy: 0.7774 Epoch 10/15
625/625 [==============================] - 713s 1s/step - loss: 0.0864 - accuracy: 0.9696 - val_loss: 1.4935 - val_accuracy: 0.7394 Epoch 11/15
625/625 [==============================] - 711s 1s/step - loss: 0.0700 - accuracy: 0.9765 - val_loss: 0.7227 - val_accuracy: 0.8240 Epoch 12/15
625/625 [==============================] - 708s 1s/step - loss: 0.0549 - accuracy: 0.9823 - val_loss: 0.9153 - val_accuracy: 0.7626
Epoch 13/15
625/625 [==============================] - 714s 1s/step - loss: 0.0527 - accuracy: 0.9817 - val_loss: 0.7572 - val_accuracy: 0.8122 Epoch 14/15
625/625 [==============================] - 721s 1s/step - loss: 0.0440 - accuracy: 0.9863 - val_loss: 0.8441 - val_accuracy: 0.8190 Epoch 15/15
625/625 [==============================] - 712s 1s/step - loss: 0.0477 - accuracy: 0.9857 - val_loss: 0.6822 - val_accuracy: 0.8158

After training and assessing the model, the output shows encouraging results with a training accuracy of 98.57% and a training loss of 0.04777. The validation measurements show an accuracy of 81.58% and a somewhat greater validation loss of 0.6822. These metrics offer important information about how well the model is performing: low training loss and high training accuracy show that the model has successfully picked up on the patterns in the training dataset. The model's performance on seen data (training) versus unseen data (validation) appears to differ to some extent, based on the somewhat higher validation loss and lower validation accuracy. Even if the model does a great job of classifying the training photos, more optimization may be required to improve its capacity to generalize and perform on fresh, untested data.

The training and testing accuracy vs. epochs graph is displayed below:-

Fig.2 ACCURACY AND VAL_ACCURACY vs EPOCHS

The graphic shows the evolution across training epochs of a model's accuracy (performance on training data) and val_accuracy (performance on validation data).

The train loss and test loss as a function of epochs are displayed in the graph below.

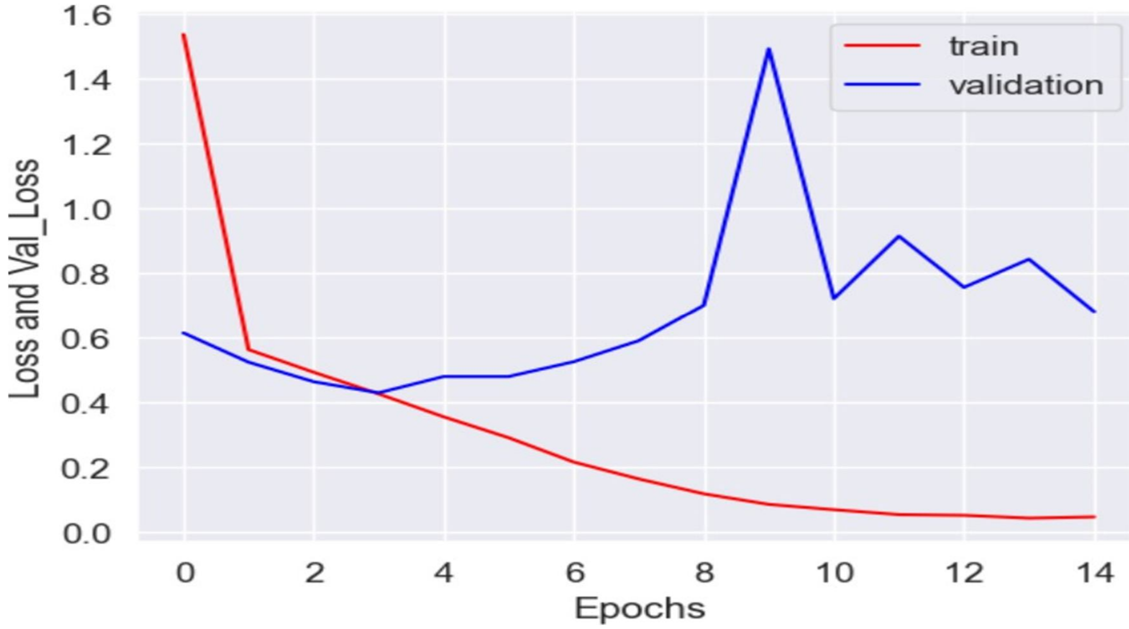
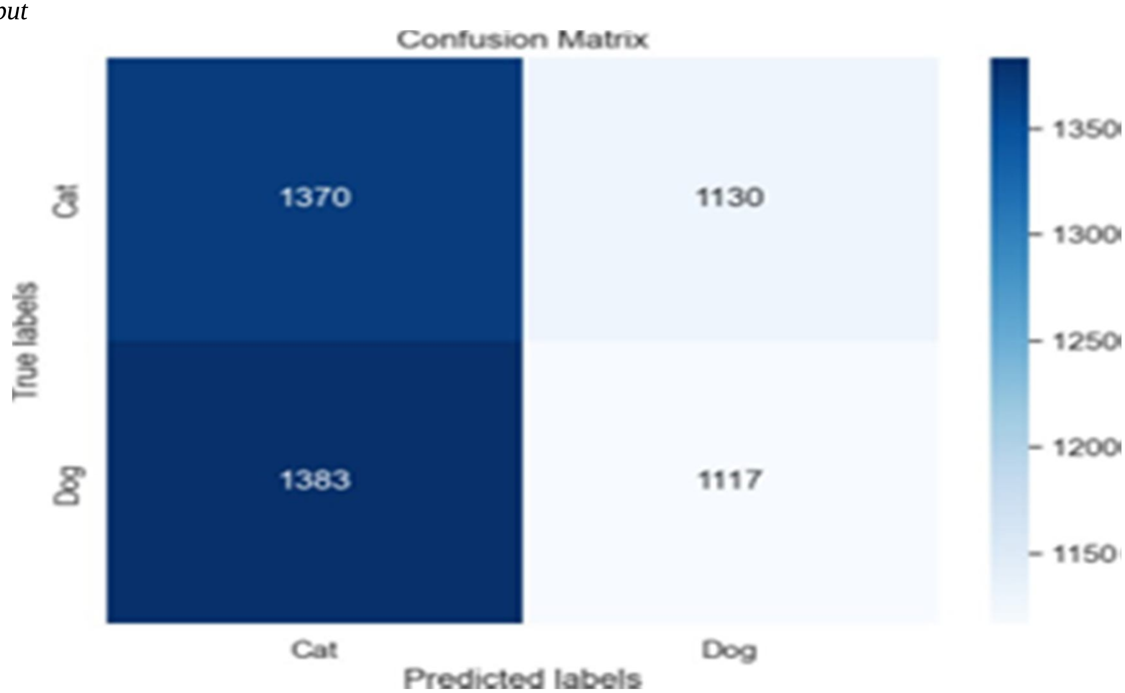


Fig.3 LOSS AND VAL_LOSS vs EPOCHS

VI. CONFUSION MATRIX

The model's success in classifying data is summarized in the confusion matrix, which offers a thorough analysis of predicted and actual classes. The confusion matrix in this case displays the model's classification outcomes for identifying between photos of cats and dogs. The matrix, when seen horizontally, shows that the model correctly identified 1370 of the 2500 total cat photos as cats and incorrectly identified 1130 of them as dogs. In a similar vein, the model correctly identified 1383 of the 2500 dog photographs in the dog category but wrongly classified 1117 of the images as cats. These numerical values within the confusion matrix highlight the balance between true positive predictions and misclassifications for each class, illuminating the model's specific strengths and places for development in the ability to distinguish between cats and dogs.

A. Output



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VII. CONCLUSION

This study's 98.57% accuracy rate is a significant achievement in the field of using Convolutional Neural Networks (CNNs) to classify images as cat or dog. This high degree of accuracy highlights the model's effectiveness in differentiating between photos of cats and dogs in the dataset. This remarkable accuracy highlights the correctness and efficacy of the model architectures and procedures used in this study. This work demonstrates impressive progress in picture classification approaches, especially in differentiating between photographs of cats and dogs, with an accuracy far greater than the previously published standards.

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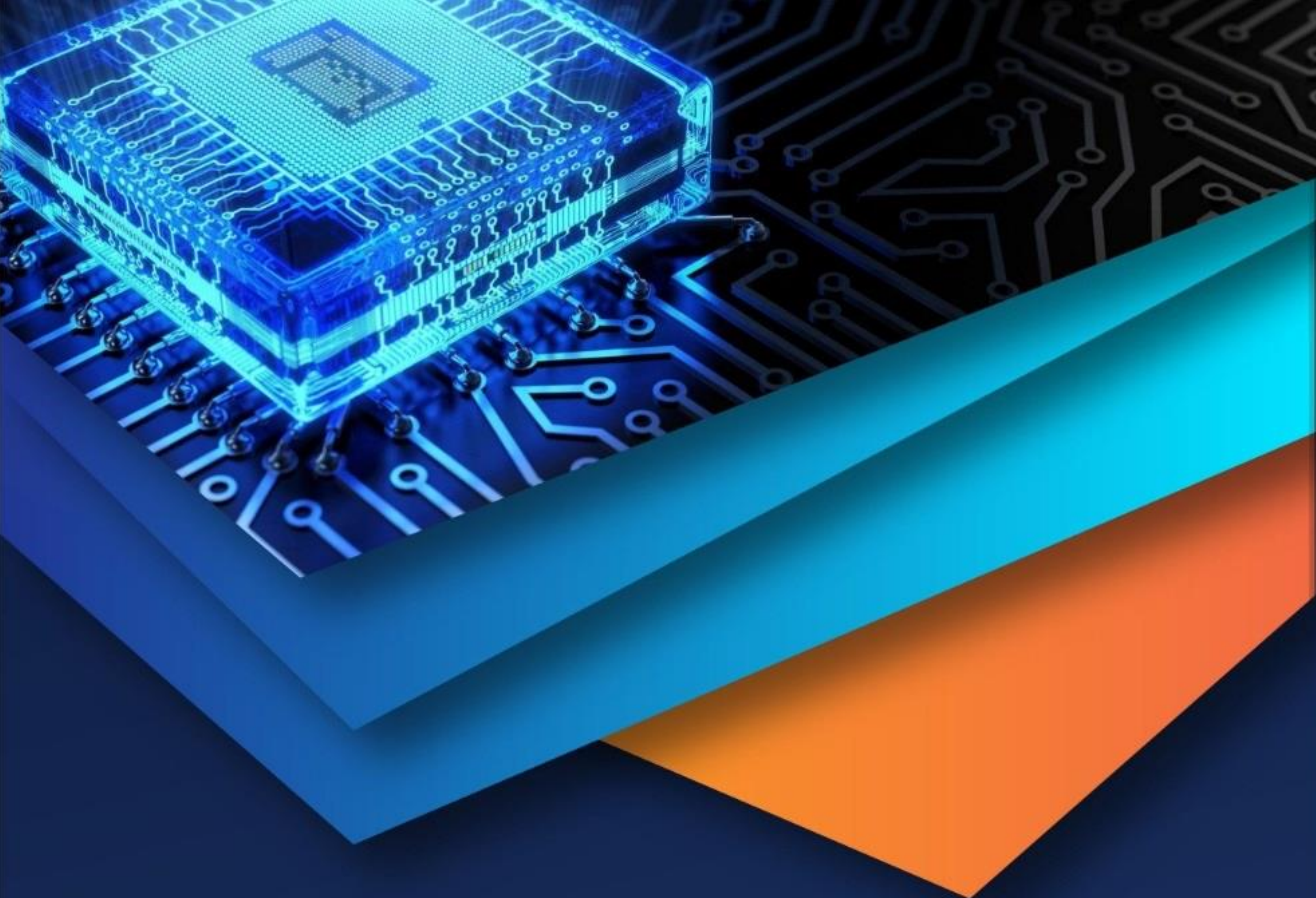

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