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Multi-View Dog Breed Classification: Integrating Image-Based and Metadata Approaches with Machine Learning

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Abstract: One of the most popular household animals is the dog. Numerous problems, including population management, a reduction in rabies outbreaks, vaccination control, and legal ownership, arise from the enormous number of dogs. There are more than 180 dog breeds available today. Every dog breed has unique traitsand medical circumstances. It is crucial to identify people and their breeds in order to administer the proper care and training. Machine learning provides the strength to train models of algorithms that will manage the challenges of classifying information and making predictions based solely on newly appearing information as raw data. Convolutional Neural Networks (CNNs) provide a single, widely used approach for detecting and classifying images. In this effort, we describe a CNN based method for identifying dogs in potentially complicated photos and as a result, we take into consideration the identity of a certain dog breed. Given that the conventional metrics were verified by the analysis of the experimental results, the graphical depiction verifies that the CNN algorithm provides excellent analysis accuracy across all tested datasets.

Keywords:CNN,MachineLearning,Classification

1. INTRODUCTION

The dog is a creature that has long been considered a companion to humans. It is well-known as a pet since it is typically amiable, entertaining, devoted, and submissive. Dogs differ from other household animals because they are the result of human behavior choices. Furthermore, it is the species with the most genetic and morphological diversity on earth, displaying a high degree of behavioral phenotypic variety. This results in its extraordinary capacities for employment and social tasks, such as those of a security guard, hunting aide, combatant, artist, guide, pet, waste disposal, and provider of food and fiber. Neurons in Convolutional Neural Networks (CNNs) have weights and biases that may be changed. Every neuron computes the dot product based on incoming data. Convolution Neural network designs differ from earlier neural network layouts in that they employ real pictures as inputs. This makes it possible to include certain elements in the design. CNN reduces the amount of observable components that define a network. Before-layer neurons have no effect on the behavior of single-layer neurons. We are employing a successful strategy in this study called transfer learning. To categories the dog breeds, we have employed pre-trained models in this manner. Overall, After being trained on the Stanford Dog dataset, the accuracy of the two neural networks we used—Inception V3 and VGG16—is compared. When the new dataset is smaller than the previous dataset but still contains the same data, overfitting lowers the CNN's effectiveness. If there is material in the new, large dataset The full network may be used to improve the model in comparison to the previous data.

2. LITREATURE REVIEW

A. Automatic Classification of Breeds of Dog using Convolutional Neural Network

In this work, we tackle the problem of appropriately classifying dog breeds in light of the substantial phenotypic variability that exists within the species.(1)To bridge this gap, we developed a model that can automatically categorize dog breeds in compliance with AKC rules using the Stanford dog dataset and the Convolutional Neural Network (CNN) approach. Furthermore, there is a lot of intra-class variance among some dog breeds since they don't all have the same age-related fur color or size.(1) Consequently, it is difficult to identify, classify, and differentiate them. Moreover, in comparison with related research using the same dataset,

our model performed exceptionally well. Furthermore, we verified our experimental results with classical CNN models, such as ResNet-50 and SqueezeNet, which produced consistent results with the same parameters.

B. Hybrid Deep Learning Algorithms for Dog Breed Identification—A Comparative Analysis

In applications such as optical character recognition and facial identification, convolutional neural networks (CNNs) play a crucial role in picture categorization and verification. CNNs are excellent at classifying pictures because they can analyze real images and minimize observable variables.(2) Notable CNN designs with distinct optimizations are Inception-v3, Xception, NASNet, EfficientNet, and ResNet. Deep CNNs need the use of transfer learning, which uses pre-trained models on huge datasets.(2)This is especially true when fresh datasets are lower in size but have comparable content. This method increases the efficacy of the model and reduces overfitting.

C. Dog Breed Identification

In this study, we leverage computer technology for pattern recognition (PR) to identify dog breeds. We enhance the recognition process by providing pertinent data to the computer and abstracting the recognized object to establish its mathematical model.(3) We employ four distinct approaches, utilizing over 10,000 images representing 120 dog breeds. The DenseNet161, AlexNet, VGG16, and ResNet18 models are utilized for identification.(3)To improve accuracy, we refine optimization techniques tailored to each model.Through comparisons, we determine that the DenseNet model yields the highest effectiveness, achieving an accuracy of 85.14%.

D. Transfer learning using VGG-16 with Deep Convolutional Neural Network for Classifying Images

Models trained on certain feature spaces and distributions are used in data mining and machine learning techniques, which are traditionally intended to handle problems independently.(4) However, it's a common misconception in machine learning that training and test data should have the same feature spaces and underlying distributions. This may not always be the case in real-world scenarios.(4) This discrepancy can necessitate rebuilding models from scratch when characteristics or distributions change, which is a labor-intensive process.Transfer learning offers a solution by leveraging previously learned model information for new tasks, including regression, grouping, and classification issues. This study shows the efficacy of transfer learning in practical scenarios by classifying photos using a Deep Convolutional Neural Network and the pre-trained VGG-16 model.

E. Dog Breed Classification Using Deep Learning

Models trained on certain feature spaces and distributions are used in data mining and machine learning techniques, which are traditionally intended to handle problems independently.(5) However, it's a common misconception in machine learning that training and test data should have the same feature spaces and underlying distributions. This may not always be the case in real-world scenarios.(5) This discrepancy can necessitate rebuilding models from scratch when characteristics or distributions change, which is a labor-intensive process.Transfer learning offers a solution by leveraging previously learned model information for new tasks, including regression, grouping, and classification issues. This study shows the efficacy of transfer learning in practical scenarios by classifying photos using a Deep Convolutional Neural Network and the pre-trained VGG-16 model.

3. DATASET AND FEATURES

Metrics for evaluating an experiment's performance are called evaluation metrics.(6)The study's chosen metrics were AUC, sensitivity, specificity, and accuracy, quantifiable standards for evaluation.(7)(8)Eqns (1), (2), and (3) were used, respectively, to compute the accuracy, sensitivity, and specificity.

$$Accuracy = \frac{}{T} \quad (1)$$

$$Perceptive \quad (2)$$

$$Specifica \quad (3)$$

The True Positive Rate (TPR) is shown on the y-axis and the False Positive Rate (FPR) is shown on the x-axis of a probability curve known as a receiver operating characteristic (ROC) curve.(9)(10)Equations (4) and (5) can be utilized to represent the true positive rate and false positive rate.

$$False\ Positive\ rate\ (FPR) \quad (4)$$

$$True\ Positive\ rate\ (TPR) \quad (5)$$

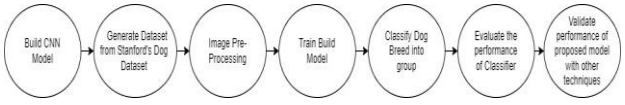

Figure 1. Flow diagram for dog breed classification

In this above figure 1 the process of creating a Convolutional Neural Network (CNN) model to categorize dog breeds using the Stanford Dog Dataset is shown in the image. To ensure accuracy and efficacy, the procedures involve constructing the CNN model, creating and pre-processing the dataset, training the model, categorizing dog breeds, assessing the classifier's performance, and testing the model against other approaches.

TABLE I. THE DEVELOPED TECHNIQUE'S OVERALL PERFORMANCE

Metric for evaluating performance	*Outcome(%)*
Precision	92.04%

Metric for evaluating performance	*Outcome(%)*
Perceptiveness	80.08%
Specifications	95.02%
The Area Under the Curve	93.04%

In this above table 1 Our method produced an overall Precision of 92.04%, Perceptiveness of 80.08%, Specifications of 95.02%, and The Area Under the Curve of 93.04%, as shown in Table 1.(11)(12)(13)The project managed to determine that dog breeds shared a number of characteristics. The model's Precision was 92.04%. With an overall The Area Under the Curve of 93.04%, the model demonstrated excellent ability to distinguish between the five dog breed groupings.(14)(15) 80.08% Perceptiveness means that 80.8% of the positive samples were properly categorized by the model.(16) Therefore, it is safe to assume that the constructed model will be able to identify more positive samples.

4. METHODOLOGY

A. VGG16

Renowned Convolutional Neural Network (CNN) architecture VGG16 was created by the University of Oxford's Visual Geometry Group (VGG). Its depth is attributed to its 16 learnable weight layers, which include 3 fully linked layers and 13 convolutional layers. (17)(18) The architecture's capacity to catch fine features in pictures is improved by the use of tiny 3x3 filters across the convolutional layers. Furthermore, to gradually lower the spatial dimensions and boost computing performance, max-pooling layers are employed.(19)(20)On the ImageNet dataset, a large-scale picture classification benchmark, VGG16 achieved state-of-the-art performance, demonstrating its capacity to handle challenging image identification tasks. In the figure 2 the VGG-16 model is shows below.

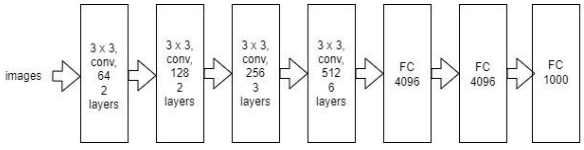

Figure 2. VGG-16 model

B. Neural networks using convolutions (CNN)

TheConvolutional neural networks (CNNs) evaluate picture inputs using numerous perceptrons, each of which has learnable weights and biases tailored to certain regions of the image. CNNs are effective in terms of complexity and memory utilization by utilizing weight sharing to minimize the number of parameters by utilizing local spatial coherence in input pictures. A feature map for the layer above is obtained by applying a kernel matrix to the input matrix in the convolutional layer. This process involves sliding the kernel matrix over the input to build the feature map, multiplying the elements of the matrix at each place, and then adding the results. Convolution, a specialized linear operation employed in CNNs, finds extensive applications in fields like statistics, physics, and image processing.

C. Data Augmentation

The amount of data rises when the data analysis technique is used, which adds an average of modified copies of previously existing datasets or newly produced data sets.(21) The main goals of data augmentation are to reduce overfitting and expand the training set's dataset.(22)This technique has been used, and the result is displayed in Fig. 4, where we can see that the images are enhanced by the settings we apply in the Image data Generator class. These serve as the attributes of this class and facilitate the construction of new datasets.

D. AlexNet

The Three fully connected layers, three convolutional layers, and several max-pooling layers make up AlexNet., with 60 million parameters and 650,000 neurons. layers terminating in a 1000-way softmax.(23)AlexNet uses an extremely efficient GPU version of the convolution operation with non-saturating neurons to accelerate training. To enable simultaneous training on two Nvidia Geforce GTX 580 GPUs, the channels are divided into two phases.(24)(25)To reduce overfitting in the fully-connected layers, the network employs dropout.(26) In this instance, AlexNet was trained using ImageNet.

5. RESULT AND DISCUSSION

The accuracy comparison results after 75 epochs are displayed in figure 3

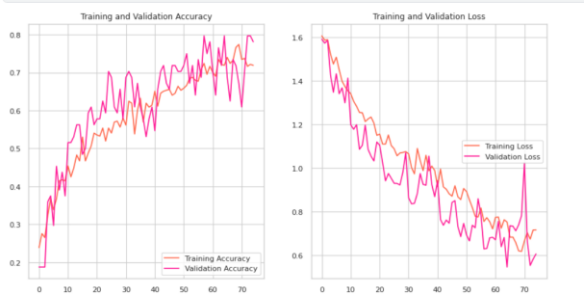

Figure 3. Accuracy of training and validation after using CNN and Validation loss and training after using CNN

The graph in the above figure indicates that the model is learning from the training data and generalizing well to new data because both the training and validation accuracy are rising over time, while the training and validation loss are falling.(27)(28) It also indicates that the model is not overfitting to the training data because the validation accuracy and validation loss are rising and falling more slowly than the training accuracy and training loss.

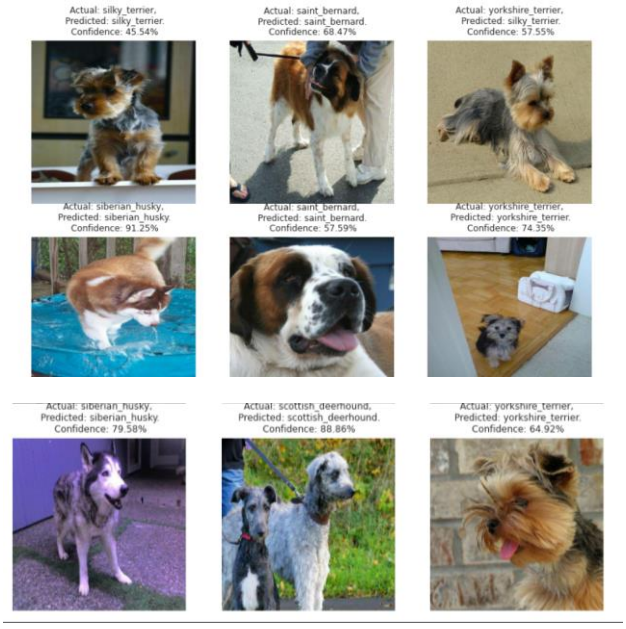

Figure 4. The final accuracy of our model can reach to 84% shows one of our sample output.

The image you sent me shows a collection of different dog breeds. Each dog is pictured next to a caption that identifies the breed according to a machine learning model.(29)(30) The model's confidence in its prediction is listed next to each breed identification. For example, the model identified a Siberian Husky with 91.25% confidence.

6. CONCLUSION

TheConvolutional Neural Networks (CNNs) were employed in our experiment to detect 120 distinct dog breeds. Transfer learning was used to overcome the small dataset size and increase accuracy. The collection of dog photos was expanded and arranged by breed into distinct folders as part of the pre-processing of the information. During model training, we adjusted parameters and used adaptive learning rates to maximize efficiency. This method successfully increased the model's accuracy, suggesting that transfer learning and adaptive learning rates may be used to improve CNNs' capacity to recognize a variety of dog breeds.

7. FUTURE WORK

We exclusively utilize CNN to implement categorization in our project. We may compare it with other train models, such as SVM and PCA, to help us make a better decision. Second, our model only allows us to Using the pre-trained model, add two FC layers. We can attempt to add further layers in order to increase the accuracy. Third, there is still a lack of sufficient precision. We may experiment with different strategies to prevent overfitting (such as stopping early) and adjust the parameters (such as learning rate, momentum, and batch size) to increase accuracy.

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