International Journal of
INTELLIGENT SYSTEMS AND APPLICATIONS IN ENGINEERING
ISSN:2147-6799 www.ijisae.org Original Research Paper

Optimized Transfer Learning for Dog Breed Classification

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Submitted: 06/06/2022 **Accepted:** 10/09/2022

Abstract: Animal breed classification using deep learning algorithms is required in presentation arenas. In this paper, a dataset of 70 dog breeds was considered for training and testing of transfer deep learning algorithms. The used dataset is a statistically stable dataset including approximately 100 images under each category of dog breeds. Then collected dataset was trained and tested using different deep learning algorithms like Convolutional Neural Network, VGG16, ResNet, DenseNet, InceptionNet, InceptionResNet, etc, were implemented. The outcome results were compared during algorithm training and testing based on parameters like accuracy, precision, recall, and area under curve. Further, one of the best algorithms was optimized by tuning through optimization algorithms or learning rate configurations. In the future, the proposed modules will be added along with implementations in events to fulfill the requirement of real-time dog breed recognition.

Keywords: *Classification. Transfer learning, Deep learning, Image processing*

1. Introduction

For the vast majority of data mining activities, machine learning has shown to be an effective strategy. Machine learning excels in classifying among its many applications[1-2]. Classification is the process of determining to which category the collected data belongs. Data characteristics are taken from the observations and a model is built using them[3-4]. A series of photos or a simple set of numbers might be included in the data. Machine learning learns the assigned task from the data through a mathematical relation to describe its relationship with the data. Such representation is learned during the training phase of its construction. The representations are described by a set of weights called parameters. Another set of parameters that are not learned during training steps is called hyperparameters. Hyperparameters are usually tuned by humans or automatically adjusted by specific algorithms [5-6].

When just a few labeled examples are available for training, an ideal image classifier should be able to exploit sophisticated high-dimensional feature representations. For many real-world applications, learning from tiny training sets is critical since only a few labeled instances are available. Instead of asking for the user to identify hundreds of photographs in a personal photo collection, an engaging application can ask them to merely label a handful[7-8].

Over-fitting classifiers with poor generalization skills are the result of using machine learning techniques to create a classification model for a new target domain with few training data. Gathering an adequate number of manually labeled training samples, on the other hand, might prove costly. With Transfer Learning, the solution to this type of challenge is to use data from a similar source domain that contains a lot more data to aid classification[9]. Transfer learning may be divided into three types based on distinct assumptions about the target and source domains: Inductive Transfer Learning[10], Transductive Transfer Learning(Domain Adaptation)[11], and Unsupervised Transfer Learning[12]. We concentrate on the first one, which implies that the goal and source tasks are distinct yet linked. To be more precise, we believe that both the target and the source tasks are classification tasks, with the target categories and the source categories being distinct but connected.

Numbers of dog breeds are available in the world and recognition of all breeds without assistive technology is very difficult for the human being. Several similar dog

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breeds such as Alaskan Malamute & Siberian Husky, Whippet & Italian Greyhound, etc, look alike that raise difficulty for the human to identify correctly. There are several problems that are specific to certain dog breeds. These problems include population management, the prevention of disease outbreaks like rabies, the regulation of vaccinations, and legal ownership. Without identification of breed details, high difficulties are faced by workers in solving mentioned issues. In the contemporary era, deep learning in image classification works very efficiently for solving classification problems and also predicting with high accuracies and low losses.

The objective of this paper is to implement and experimentally analyze the impact of different optimization techniques such as Stochastic Gradient Descent (SGD), Adam, Nadam, RMSprop, Adamax, Adadelta, and Adagrad on the dataset based best-identified transfer learning algorithm.

The remainder of the paper is presented below: section 2 consists of a preliminary explanation of related topics such as neural networks, various deep learning models, meta-learning, and transfer learning. Section 3 presents the datasets, proposed methodology, and experimental setup. Section 4 consists of results and discussions. Lastly, section 5 discussed the findings and further possible improvements of current research.

2. Related Study

One collection of the most comparable characteristics in the deep neural networks was shorted using principal component analysis (PCA) by Kumar et al.[13]. Additionally, the face characteristics were saved as a vector. Each feature of the dog in the database was compared to this vector to see which one yields the best results. A total of 13233 photos of humans and 8351 photographs of dogs were used in the experiment. The photographs being tested had a minimal weight difference between them and the train images, thus they were grouped as a breed. Findings were drawn from a study that used CNN to categorize various dog breeds. It worked to locate the dog's breed and comparable traits if an image of a dog is provided; otherwise, it tries to find face features that exist in a dog and vice versa. For the prediction of dog breeds, Jain et al.[14] employed a convolutional neural network as a foundation. Two more scenarios were incorporated to improve the model's performance. Using a human image as an input, it will return a dog breed that looks like it, and using an image of something other than a dog or a human will return "something else" as an output. This was the first example. The model has an accuracy rating of 84.578 percent during actual testing. Borwarnginn et al.[15] proposed a method for classifying dog breeds based on facial features captured in photographs. To identify the breeds of dogs, the suggested technique makes use of a deep learning methodology. As a starting point, the technique uses pre-trained convolutional neural networks (CNNs) to retrain on a public dataset of dog breeds. After that, various variables for image augmentation are applied to the training dataset to help in categorization. Three distinct CNNs are used with varying augmentation parameters and extensive experimental comparisons to assess the suggested approach. 89.92% accurate prediction on the available dataset of 133 dog breeds is achieved by the model's current iteration. Part Localization was proposed by Jiongxin et al[17] for the categorization of dog breeds. In their study, they were able to garner a recognition rate of 67%. For picture categorization, Dbrowski and Michalik [18] investigated "How successful is Transfer Learning method?" Transfer Learning was demonstrated to be an effective method for boosting model accuracy by retraining neural networks used in image categorization. It was discovered by Vrbani et. al[19] that they could identify COVID-19 patients by looking at their chest radiographs and using a novel customized classification algorithm that utilized a local interpretable model-independent explanatory approach. To optimize hyper-parameter values inside a CNN's transfer learning tuning, the classification technique makes use of a grey wolf optimizer algorithm. In some cases, adaptive optimization algorithms like Adam and RMSprop outperform stochastic gradient descent (SGD). Although recently conducted research, however, reveals that they frequently lead to poorer generalization performance than SGD, particularly when training deep neural networks (DNNs). When Adam generalizes less well than SGD, Zhang et al.[20] developed a variation of Adam to close the generalization gap. To increase generalization, they devised a new approach called normalized direction-preserving Adam (ND-Adam), which allows users to fine-tune the direction and step size of updating weight vectors. They use similar logic to regularise the softmax logits in classification tasks to boost generalization performance.

3. Methodology

In this section, the implemented methodology is discussed as shown in figure 1. The collected dataset of dog breed images included 70 different classes were used [21]. Approximately 10000 images were split into train and test images by considering ratio of 70 percent training and 30 percent testing. Further, the preprocessing of images was conducted to resize dataset images in 75x75 size and also converted to grayscale images from RGB images. Initially, the preprocessed data used for training and analyzing the transfer learning algorithms such as VGG16, ResNetV2, DenseNet, and InceptionResNetV2. Further, the better-identified algorithm advanced for optimization to improve analyzing parameters using optimizers viz., AdaDelta, AdaGrad, Adam, RMSProp, and SGD.

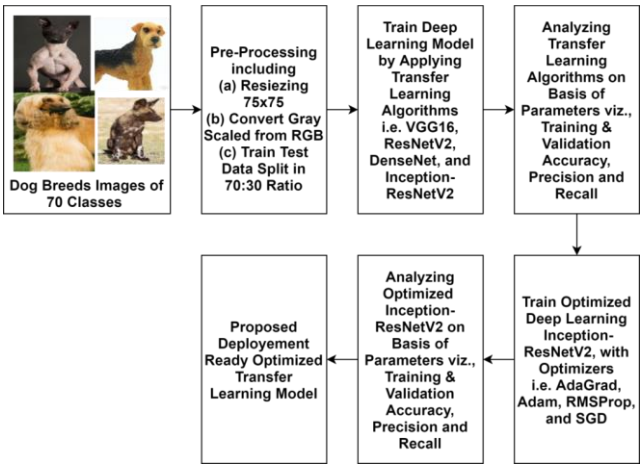

Figure 1- Overall Methodology of Implementing Optimized Transfer Learning for Dog Breed Classification

VGG16, ResNetV2, DenseNet, and InceptionResNetV2 are among the four network architectures we use. We closely adhere to the original design of each network architecture, but we update the final linear classification layer to fit the number of categories in our datasets. Further, the best responded transfer learning algorithm were analyzed by applying various optimizers such as AdaDelta, AdaGrad, Adam, RMSProp, and SGD.

4. Results

In this section, analysis of utilized dog breed dataset was initially analyzed for classification using different transfer learning algorithms such as VGG16, ResNetV2, DenseNet, and InceptionResNetV2. All models were built and trained using open-source Tensorflow on a cluster of NVIDIA Tesla K80 GPUs. Training images were cropped from the source picture and resized to the intended input size using scaling and aspect ratio augmentations throughout the process. We trained all networks using the optimizers. As depicted in figure, InceptionResnetV2 is resulting higher accuracy, precision and recall in comparison to other transfer learning algorithms. Simultaneously our further analysis focused on InceptionResnetV2 model with discussed optimizes. The results shown in the figure, pretending AdaDelta as a better optimizer in comparison to implemented optimizers i.e., AdaGrad, Adam, RMSProp, and SGD. Futher details reflected in figure 2 and 3.

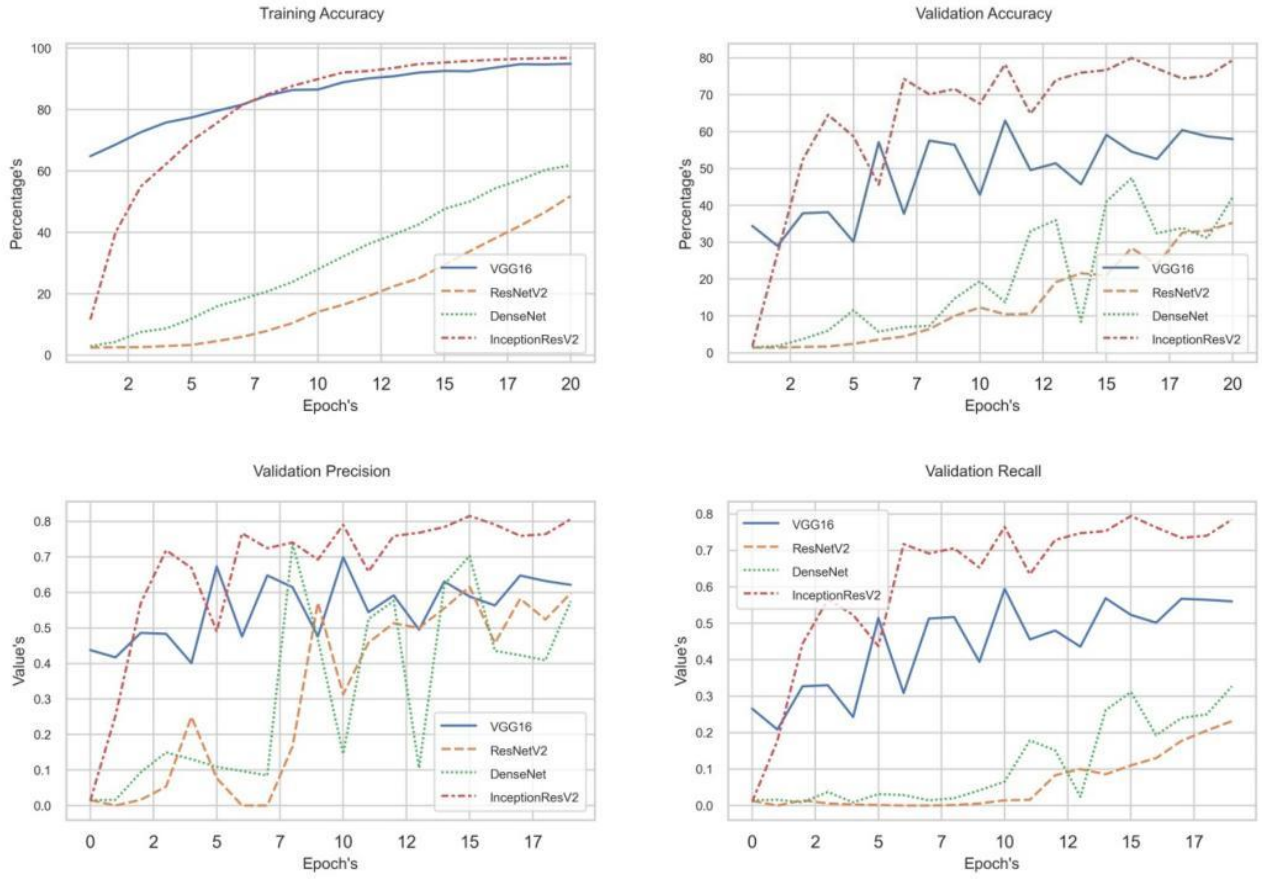

Figure 2- Result Analysis of Different Transfer Learning Algorithms for Dog Breed Classification

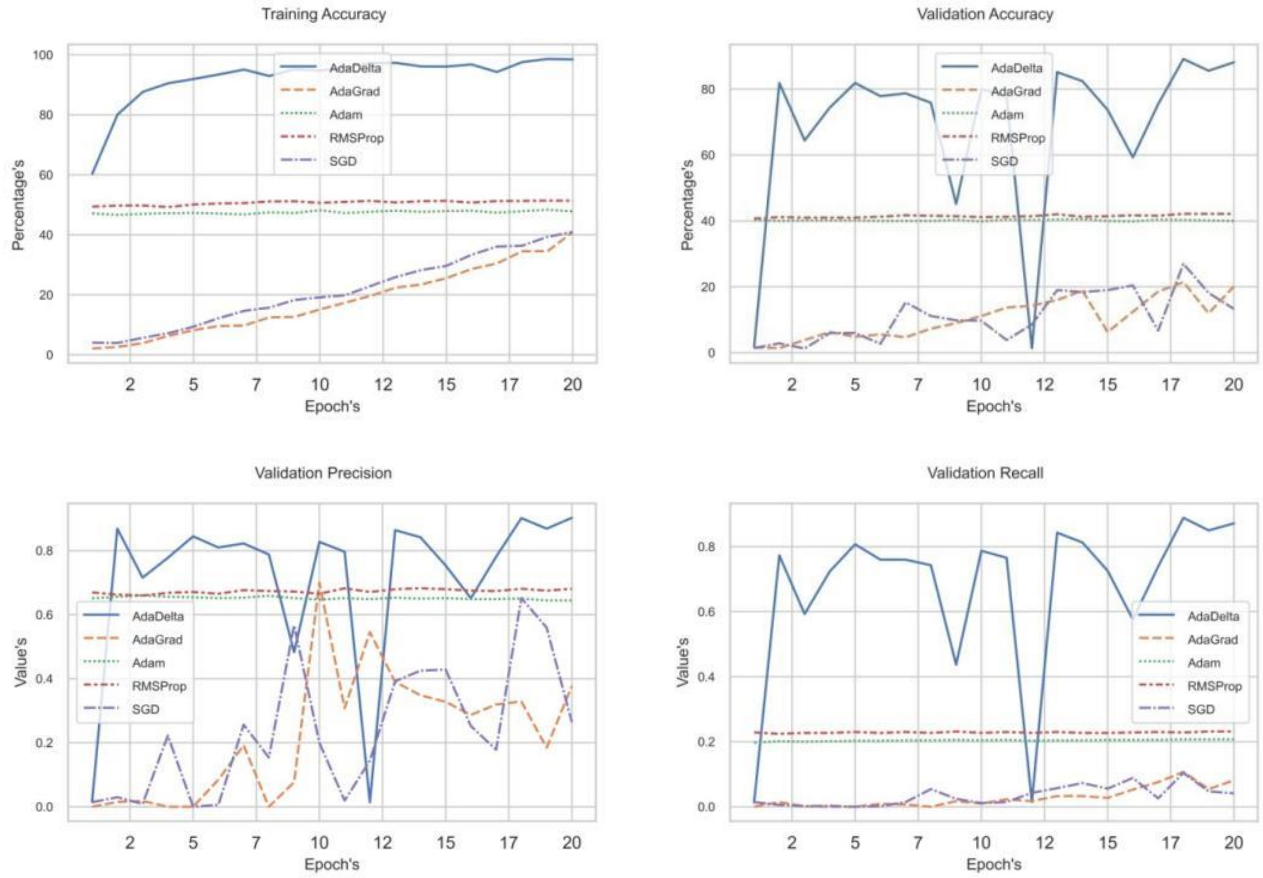

Figure 3- Result Analysis of Optimized InceptionResNet2 Transfer Learning Algorithm for Dog Breed Classification

5. Conclusion

The bulk of data mining problems can be solved using machine learning. In the field of machine learning, classification is one of the areas where it shines the brightest. An observation's classification is determined by performing a classification job. A state-of-the-art solution to picture categorization is deep learning models. In this paper, we analyzed for classification using different transfer learning algorithms such as VGG16, ResNetV2, DenseNet, and InceptionResNetV2. Further, the best responded transfer learning algorithm was analyzed by applying various optimizers such as AdaDelta, AdaGrad, Adam, RMSProp, and SGD. Experimental results show that InceptionResnetV2 is resulting higher accuracy, precision, and recall in comparison to other transfer learning algorithms. Thus we applied various optimization algorithms on InceptionResnetV2 model and found that AdaDelta outperforms other optimizers i.e., AdaGrad, Adam, RMSProp, and SGD.

6. References and Footnotes

Acknowledgements

We thank our colleagues from Sharda University and Chitkara University who provided insight and expertise that greatly assisted the research, although they may not agree with all of the interpretations/conclusions of this paper.

Author contributions

Ambuj Kumar Agarwal1: Conceptualization, Methodology, **Vidhu Kiran2Name2 Surname2:** Data curation, Writing-Original draft preparation, Field study **Rupesh Jindal3:** Visualization, Investigation, Writing-Reviewing and Editing. **Deepak Chaudhary4:** Software, Validation. **Raj Gaurang Tiwari5:** Software, Field study

Conflicts of interest

The authors declare no conflicts of interest.

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