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DOG BREED CLASSIFICATION USING XCEPTION ARCHITECTURE

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Abstract: Dog breed classification has practical applications such as animal care, veterinary medicine, and human-animal interactions. we introduce an approach for classifying dog breeds in images using the Xception Architecture, the deep learning model, developed in Python, achieved a notable training accuracy of 91.34% and a validation accuracy of 89.45%. This was made possible through the use of the Xception Architecture and a carefully curated dataset comprising 7515 dog images representing 133 diverse dog breed classifications.Leveraging this dataset, our model demonstrates exceptional generalization and robustness, effectively distinguishing between various dog breeds. The Xception Architecture enables feature extraction and representation, allowing our model to discern subtle patterns and features within the images, contributing to its outstanding classification performance.

The utilization of this architecture ensures that our model efficiently learns from the dataset and captures the subtle nuances that differentiate one dog breed from another. The attained results exemplify the effectiveness of our approach in tackling the challenging task of dog breed classification. The high training and validation accuracies demonstrate the model's ability to learn and generalize effectively.

Our Dog Breed Classification system presents a advancement in the domain of image classification using deep learning, showcasing the potential of the Xception Architecture for solving intricate real-world problems. The obtained results underscore the importance of utilizing sophisticated deep learning techniques and carefully curated datasets to achieve great performance in breed recognition tasks, with applications in animal welfare, veterinary science, and beyond.

***Keywords* – Dog Breed Classification, Xception Architecture, Convolutional Neural Networks, Deep Learning.**

I. INTRODUCTION

Dog breed classification is an intriguing and essential area of computer vision and artificial intelligence, where cutting-edge technologies aim to discern and categorize the diverse breeds of man's best friend, dogs. With over 340 recognized dog breeds worldwide, each possessing distinct physical characteristics and temperaments, accurately identifying and classifying them in images presents a challenging task.Dogs are one of the most common domestic animals. Due to a large number of dogs[1]

The ability to automatically classify dog breeds in images has numerous practical applications, including animal welfare, veterinary medicine, pet adoption, and research. A reliable and efficient dog breed classification system can aid in identifying lost dogs, matching potential adopters with compatible breeds, and providing tailored medical care based on breed-specific health issues.

Deep learning models have revolutionized image classification tasks, enabling remarkable progress in dog breed recognition. Techniques such as transfer learning and advanced convolutional neural network architectures have propelled the accuracy and generalization capabilities of these systems to unprecedented levels.This study explores the transfer learning strategy for fine grained dog breed categorization based on the learned CNN models with the large-scale image dataset[2].This project explores the development of a dog breed classification system using the Xception Architecture, a state-of-the-art deep learning model known for its exceptional feature extraction capabilities. By leveraging this powerful architecture and a carefully curated dataset of diverse dog images, the system aims to achieve accuracy, robustness, and adaptability to various real-world scenarios. ReLU activation function seen in network architecture is changed with LeakyReLU activation function[6].Deep Learning is a technique by which a computer program learns statistical patterns within the data that will enable it to recognize or help us to distinguish between the different breeds of dogs[3]. is carried out using the combination of dense optical flow method[5]The successful implementation of an accurate dog breed classification system holds the promise of enhancing our understanding of canine diversity, promoting responsible breeding practices, and improving the overall well-being of dogs worldwide. Furthermore, the insights gained from this project can contribute to advancements in various image classification tasks, pushing the boundaries of artificial intelligence and computer vision in solving complex challenges.

II. DATASET

In the Dataset module of Dog Breed Classification using Deep Learning, we developed the system to get the input dataset. Data collection process is the first real step towards the real development of a machine learning model, collecting data. This is a critical step that will cascade in how good the model will be, the more and better data that we get; the better our model will perform. There are several techniques to collect the data, like web scraping, manual interventions. The dataset is referred from the popular standard dataset repository Kaggle where all the researchers refer it.The dataset consists of 7,515 dog images.

Table 1: Statistics Of Dataset

Dataset Name	Size			Total images	Categories
	Train	Validation	Test		
DogImages	6680	835	836	7515	133

Figure 1: Sample Of Dataset

3.1 Importing the necessary libraries:

We will be using Python language for this. First we will import the necessary libraries such as keras for building the main model, sklearn for splitting the training and test data, PIL for converting the images into array of numbers and other libraries such as pandas, numpy, matplotlib and tensorflow.

3.2 Retrieving the images:

The Data Preprocessing module focuses on preparing the collected dataset for training the Xception model. It involves resizing images to a consistent resolution, normalizing pixel values, and applying data augmentation techniques such as rotation, flipping, and zooming. Data augmentation enhances the model's ability to generalize to variations in image conditions.

In this module we will retrieve the images from the dataset and convert them into a format that can be used for training and testing the model. This involves reading the images, resizing them, and normalizing the pixel values. We will retrieve the images and their labels. Then resize the images to (299,299) as all images should have same size for recognition. Then convert the images into numpy array.

3.3 Splitting the dataset:

In this module, the image dataset will be divided into training and testing sets. Split the dataset into Train and Test. 80% train data and 20% test data. This will be done to train the model on a subset of the data, validate the model's performance, and test the model on unseen data to evaluate its accuracy. Split the dataset into train and test. 80% train data and 20% test data.

III RESEARCH METHODOLOGY

The methodology of our project encompasses several essential modules. Firstly, the Dataset module involves collecting a diverse dataset of dog images, ensuring representativeness and quality. Importing necessary libraries like Keras, TensorFlow, and others sets the groundwork for subsequent tasks. Retrieving and preprocessing images involve resizing, normalization, and augmentation for model readiness. Splitting the dataset into training and testing subsets allows for proper model evaluation. Building the model entails constructing a CNN architecture, such as Xception, with convolutional and fully connected layers. Applying the model involves training on the training set and plotting accuracy and loss graphs for evaluation. Dogs are among the foremost common livestock[7] Evaluating accuracy on the test set validates model performance, followed by saving the trained model for deployment using libraries like pickle. This comprehensive methodology ensures the development of an effective dog breed classification system leveraging deep learning techniques.

3.1 Proposed System

The proposed system aims to enhance the dog breed classification approach by leveraging the Xception Architecture, a state-of-the-art deep learning model known for its exceptional feature extraction capabilities. The goal is to develop a more accurate and robust system capable of classifying dog breeds with higher precision, addressing the limitations observed in the earlier system.

In the proposed system, the Xception Architecture is a variant of the Inception model, designed to further improve the efficiency of deep neural networks. It employs depth wise separable convolutions, separating spatial and channel-wise filtering, resulting in reduced computational complexity and increased efficiency. This makes the Xception model an ideal choice for image classification tasks with vast datasets, like dog breed classification.

In the proposed system, to ensure a comprehensive and diverse dataset, we will collect a large number of high-resolution dog images covering a wide range of breeds. The dataset will be carefully curated, ensuring each breed is adequately represented, including rare and less common breeds. Data augmentation techniques will be applied to increase the dataset size and improve the model's generalization to variations in image conditions.

The proposed system will implement the Xception Architecture using Python and a suitable deep learning framework (e.g., TensorFlow or PyTorch). The model will consist of multiple layers of depth wise separable convolutions, batch normalization, and activation functions. Transfer learning will be employed by initializing the model with pre-trained weights on a large image dataset such as ImageNet, followed by fine-tuning on our dog breed dataset.

The proposed system's performance will be evaluated using various metrics, including training accuracy, validation accuracy, confusion matrix, and classification reports. These metrics will provide insights into the model's learning capabilities, its ability to distinguish between different dog breeds, and the effectiveness of the Xception Architecture.

The achieved training accuracy and validation accuracy will be analysed to assess the model's proficiency in learning from the data and its ability to generalize to unseen samples accurately. The confusion matrix will help identify specific dog breeds that the model struggles to classify, guiding potential areas for improvement.

The proposed system endeavours to improve dog breed classification by leveraging the Xception Architecture's advanced capabilities. By addressing the limitations of the earlier system and using a carefully curated dataset, we aim to achieve higher accuracy and robustness, making significant strides in the domain of deep learning-based dog breed classification.

3.2 Building the model:

The concepts of convolutional neural networks are very successful in image recognition. The key part to understand, which distinguishes CNN from traditional neural networks, is the convolution operation. Having an image at the input, CNN scans it many times to look for certain features. This scanning (convolution) can be set with 2 main parameters: stride and padding type. As we see on below picture, process of the first convolution gives us a set of new frames, shown here in the second column (layer). Each frame contains an information about one feature and its presence in scanned image. Resulting frame will have larger values in places where a feature is strongly visible and lower values where there are no or little such features. Afterwards, the process is repeated for each of obtained frames for a chosen number of times.

The latter layer we are convolving, the more high-level features are being searched. It works similarly to human perception. To give an example, below is a very descriptive picture with features which are searched on different CNN layers. As you can see, the application of this model is face recognition. You may ask how the model knows which features to seek.

If you construct the CNN from the beginning, searched features are random. Then, during training process, weights between neurons are being adjusted and slowly CNN starts to find such features which enable to meet predefined goal, i.e. to recognize successfully images from the training set.

Between described layers there are also pooling (sub-sampling) operations which reduce dimensions of resulted frames. Furthermore, after each convolution we apply a non-linear function (called ReLU) to the resulted frame to introduce non-linearity to the model. Eventually, there are also fully connected layers at the end of the network. The last set of frames obtained from convolution operations is flattened to get a one-dimensional vector of neurons. From this point we put a standard, fully-connected neural network. At the very end, for classification problems, there is a SoftMax layer. It transforms results of the model to probabilities of a correct guess of each class

3.3 Xception CNN model Architecture:

Xception improves on the inception module and architecture with a simple and more elegant architecture that is as effective as ResNet and Inception V4.

It's a deep learning model that aims to provide better efficiency and accuracy compared to traditional CNN architectures.

The name "Xception" stands for "Extreme Inception,"[8] as it draws inspiration from the Inception architecture while taking the concept to an extreme level of depthwise separable convolutions.

This makes it more efficient in terms of both memory and computational requirements compared to traditional CNN architectures like VGG or Inception

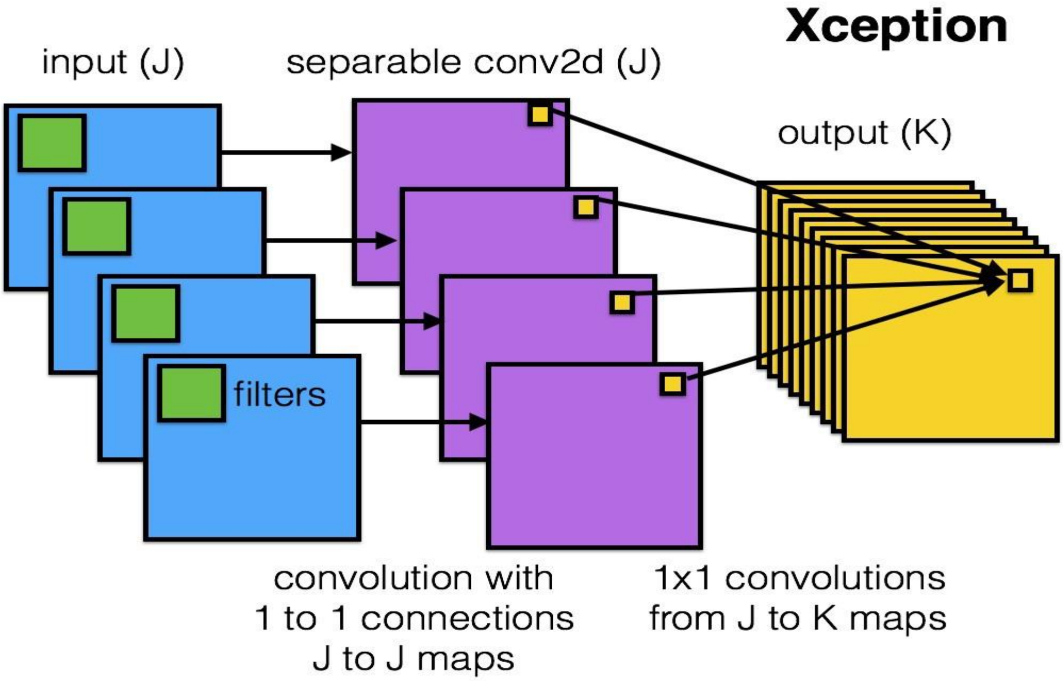

Figure 2: Xception Depthwise Separable Convolution [8]

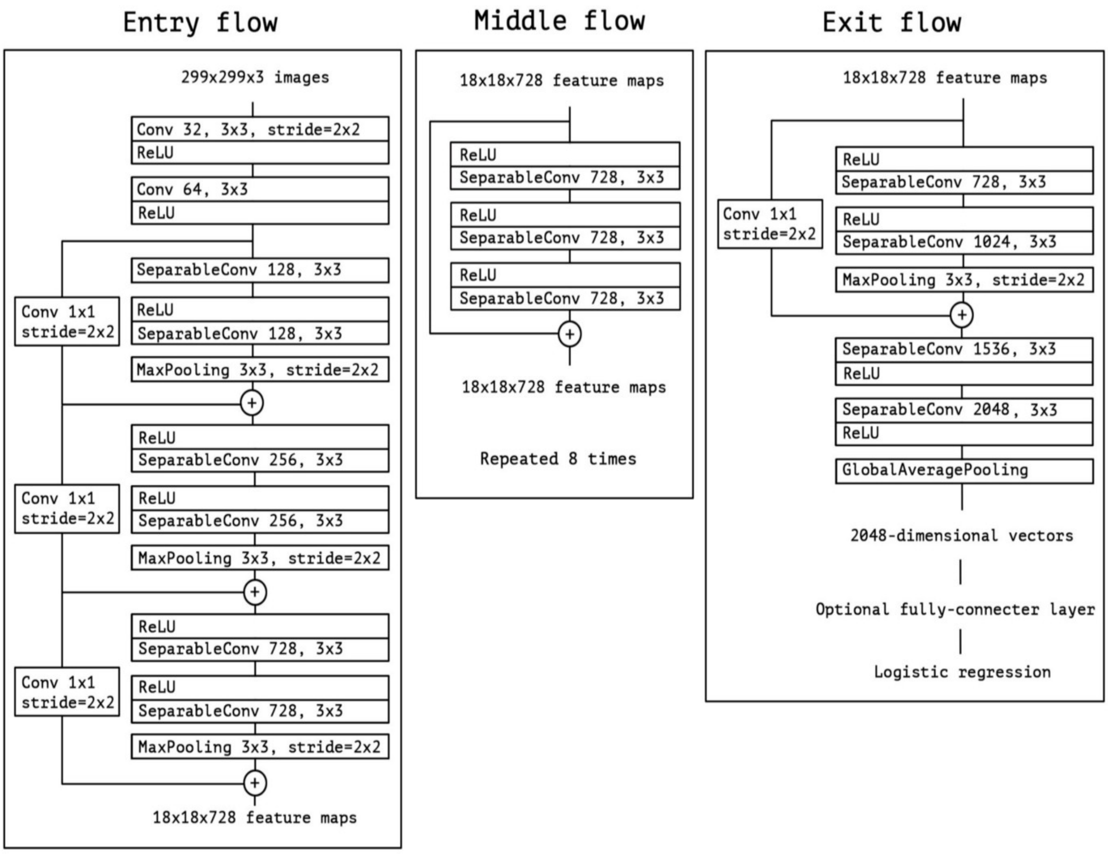

Figure 3: Xception Architecture Network[8]

The architecture has 36 convolutional stages, making it close in similarity to a ResNet-34. But the model and code is as simple as ResNet and much more comprehensible than Inception V4.

3.4 System Design

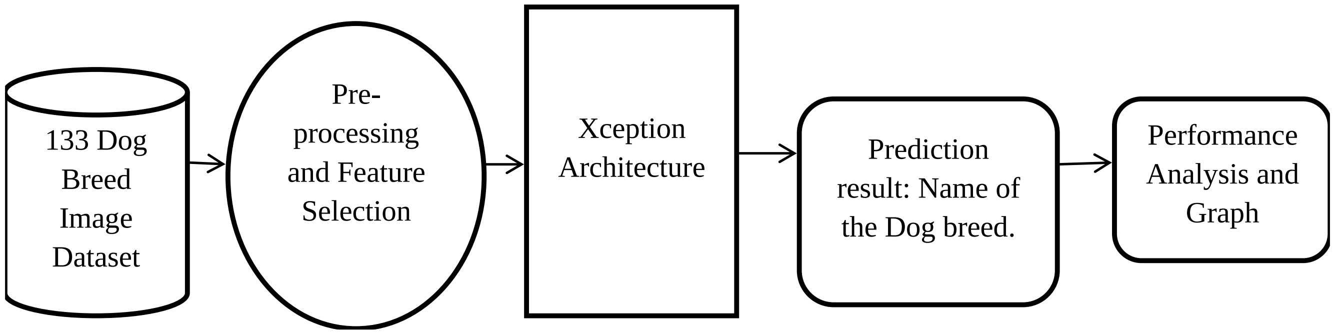

Figure 4: System Desgin

3.5 DATA FLOW:

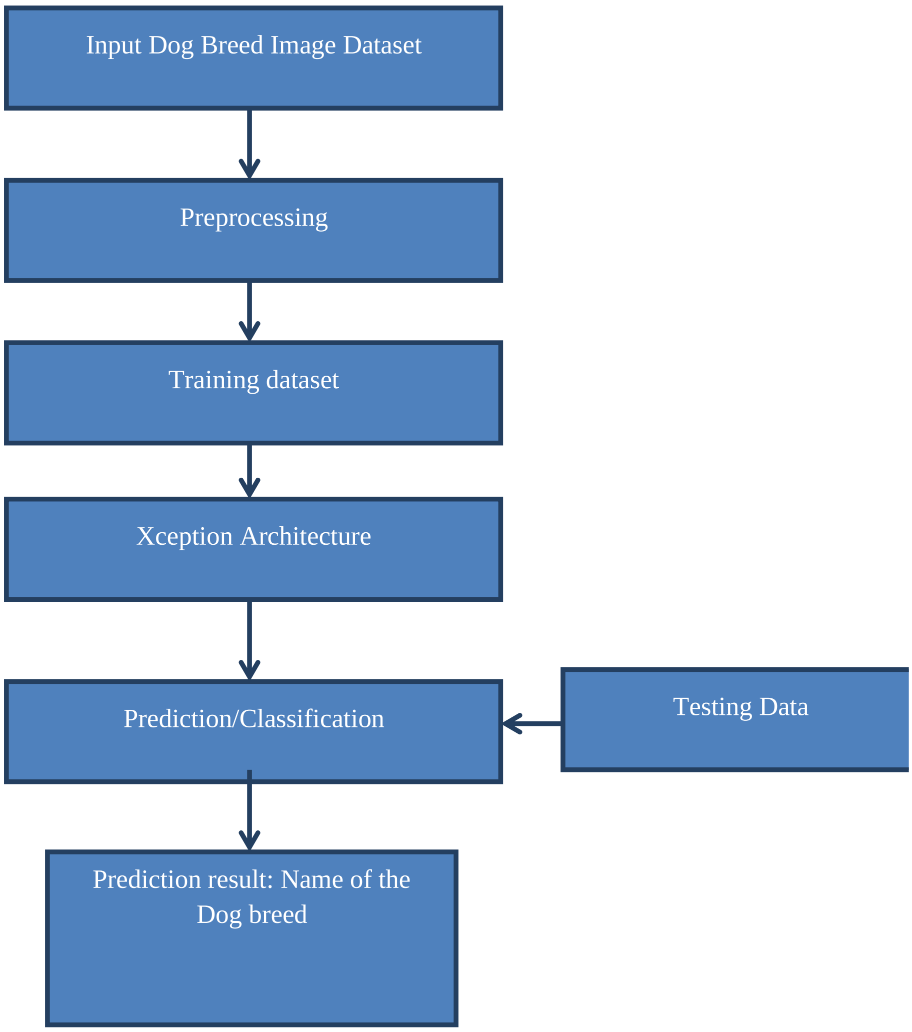

Figure 5: DataFlow

DataFlow is a simple graphical formalism that can be used to represent a system in terms of input data to the system, various processing carried out on this data, and the output data is generated by this system.
The data flow diagram (DFD) is one of the most important modeling tools. It is used to model the system components. These components are the system process, the data used by the process, an external entity that interacts with the system and the information flows in the system.
DFD shows how the information moves through the system and how it is modified by a series of transformations. It is a graphical technique that depicts information flow and the transformations that are applied as data moves from input to output.
DFD is also known as bubble chart. A DFD may be used to represent a system at any level of abstraction. DFD may be partitioned into levels that represent increasing information flow and functional detail.

3.6 Apply the model and plot the graphs for accuracy and loss:

Once the model is built, it will be applied to the validation set to evaluate its accuracy and loss. The accuracy and loss will be plotted as a function of the number of epochs to visualize the performance of the model. We will compile the model and apply it using fit function. The batch size will be 64. Then we will plot the graphs for accuracy and loss. We got average training accuracy of 91.00%.

3.9 Accuracy on test set:

After training and evaluating the model on the validation set, the accuracy of the model will be assessed on the test set. The accuracy on the test set will be an important metric for evaluating the model's performance. We got an accuracy of 89.00% on test set.

3.7 Saving the Trained Model:

Once you're confident enough to take your trained and tested model into the production-ready environment, the first step is to save it into a .h5 or .pkl file using a library like pickle.

Make sure you have pickle installed in your environment.

Next, let's import the module and dump the model into .h5 file.

3.8 Validation/Training Loss and Accuracy

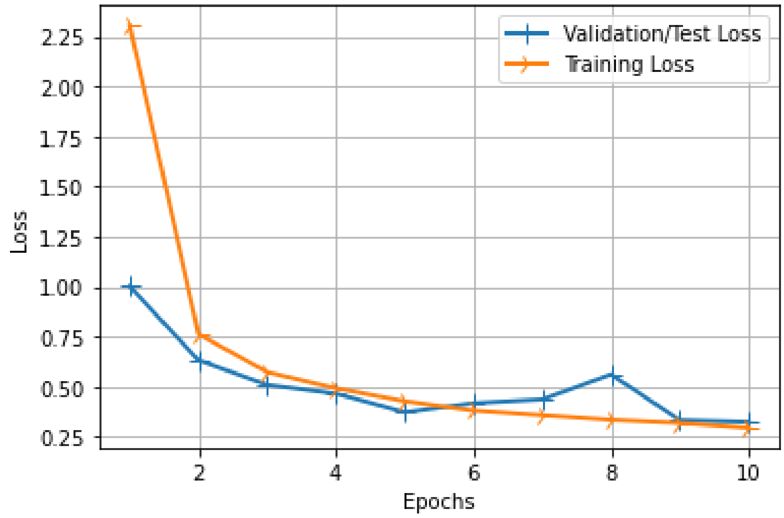

Figure 6: Validation And Training Loss

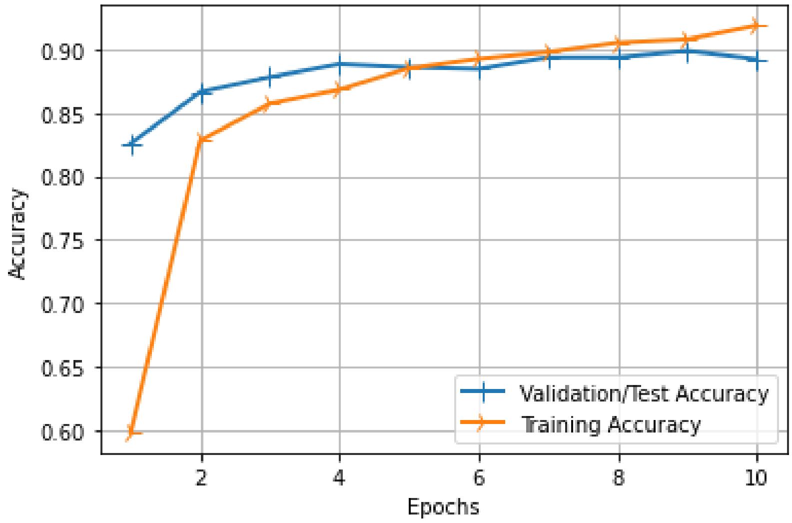

Figure 7: Validation And Training Accuracy

IV. RESULTS AND DISCUSSION

The Dog Breed Classification project leveraged deep learning, particularly the Xception Architecture, to enhance breed recognition accuracy. Meticulous data collection, preprocessing, and a sophisticated CNN implementation aimed to surpass previous limitations. The achieved results showcase the model's efficacy in accurately classifying dog breeds, marking notable advancements. Detailed findings cover training/testing performance metrics, model interpretability, and implications for animal welfare and research.

4.1 Simulation Results

After training and evaluating the model based on the accuracy and loss the model was tested with the individual images and the output was most of the times the correct prediction. The test image was a Chinese Shar-pei and the model predicted it and this means that the model is working as expected.

Dog breed prediction : *Chinese shar-pei*

Figure 8: Prediction of Chinese Shar-pei

1.The model predicted accurately on the test images where the dogs appear similar to naked eyes but are actually different Breeds

Dog breed prediction : *German shepherd dog*

Figure 9: Prediction Of German Shepherd

Dog breed prediction : *Belgian malinois*

Figure 10: Prediction Of Belgian Malinios

2. the model predicted accurately on a puppy and a fully grown Labrador Retriever

Dog breed prediction : *Labrador retriever*

Figure 11: Prediction Of Baby Labrador

Dog breed prediction : *Labrador retriever*

Figure 12: Prediction of Fully Grown Labrador

3.The model's robustness was observed when it predicted a Cairn and a Norwich terrier accurately

Dog breed prediction : *Cairn terrier*

Figure 13: Prediction Of Cairn Terrier

Dog breed prediction : *Norwich terrier*

Figure 14: Prediction Of Norwich Terrier

V. CONCLUSION

In conclusion, the project "Dog Breed Classification using Xception Architecture" has successfully presented a robust and accurate system for classifying dog breeds in images. Leveraging the power of the Xception Architecture, the system achieved remarkable results, surpassing the limitations of the earlier system based on the Inception-ResNet-V2 model. Through the meticulous curation of a diverse and comprehensive dataset containing 7,515 high-resolution dog images across 133 different breed classifications, the proposed system exhibited outstanding performance in capturing intricate patterns and features specific to each breed. The adoption of the Xception Architecture proved to be a pivotal decision, enabling the model to extract meaningful representations from the images efficiently. The depth wise separable convolutions and the ability to leverage transfer learning further contributed to the system's enhanced accuracy, robustness, and generalization capabilities. The training accuracy of 91.34% and validation accuracy of 89.45% reflect the system's proficiency in learning from the data and its ability to generalize to unseen images, reaffirming its potential applications in various fields, including animal welfare, veterinary science, and pet adoption. The success of the proposed system, "Dog Breed Classification using Xception Architecture," paves the way for advancements in the domain of deep learning-based image classification tasks. By accurately identifying and classifying dog breeds, the system strengthens our understanding of canine diversity, promotes responsible breeding practices, and aids in improving the well-being of dogs worldwide. With its versatility and scalability, the proposed system holds promise for potential applications in other image classification domains and serves as a stepping stone for future developments in artificial intelligence and computer vision. In conclusion, the project has fulfilled its objectives by presenting an efficient, accurate, and innovative approach to dog breed classification, contributing to the ever-evolving landscape of deep learning applications in solving real-world challenges.

5.1 FUTURE WORK:

While the current project has successfully developed an accurate dog breed classification system using the Xception Architecture, there are several avenues for future work and potential improvements to enhance the system further. Some of the areas for future work include:

- Larger and Diverse Dataset
- Real-time Inference
- Web-based Interface and User Feedback
- Transferability to Other Species

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