A Project Report

on

Dog Breed Detection using CNN

carried out as part of the ***Minor Project IT3270*** *Submitted*

by

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in partial fulfilment for the award of the degree of

Bachelor of Technology

in

Information Technology

School of Information, Security and Data Science
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MANIPAL UNIVERSITY JAIPUR
RAJASTHAN, INDIA

May 2024

CERTIFICATE

Date:

This is to certify that the minor project titled **Dog Breed Detection using CNN** is a record of the bonafide work done by **Chhaayan Goswami** (219302249) submitted in partial fulfilment of the requirements for the award of the Degree of Bachelor of Technology in Information Technology of Manipal University Jaipur, during the academic year 2023-24.

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ABSTRACT

This project aims to elucidate the methodology underpinning the utilization of CNNs for the meticulous identification of dog breeds. It navigates through key aspects such as dataset curation, network training procedures, and model evaluation, shedding light on both challenges encountered and breakthroughs achieved in the domain. Key objectives include assembling a diverse dog image dataset, optimizing a CNN for accurate breed identification, and implementing robust training methodologies. Uniquely feature selection with the combined powers of three models. The project will address class imbalances, explore transfer learning, and fine-tune the model for enhanced performance. The result will predict high accuracy with minimum loss. A user-friendly interface will be developed for seamless predictions. Ethical considerations will be paramount, and the project aims to provide resources and foster collaboration for continued advancements in the field of canine classification using CNNs. Beyond the scope of canine enthusiasts, advancements in dog breed identification contribute significantly to the broader field of computer vision, with potential applications spanning various industries.

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1.Introduction

The projects aim to use the technology of Machine Learning and Convolutional Neural Network to identify dog breeds, characterized by varying sizes, shapes, coat colors, and unique features. Traditionally, the identification of dog breeds relied heavily on manual examination of distinct physical traits by experienced professionals. This process often proved to be time-consuming, subjective, and prone to human error. However, the integration of CNNs into this domain has revolutionized the landscape, offering a novel means of achieving precision in breed identification with remarkable efficiency and accuracy. Inspired by the intricate architecture of the human visual system, CNNs excel in recognizing intricate patterns and hierarchical structures within images, making them exceptionally well-suited for the nuanced distinctions between various dog breeds.

At the heart of CNNs lies their ability to automatically learn and extract meaningful features from raw image data through a series of convolutional, pooling, and fully connected layers. The feature extractors such as resnet, desnenet and nasnet are used to identify and extract the required features from the images. This hierarchical feature extraction process allows CNNs to capture both low-level features like edges and textures, as well as high-level features such as shapes, patterns, and even breed-specific characteristics. By training on large datasets of labeled dog images, CNNs can learn to identify subtle differences in breed-specific features and accurately classify images into their respective categories.

Beyond the scope of canine enthusiasts, advancements in dog breed identification contribute significantly to the broader field of computer vision, with potential applications spanning various industries. In addition to pet adoption services and veterinary diagnostics, CNN-based dog breed detection systems can be applied in fields such as wildlife conservation, agriculture, law enforcement, and even healthcare. For example, these systems can be used to identify and track endangered species, monitor livestock health, assist in search and rescue operations, and even aid in the diagnosis of genetic disorders in humans based on facial features.

1.1 *Problem statement*

We need to develop a CNN model that predicts dog breeds with High Accuracy. We have achieved this by combining three different feature extractors namely ResNet50V2, DenseNet121 and NASNetMobile. The accuracy provided by each model by itself is not very high. We hope to maximize the model's performance and give the people accurate information about their favorite dogs.

1.2 *Objectives*

The project aims to revolutionize dog breed identification through Convolutional Neural Networks (CNNs). Key objectives include assembling a diverse dog image dataset, optimizing a CNN for accurate breed identification, and implementing robust training methodologies. The project will address class imbalances, explore transfer learning, and fine-tune the model for enhanced performance. A user-friendly interface will be developed for seamless predictions. Real-world testing will ensure applicability, and documentation will be shared for research and practical use. Ethical considerations will be paramount, and the project aims to provide resources and foster collaboration for continued advancements in the field of canine classification using CNNs.

1.3 *Scope*

- In this project a machine learning model is built to identify and classify dog breeds. Model is made such that it predicts the dog breeds with high accuracy to be useful in day-to–day lives.
- For the scope of this project, I have not included the real-time image detection, i.e , user will not be able to scan the dog and immediately get the result.

2 Background Detail

2.1 *Conceptual Overview*

Convolutional Neural Networks (CNNs) are a powerful class of deep learning models that have revolutionized the field of computer vision. Unlike traditional machine learning approaches that rely on manually engineered features, CNNs are able to automatically learn and extract relevant features from raw image data through a hierarchical series of convolutional and pooling layers. This hierarchical structure allows CNNs to capture local patterns and gradually build up more complex, abstract representations of visual information.

The core components of a CNN architecture include convolutional layers, which apply a set of learnable filters to the input image to extract local features, and pooling layers, which downsample the feature maps to reduce the spatial size and introduce translation invariance. These layers are stacked in a sequential manner, with the output of one layer serving as the input to the next. The final layers of a CNN typically consist of one or more fully connected layers that aggregate the learned features and produce the final classification or regression output.

The success of CNNs in computer vision tasks, such as image classification, object detection, and semantic segmentation, can be attributed to their ability to effectively capture spatial and local relationships within images. By leveraging the hierarchical structure and parameter sharing, CNNs are able to learn rich representations that scale well to large and complex datasets, making them a go-to choice for many real-world visual recognition problems, including dog breed classification.

2.2 *Literature Review*

In [1] the main principle is to implement Image classification with Deep learning and Convolution Neural Networks using Tensor flow. Is focused on a machine leaning model which classifies the breed of the dog from an image. Then in [2] the main aim being a deep learning approach to identify dog breeds. It Used transfer learning by retaining pre trained CNNs. It is basically an image classification model which achieves a promising accuracy of 89.92% on the published dataset with 133 dog breeds "Dog Breed Classifier using Convolutional Neural Networks. Furthermore in [3] the basic principle is to implement Image classification with Deep learning. It is a machine leaning model which identifies the breed of dog from an image. In [4] the main principle was to find a deep learning approach to identify dog breeds. Its main outcome was an image classification model which has an accuracy of 89.92% on a dataset of 133 dog breeds. To continue with the literature survey, [5] was focused on implementing an Image classification model with Deep learning. A model which identifies the breed of the dog from any image by using CNN. Next, in [6] the purpose was to find a deep learning approach to identify various breeds of dogs. Then, in [7] the main focus was dog breed classification using size and position of each local part. In [8] the aim was to classify dog breeds using deep learning approach. Lastly, [9] consisted of a Dog Breed Classification Model Based on Deep Learning which used transfer learning by retaining pertained CNNs.

3 System design and methodology

3.1 *Dataset Curation*

Central to the success of CNN-based dog breed identification systems is the availability of high-quality, diverse datasets. These datasets serve as the foundation for training, validating, and testing CNN models. Curating a comprehensive dog breed dataset involves collecting a large number of images covering a wide range of breeds, variations within breeds, and environmental conditions.

Several publicly available datasets have been curated specifically for dog breed identification tasks. In our project we used the Stanford Dogs dataset, which contains over 20,000 images of 120 different dog breeds. Each image in the dataset is labeled with the corresponding breed, allowing the CNN model to learn the visual characteristics associated with each breed.

3.2 *Network Architecture and Training*

Once the dataset is curated, the next step is to design a CNN architecture and train it on the dataset. CNN architectures for dog breed identification typically consist of multiple convolutional layers followed by fully connected layers. These architectures are designed to extract hierarchical features from input images and learn discriminative representations for each dog breed.

During the training phase, the CNN model learns to minimize a loss function by adjusting its parameters (weights and biases) based on the discrepancy between predicted breed probabilities and ground truth labels. The training process involves feeding batches of images through the network, computing the loss, and updating the parameters using optimization algorithms such as stochastic gradient descent (SGD) or Adam. Training is typically conducted over multiple epochs until the model converges to a stable state.

The detailed description of the training parameters used are as follows:-

Preprocessor: every model takes different input so we preprocess the data according to the requirement of that model.
Optimizer Choice: Selected an optimizer like Adam to update model weights based on the loss function.
Loss Function: Use categorical cross-entropy for multi-class classification.
Hyperparameter Tuning: Experiment with different learning rates, activation functions, and network configurations to find the optimal model settings.
Validation and Testing: Split the data into training, validation, and testing sets. Train the model on the training set, monitor performance on the validation set, and evaluate the final model on the testing set.

3.3 *Model Evaluation and Fine-Tuning*

Once the CNN model is trained, it is evaluated on a separate validation set to assess its performance and generalization ability. Evaluation metrics such as accuracy, precision, recall, and F1 score are used to quantify the model's performance in classifying dog breeds. Additionally, confusion matrices and classification reports provide insights into the model's strengths

3.4 *Development Environment*

Software Requirements:

- **OpenCV:** OpenCV (Open Source Computer Vision Library) is a powerful open-source library for computer vision and image processing tasks, facilitating development.

- **Keras:** Keras is a high-level neural networks API written in Python, serving as an interface for building and training machine learning models, especially deep neural networks, with simplicity and flexibility.

- **Tensorflow:** TensorFlow is an open-source machine learning framework developed by Google. It provides a comprehensive platform for building and deploying machine learning models, supporting both beginners and experts in AI development.

- **Kaggle:** Kaggle is a platform for data science competitions, collaborative projects, and machine learning education, fostering a vibrant community of data enthusiasts worldwide.

- **JupyterLab:** JupyterLab is an open-source web-based interactive development environment for Jupyter notebooks, code, and data. It provides a flexible and intuitive interface for writing code, running experiments, and analysing data

- **Pandas:** Pandas is a powerful Python library for data manipulation and analysis. It provides easy-to-use data structures like Data Frame and Series, making it ideal for tasks such as data cleaning, exploration, and transformation.

Hardware Requirements:

- **Development Machine:** A computer or laptop capable of running advanced machine learning models with sufficient processing power, RAM, and storage.

- **Internet Connection:** A stable internet connection is necessary for downloading dependencies, updates, and collaborating with version control systems.

4 Implementation and result

4.1 Loss analysis

We use softmax and cross-entropy to evaluate their performance in terms of the training and testing loss. The softmax function is a generalization of the logistic function that "squashes" a K-dimension vector z of arbitrary real values to a K-dimensional vector a(z) of real values, where each entry is in the range (1,0), and all the entries add up to 1 [10]. The function is given by:

$$\sigma : R^K \to \left\{\sigma \in R^K \mid \sigma_i > 0, \sum_{i=1}^{K} \sigma_i = 1\right\}$$
$$\sigma(Z)_j = \frac{e^{z_j}}{\sum_{k=1}^{K} e^{z_k}}$$

Cross-Entropy loss measures the performance of a classification model whose output is a probability value between 0 and 1. Cross-entropy loss increase as the predicted probability diverges from the actual label. In multiclass classification, cross-entropy can be calculated as [10]:

$$-\sum_{c=1}^{M} y_{o,c} log(p_{o,c})$$

The loss comparison results after 60 epochs are shown in Fig: -1

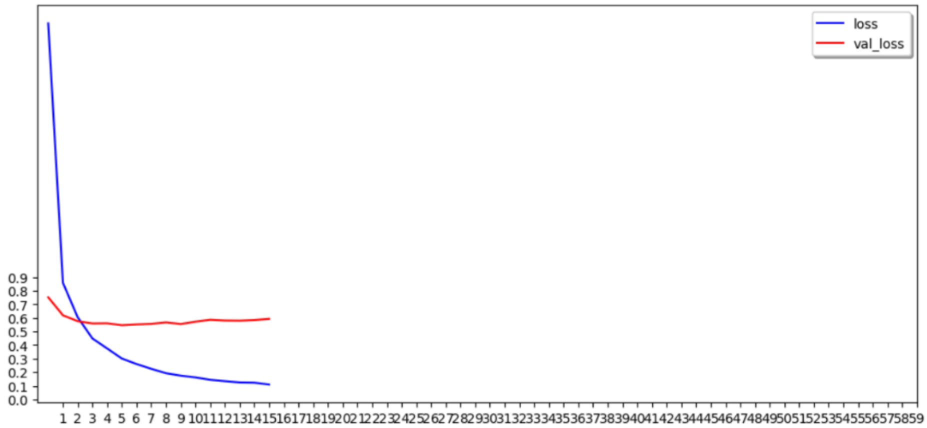


Fig:- Loss Graph

4.2 Accuracy analysis

To better evaluate the performance of these four models, we also compare their accuracy. The accuracy comparison results after 50 epochs are shown in Fig.2

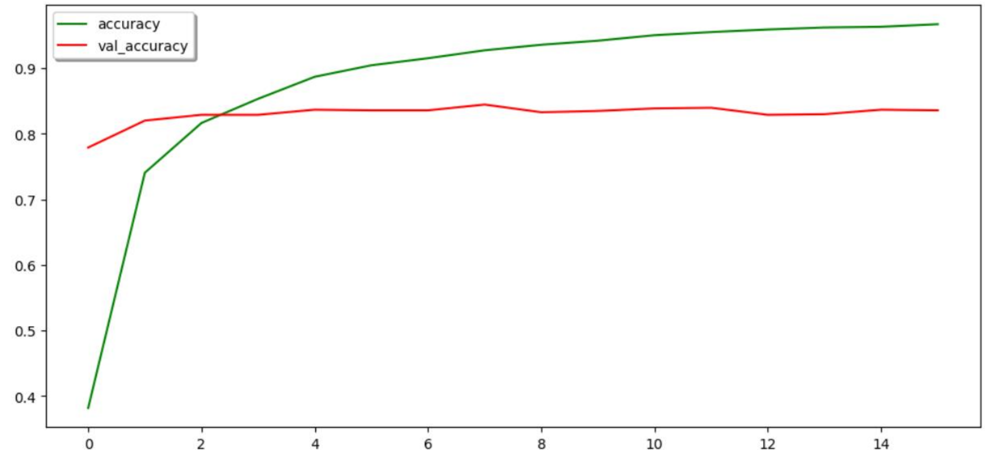
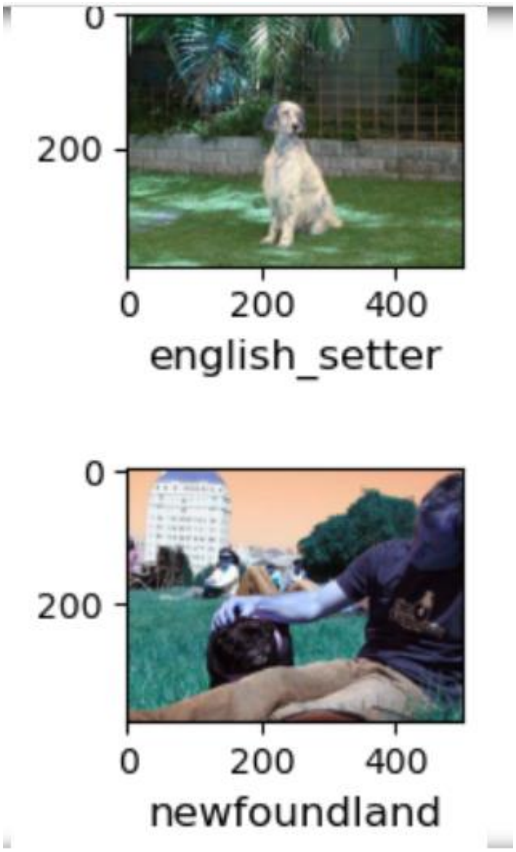


Fig:- Accuracy Graph

4.3 Model Output:

The first few outputs of our project in Jupyter Lab is shown in Fig-3 and Fig-4 as seen by the images and the label below it our model is working correctly.



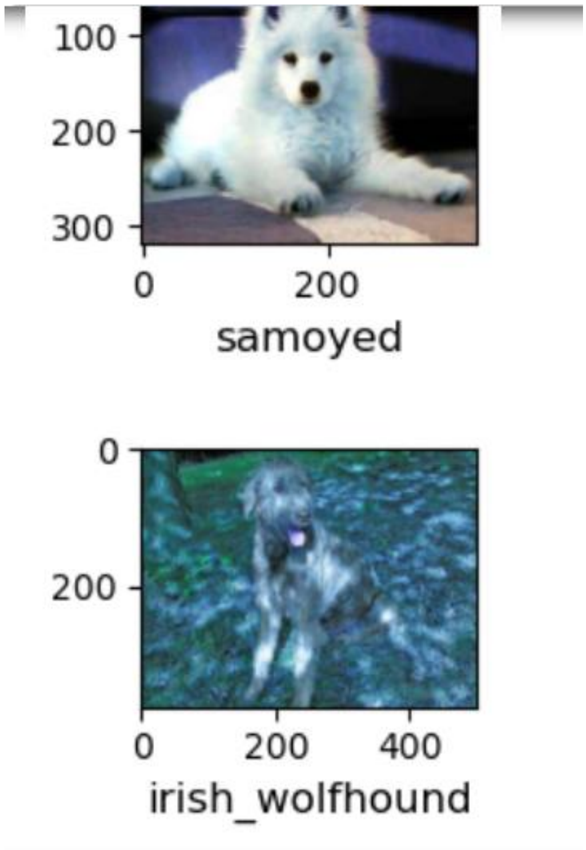


Fig:- Output 1

Fig:- Output 2

Tables

Table-1: Dog Breed Identification from previous research over 50 epochs [10]

Models	**Loss**	**Accuracy**
ResNet18	0.0056	0.8013
DenseNet161	0.0031	0.8954
AlexNet	0.0131	0.5419
VGG16	0.0067	0.7630

Table-2: Results from proposed project over 20 epochs

Model	**Loss**	**Accuraccy**
ResNet50V2	0.4476	0.8584
DesseNet121	0.3873	0.8653
NASNetMobile	0.4657	0.8391

The research taken as reference is ran 50 epochs and the combined accuracy is obtained 85.48% [10]. The proposed project is ran for 60 epochs and the combined accuracy obtained in 96.67%

Conclusion

In conclusion, Convolutional Neural Networks (CNNs) have revolutionized dog breed classification by providing a highly accurate and efficient method for identifying canine breeds from images. Through the utilization of large, curated datasets and sophisticated CNN architectures, these systems can discern subtle differences in physical traits and coat patterns, surpassing human performance in many cases.

Overall, this code constructs a neural network model that combines features extracted from ResNet50V2, DenseNet121, and NASNetMobile models, each applied to the same input image. With this type of architecture we leverage features learned by different CNN architectures for a specific task. With all three combined we get the training_accuracy 96% validation_accuracy 83% whereas by using only ResNet we get training_accuracy 81% and Validation_accuracy 65%. As CNNs continue to evolve, the potential for further improvements in dog breed classification remains promising, offering new avenues for research and practical applications.

Future work

Future efforts might concentrate on extending the model's capacity to identify additional dog breeds, enhancing its adaptability and utility. By exploring developments in transfer learning, data augmentation, and model architecture optimization, there's potential for increased classification accuracies and quicker inference times. Integration with mobile applications could enable real-time dog breed identification on mobile platforms, offering users instant access to information about their dogs wherever they are.

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