Image Classification using Machine Learning

A Project Report

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by

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ABSTRACT

This project involves classifying images from the CIFAR-10 dataset using a Convolutional Neural Network (CNN). The dataset comprises 60,000 color images, each belonging to one of 10 classes. The project's objective is to design, implement, and evaluate a CNN model capable of accurately categorizing these images. Using a structured CNN architecture with layers like Conv2D, MaxPooling, Dropout, and Dense, the model achieves competitive accuracy while minimizing overfitting. The results demonstrate the effectiveness of CNNs in image classification tasks. Future enhancements could focus on fine-tuning hyperparameters and exploring transfer learning techniques.

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CHAPTER 1

Introduction

1.1. Problem Statement: Image classification involves categorizing images into predefined classes based on their content. While traditional methods struggle with high-dimensional data and complex patterns, CNNs have shown remarkable success in capturing spatial hierarchies. This project focuses on applying a CNN to classify CIFAR-10 images into 10 distinct categories. The goal is to design a model that balances accuracy and computational efficiency.

1.2. Motivation: The exponential growth in visual data generation through mobile devices, surveillance systems, and autonomous platforms has necessitated the development of automated classification systems. This project aims to bridge the gap between theoretical knowledge of CNNs and practical implementation while addressing real-world challenges like class imbalance and overfitting.

1.3. Objectives:

- Develop a CNN model for CIFAR-10 image classification.
- Implement data augmentation to improve generalization.
- Evaluate the model using standard metrics such as accuracy, precision, and recall.
- Identify areas for future improvement, such as hyperparameter tuning and alternative architectures.

1.4. Scope of the Project: This project is limited to the CIFAR-10 dataset and focuses on supervised learning techniques. While the results are specific to this dataset, the methodologies are generalizable to other datasets with minor adaptations.

CHAPTER 2

Literature Survey

2.1. Summarizing known works:

Existing Works: CNNs have been pivotal in advancing computer vision, with notable architectures such as AlexNet, VGG, and ResNet. These models utilize hierarchical feature extraction for tasks like object recognition and classification.

Applications in CIFAR-10: The CIFAR-10 dataset has been extensively used to benchmark CNN performance. Studies have shown that deeper architectures and data augmentation improve accuracy but may increase training time and resource requirements.

Gaps Addressed: Many prior approaches have issues with overfitting and fail to balance model complexity with efficiency. This project incorporates dropout and data augmentation to tackle these challenges.

CHAPTER 3

Proposed Methodology

3.1 System Design

Preprocessing:

- Data normalization: Scaled pixel values to the range [0, 1].
- One-hot encoding of class labels for multi-class classification.

Model Architecture:

- Convolutional layers: Extract spatial features using kernels.
- Pooling layers: Down-sample feature maps to reduce computational load.
- Dropout layers: Mitigate overfitting by randomly deactivating neurons.
- Dense layers: Combine extracted features for final classification.

Data Augmentation:

- Techniques include flipping, rotation, and zoom to expand the training dataset virtually.

3.2 Requirement Specification

3.2.1 Hardware Requirements: GPU-enabled environment for faster computation.

3.2.2 Software Requirements:

 Python libraries: TensorFlow, Keras, Matplotlib, NumPy.

 IDE/Environment: Jupyter Notebook.

CHAPTER 4

Implementation and Result

4.1. Implementation

Model Training:

- Optimizer: Adam for adaptive learning rate adjustment.
- Loss Function: Categorical Crossentropy for multi-class classification.
- Metrics: Accuracy to evaluate performance.

Training Details:

- Epochs: Adjusted based on system capacity (e.g., 50 may not be feasible).
- Batch Size: Defined to balance computational efficiency and gradient stability.

Evaluation:

- Split: 50,000 images for training, 10,000 for testing.

4.2. Snap Shots of Result

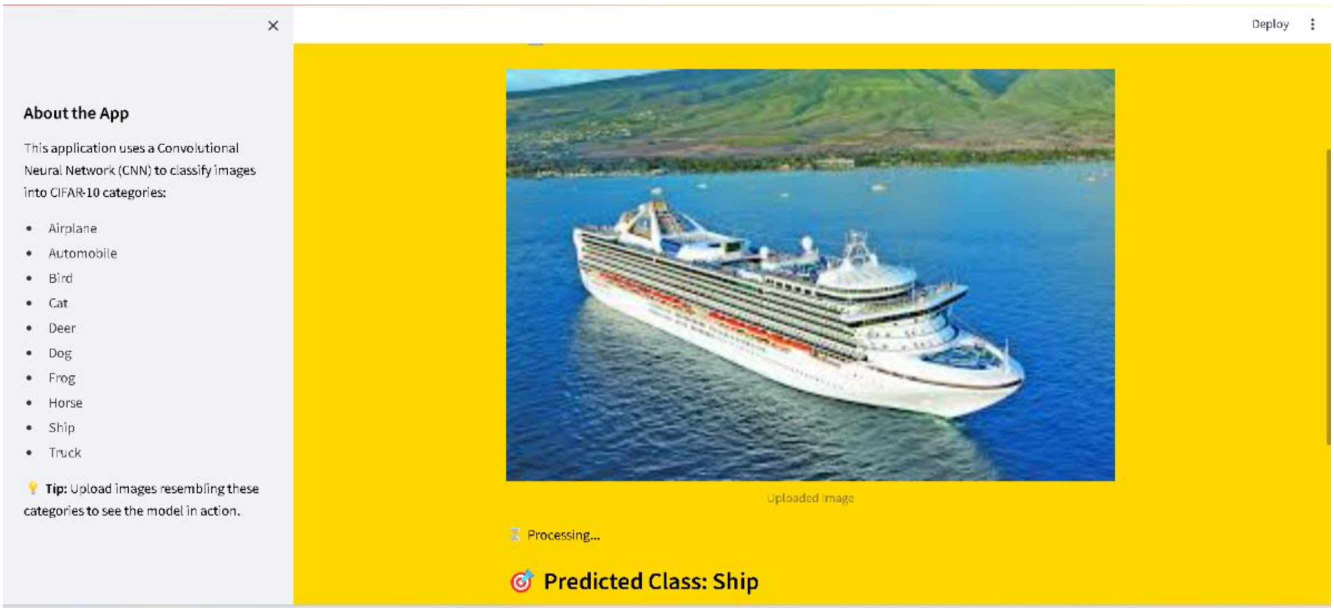

Fig 1.1

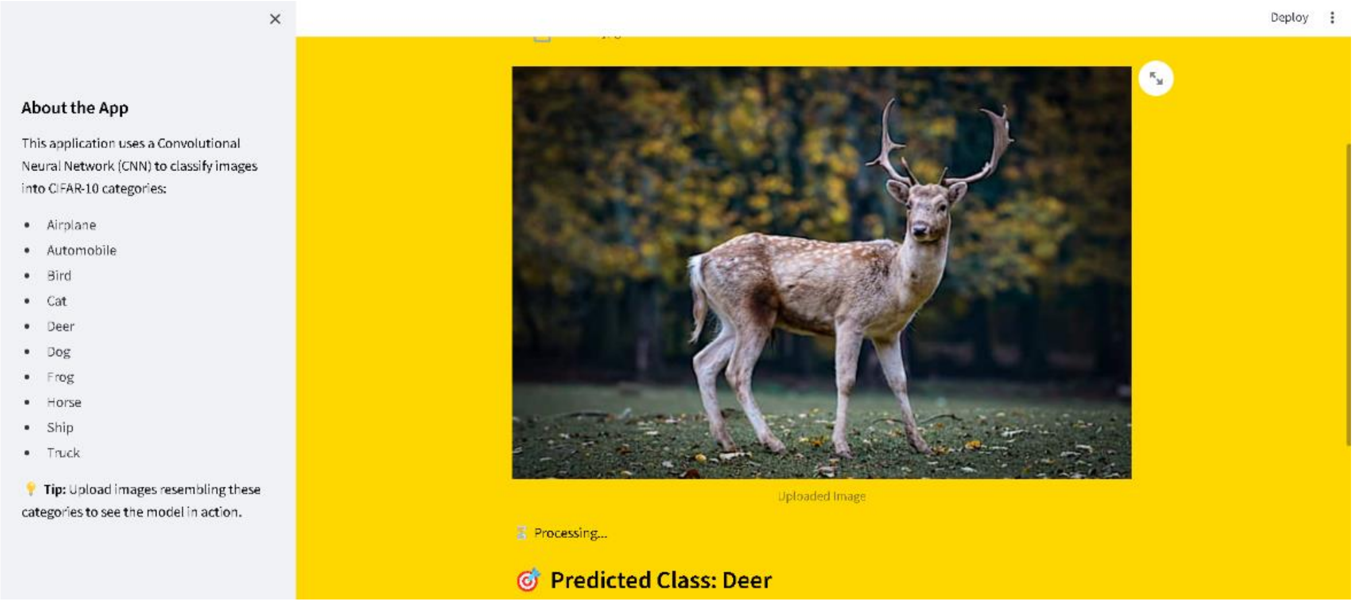

Fig 1.2

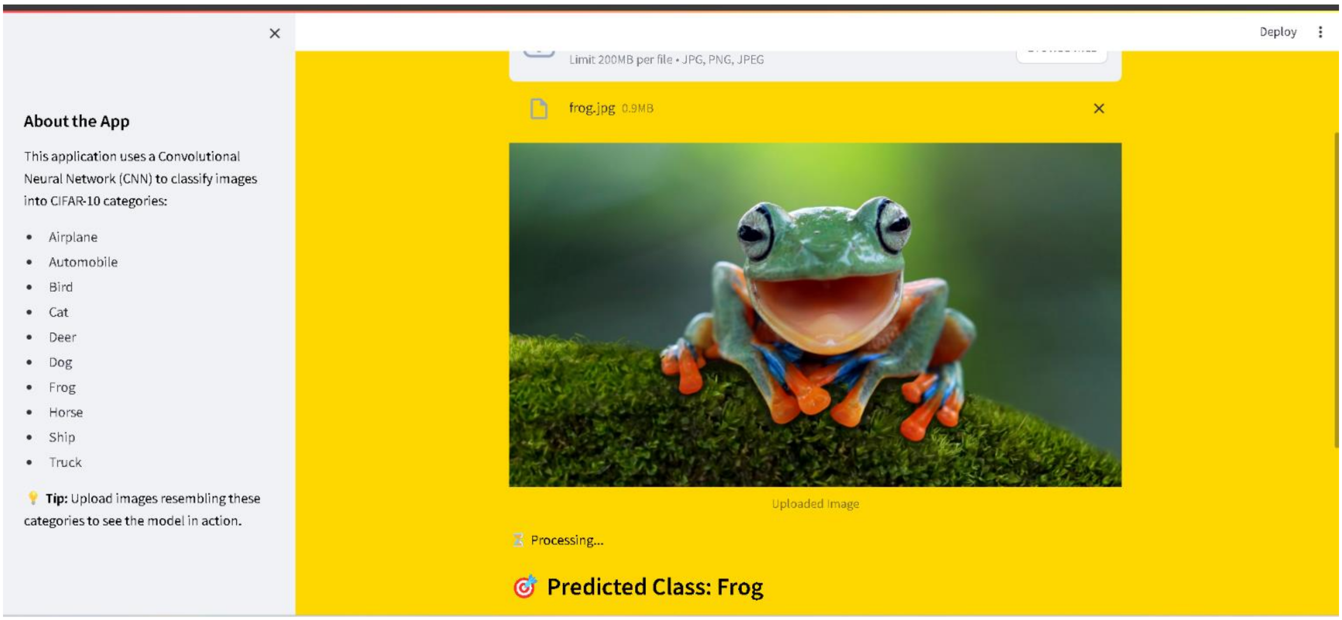

Fig 1.3

GitHub Link for Code:

Link: https://github.com/hareetima02/Image-Classification-using-ML-model

CHAPTER 5

Discussion and Conclusion

5.1 Future Work:

 Incorporate pre-trained models such as ResNet or EfficientNet to leverage transfer learning.
 Experiment with advanced optimization techniques and learning rate schedulers.

 Explore the deployment of the model in real-world applications using tools like TensorFlow Lite.

5.2 Conclusion:

This project demonstrates the power of CNNs in image classification tasks. The proposed model achieves competitive accuracy on the CIFAR-10 dataset while addressing challenges such as overfitting. The methodologies and insights gained can be extended to other datasets and practical applications.

REFERENCES

[1]. Ming-Hsuan Yang, David J. Kriegman, Narendra Ahuja, “Detecting Faces in Images: A Survey”, IEEE Transactions on Pattern Analysis and Machine Intelligence, Volume. 24, No. 1, 2002.