Performance Comparison of CNN and ANN for Animal Image Classification: A Case Study on Cats, Dogs, and Snakes

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***Abstract*—This research paper revolves around an image classification system based on deep learning principles. The analysis is with respect to identifying three specific groups of animals in given images; cats, dogs, and snakes. It employs the well-known Convolutional Neural Network (CNN) architecture having been trained on a set of 3000 images. The images were further standardized in dimensions and quality paving way for a CNN which was trained achieving a validation accuracy of 98.60% and a test accuracy of 98.40%. These results show that the implemented CNN is capable of recognizing images belonging to the categories in question. Furthermore, an Artificial Neural Network (ANN) has been subjected to testing as a second approach and this was found to yield low performances with high error returns and low classification accuracy. This analysis demonstrates that Convolutional Neural Networks have greater potential in feature extraction from images thus processing them more effectively than an Artificial Neural Network. Further improvements of performances in the future studies may include applying more complex networks.**

***Index Terms*—CNN, ANN, Animal Classification, Deep Learning, Image Processing.**

I. INTRODUCTION

Classifying images remains a challenge in the field of computer vision, with diverse applications, such as aiding in medical diagnoses and monitoring wildlife populations. This research focuses on distinguishing between cats, dogs, and snakes using deep learning methods. Convolutional Neural Networks (CNNs) have emerged as the preferred approach for image classification due to their ability to leverage large datasets and computational resources. In this study, we assess the effectiveness of CNN models against a fully connected Artificial Neural Network (ANN), which serves as a baseline for comparison.

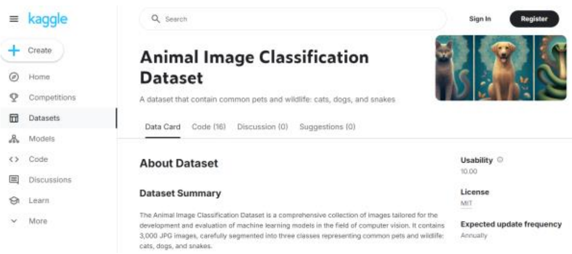
The aim of this study is to evaluate the performance of CNNs in comparison to ANNs in categorizing animals, using a publicly accessible dataset from Kaggle.

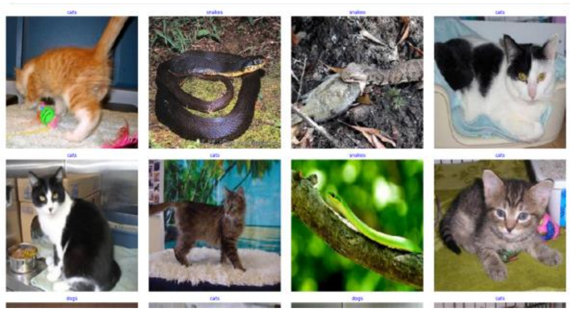
II. RELATED WORK

Numerous studies have explored animal image classification using CNNs. For instance, CNNs demonstrated outstanding capability in classifying animals into ten categories with 90% accuracy [1]. Another study improved classification accuracy by applying transfer learning techniques, using pre-trained VGG16 and ResNet50 models through fine-tuning [2]. Despite CNNs achieving state-of-the-art results in image classification, traditional ANNs have consistently underperformed due to their inability to effectively capture spatial features.

III. DATASET DESCRIPTION

The dataset used in this study was sourced from Kaggle [3] and comprises images of three animal categories: cats, dogs, and snakes. It includes a total of 3,000 training images and 1,500 test images. The images, originally of varying sizes, were resized to 224×224 pixels to be processed by the CNN.





- *Training Set:* 3,000 images (cats, dogs, snakes).
- *Validation Set:* 1,500 images.
- *Test Set:* 1,500 images.

```
train_gen = tr_gen.flow_from_dataframe(train_df, x_col='filepaths', y_col='labels', target_size=img_size, class_mode='categ
                                        color_mode='rgb', shuffle=True, batch_size=batch_size)

valid_gen = ts_gen.flow_from_dataframe(valid_df, x_col='filepaths', y_col='labels', target_size=img_size, class_mode='categ
                                        color_mode='rgb', shuffle=True, batch_size=batch_size)

test_gen = ts_gen.flow_from_dataframe(test_df, x_col='filepaths', y_col='labels', target_size=img_size, class_mode='categor
                                       color_mode='rgb', shuffle=False, batch_size=batch_size)
Found 3000 validated image filenames belonging to 3 classes.
Found 1500 validated image filenames belonging to 3 classes.
Found 1500 validated image filenames belonging to 3 classes.
```

IV. METHADOLOGY

A. Data Preprocessing

All images were rescaled to a 0–1 range to normalize pixel values, and one-hot encoding was applied to the labels. An 80/20 train-validation split was used for hyperparameter tuning and early stopping.

B. Model Architectures

CNN Architecture:

The CNN model is a sequential model consisting of the following layers:

- *Input layer:* (224x224x3) dimensions.
- Three convolutional layers with ReLU activation and max-pooling.
- Fully connected layer with 128 units and a 50% dropout rate.
- Softmax activation output layer for multiclass classification.

The model was optimized using the 'adam' optimizer and trained for 10 epochs.

ANN Architecture:

The ANN employed was a basic feedforward network with three layers. Each dense layer was followed by an activation function, and a softmax output layer was used for classification. The input consisted of the 224x224x3 images flattened into 150,528-dimensional vectors.

C. Training

Both models were trained using categorical cross-entropy as the loss function, with data augmentation turned off. A batch size of 16 was used for 10 epochs for both the CNN and ANN models.

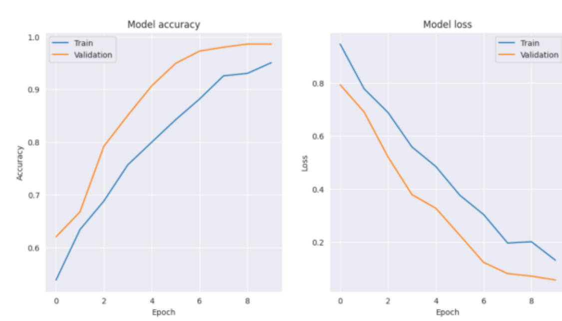
V. RESULTS AND DISCUSSION

A. CNN Performance

The CNN model achieved a validation accuracy of 98.60% and a test accuracy of 98.40%. The confusion matrix illustrates the distribution of correctly and incorrectly classified instances, indicating that the model generalized well across all three classes.

- *Test Accuracy:* 98.40%
- *Test Loss:* 0.0551

```
test_loss, test_accuracy = model.evaluate(test_gen)
print(f"Test Loss: {test_loss:.4f}")
print(f"Test Accuracy: {test_accuracy:.4f}")
94/94 ━━━━━━━━━━━━━━━━━━━━ 2s 21ms/step - accuracy: 0.9825 - loss: 0.0562
Test Loss: 0.0551
Test Accuracy: 0.9840
```



B. ANN Performance

In contrast, the ANN model yielded a significantly lower test accuracy of 34.40%. The ANN struggled to extract spatial features from the images, leading to suboptimal classification performance. The confusion matrix revealed substantial misclassifications across all categories.

- *Test Accuracy:* 34.40%
- *Test Loss:* 1.0927

```
# Evaluate the model
test_loss, test_accuracy = ann_model.evaluate(X_test.reshape(X_test.shape[0], -1), y_test)
print(f'Test loss: {test_loss}')
print(f'Test accuracy: {test_accuracy}')
```

```
47/47 ━━━━━━━━━━━━━━━━━━━━ 2s 31ms/step - accuracy: 0.3321 - loss: 1.0970
Test loss: 1.0927692651748657
Test accuracy: 0.3440000116825104
```

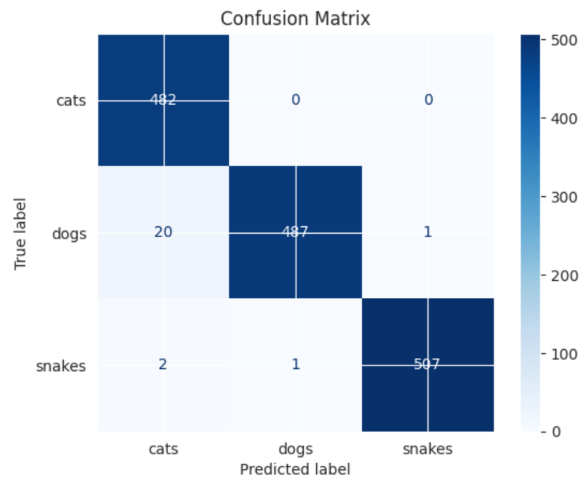
C. Confusion Matrix and Classification Report

The confusion matrix for the CNN model shows high precision and recall scores for all three classes, as indicated in the classification report: Class 1 (Precision: 0.96), Class 2 (Precision: 1.00), and Class 3 (Precision: 1.00). Conversely, the ANN produced relatively low classification metrics, further supporting the general observation that CNNs outperform ANNs in image-based classification tasks.

```
from sklearn.metrics import classification_report

report = classification_report(true_classes, predicted_classes, target_names=class_labels)
print(report)
```

```
              precision    recall  f1-score   support

        cats       0.96      1.00      0.98       482
        dogs       1.00      0.96      0.98       508
      snakes       1.00      0.99      1.00       510

    accuracy                           0.98      1500
   macro avg       0.98      0.98      0.98      1500
weighted avg       0.98      0.98      0.98      1500
```

Class	Precision	Recall	F1-Score
Cats	0.96	1.00	0.98
Dogs	1.00	0.96	0.98
Snakes	1.00	0.99	1.00



VI. CONCLUSION

This research validates the effectiveness of CNNs in image classification problems, particularly for animal images. The CNN model greatly outperformed the ANN model, a result that aligns with the known advantage of CNNs in capturing spatial hierarchies in images. Future work may involve experimenting with advanced models, such as ResNet, to further improve classification accuracy.

REFERENCES

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