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

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

BATCH V

DATA SCIENCE WITH ARTIFICIAL INTELLIGENCE

DEEP LEARNING

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1. Introduction

In this project, we assess the application of deep learning methods to animal image classification with a focus on cats, dogs and snakes. The aim is to investigate and compare the performance of two architectures, Convolutional Neural Networks (CNN) and Artificial Neural Networks (ANN), with respect to their ability to capture the spatial characteristics essential for correct classifications.

2. Problem Statement

Image classification is a classic problem in computer vision with a wide range of practical applications that include wildlife conservation, pathology of medical images. Comparing Models We considered two models in this project to classify images of animals such as cats, dogs and snakes using deep learning comparing their accuracy, loss and ability to generalize to unseen data.

3. Objective

The aim of this study is to:

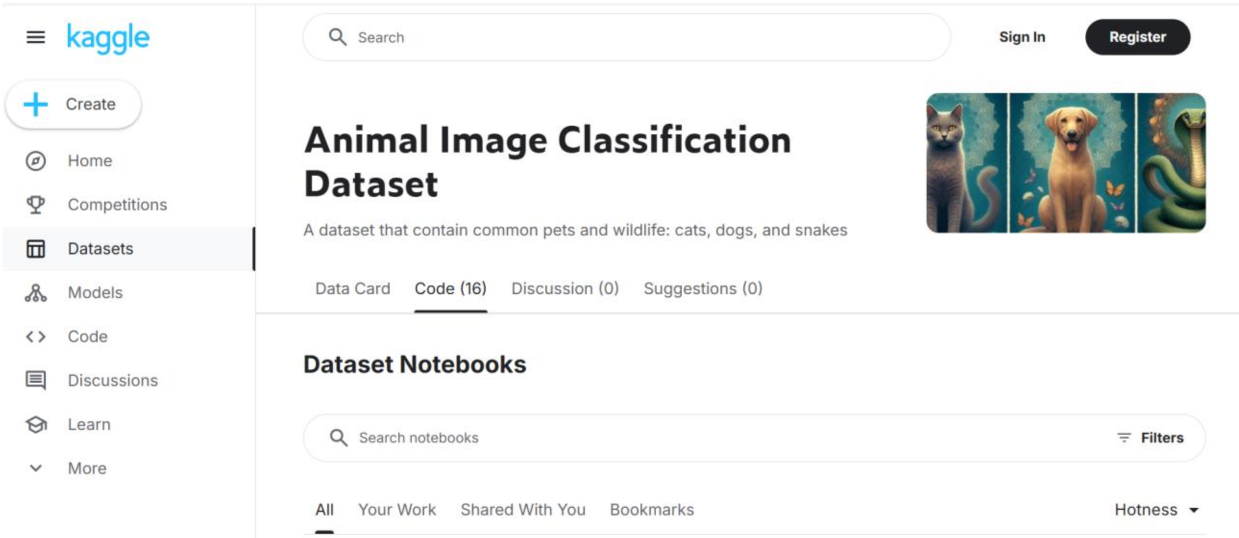
- Implement and train CNN and ANN models to classify animal images.
- Compare the classification accuracy and performance of both models.
- Analyze which model offers better feature extraction capabilities for image-based data.

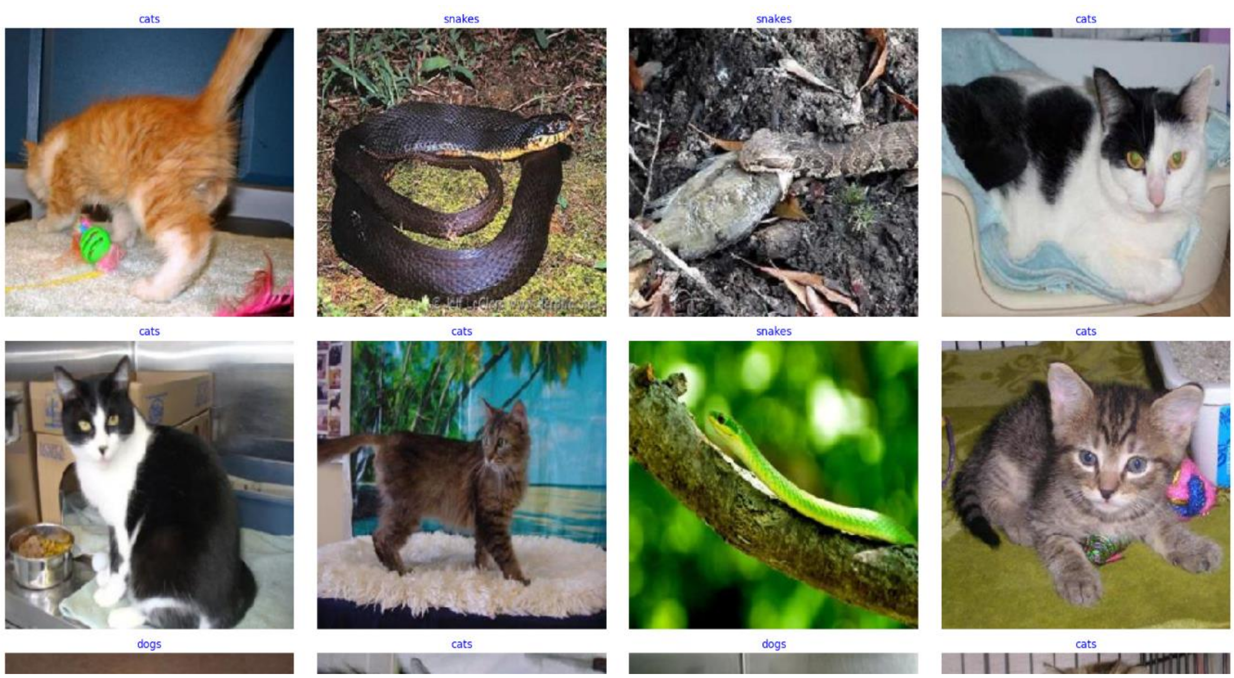
4. Literature Review

Many research works have showen that CNNs are very well-performing on image classification. Krizhevsky et al., for example achieved state-of-the-art results using CNNs in the ImageNet competition, with > top-5 accuracy of 80% [1]. Similarly, He et al. proposed ResNet [2], a residual neural network that did even better than CNN. But traditional ANNs have proved not very suitable for image classification tasks because they cannot efficiently extract spatial features.

5. Dataset Description

The data used in this project was obtained from Kaggle and includes three types of animals: cats, dogs, and snakes. There are 3,000 training images and 1,500 test images in the dataset, all resized to 224 × 224 pixels for compatibility with CNN and ANN models.





6. Methodology

A. Data Preprocessing

The pictures were adjusted to a scale from 0 to 1, and the labels were one-hot encoded. An 80% - 20% division was implemented for the train-validation data sets. This made sure that the models were trained efficiently without experiencing overfitting.

B. CNN Model Architecture

The structure of the CNN model was the following:

- Input layer size: Dimensions of (224x224x3).
- Three layers of convolution with ReLU activation and max-pooling layers.
- A layer with 128 units that is fully connected, with a dropout rate of 50%.
- Softmax output layer used for multiple classification tasks.

C. ANN Model Architecture

The structure of the artificial neural network included:

- Transformed 224x224x3 images into vectors of dimensionality 150,528 by flattening them.
- Three dense layers that are fully connected with ReLU activation.
- Output layer using Softmax for classifying multiple classes.

D. Training Strategy

The Adam optimizer and categorical cross-entropy were used to train both models. Data augmentation was not utilized. The training of the models lasted 10 epochs and used a batch size of 16.

7. Results and Discussion

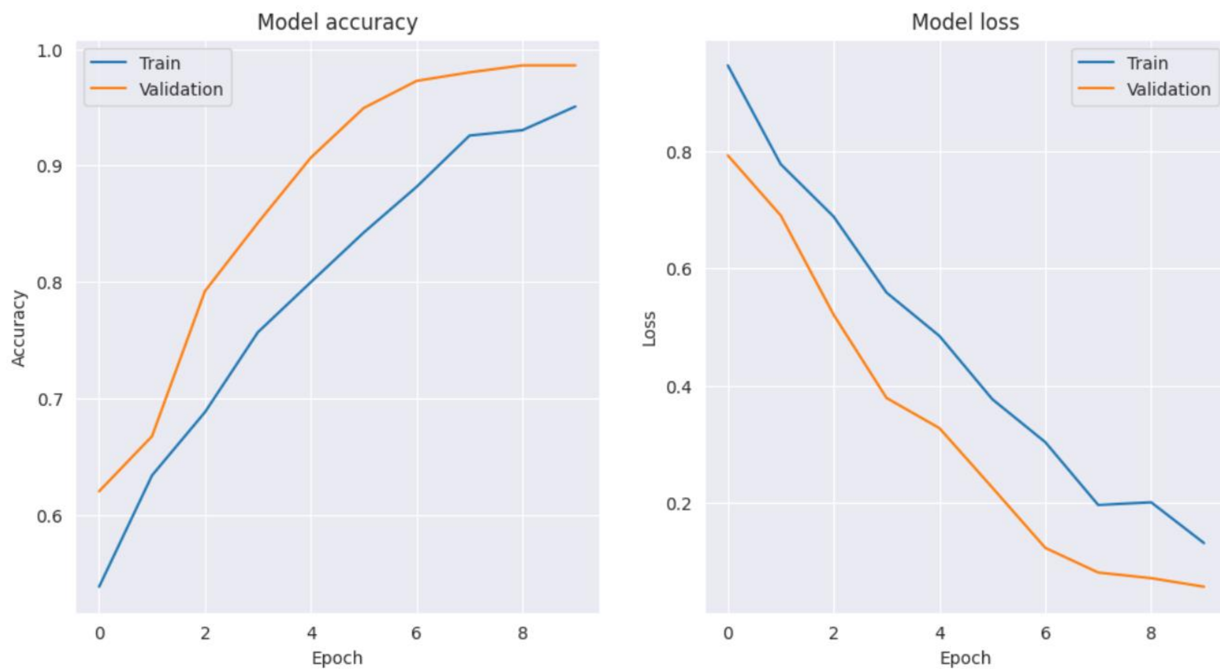
A. CNN Performance

The CNN model achieved outstanding performance:

- **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 underperformed:

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

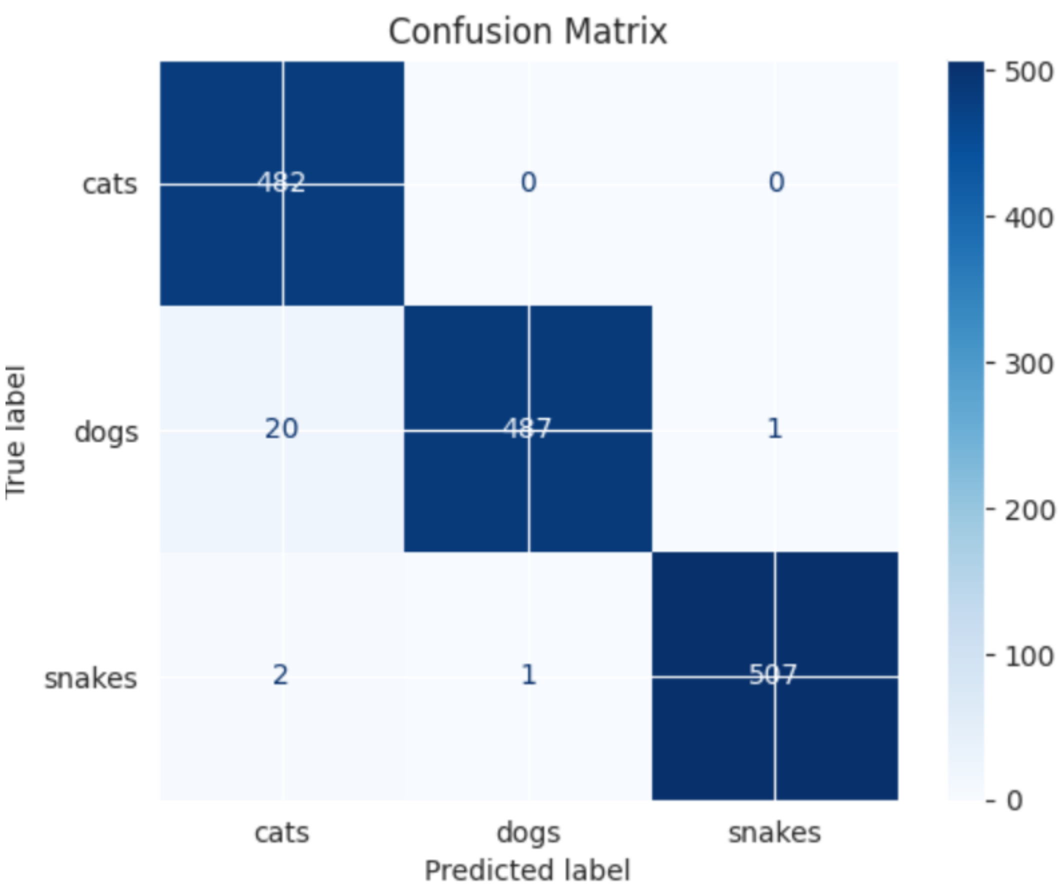
```python
# Evaluate the model
test_loss, test_accuracy = ann_model.evaluate(X_test.reshape(X_test.shape[0], -1), y_test)
print(f'Test loss: {test_loss}')
print(f'Test accuracy: {test_accuracy}')
```

```
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 from CNN displayed almost perfect classification, whereas the ANN matrix exhibited low effectiveness in all categories. The CNN's classification report listed the following:

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



8. Conclusion

The findings of this research clearly show that CNNs outperform other methods in tasks related to classifying images. CNNs use convolutional layers to capture spatial hierarchies in input data, making them well-suited for tasks involving images. However, the artificial neural network was unsuccessful in effectively categorizing the images because it could not identify spatial patterns within the data.

9. Future Work

Future research may include testing more advanced and intricate models like ResNet, InceptionNet, or DenseNet to determine if they can enhance classification accuracy. Exploring the use of pre-trained models in transfer learning is also an option worth considering.

10. References

1. A. Krizhevsky, I. Sutskever, and G. E. Hinton, "ImageNet classification with deep convolutional neural networks," Communications of the ACM, vol. 60, no. 6, pp. 84-90, 2017.
2. K. He, X. Zhang, S. Ren, and J. Sun, "Deep Residual Learning for Image Recognition," in Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition (CVPR), 2016, pp. 770-778.
3. Kaggle, "Dataset for Cats, Dogs, and Snakes Classification," [Online]. Available: https://www.kaggle.com/datasets/borhanitrash/animal-image-classification-dataset/code.

Annex: Code

A. CNN Code

- Model Definition
- Data Preprocessing
- Training and Validation Code
- Accuracy and Loss Plotting

B. ANN Code

- Model Definition

- Data Preprocessing
- Training and Validation Code