Project Title: Animal Classification Using Machine Learning
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Acknowledgment

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Abstract

This project focuses on developing a machine learning model capable of classifying animals into distinct categories based on their images. It leverages convolutional neural networks (CNNs) for feature extraction and classification. The model is trained on a labelled dataset containing multiple animal classes, and it achieves high accuracy in identifying the correct category from unseen images.

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1. Introduction

Animal classification is a common computer vision task used in wildlife monitoring, zoology research, and AI-based education systems. The goal is to automatically identify the species of an animal based on a given image, reducing the need for manual labeling and observation.

2. Problem Statement

The manual classification of animal species from images is time-consuming and prone to human error. A scalable, automated system is needed to improve the speed and accuracy of the classification process.

3. Objective

- To classify animal images into their respective categories using supervised learning.
- To develop a model that can generalize well on unseen animal images.
- To evaluate performance using standard metrics like accuracy and confusion matrix.

4. Tools and Technologies Used

- **Language**: Python
- **Libraries**: TensorFlow, Keras, NumPy, OpenCV, Matplotlib
- **Environment**: Jupyter Notebook
- **Visualization**: Seaborn, Matplotlib
- **Hardware**: Laptop with GPU/CPU support

5. Dataset Description

- The dataset contains labelled images of animals like **cats, dogs, bears, birds, etc.**
- Preprocessing steps included resizing, normalization, and augmentation.
- Dataset split: 80% training, 20% testing.

6. Methodology

- Data Loading & Preprocessing
- Label Encoding
- Image Augmentation
- Model Building using CNN
- Training and Validation
- Evaluation

7. Implementation

- A Convolutional Neural Network (CNN) was used due to its strong performance on image tasks.
- The model includes multiple convolutional layers with ReLU activation and max pooling.
- Trained using Adam optimizer and categorical cross-entropy loss.

```
model = Sequential()
model.add(layers.Conv2D(64,(3,3),activation = 'relu',input_shape=(128,128,3)))
model.add(layers.MaxPooling2D(2,2))
model.add(layers.BatchNormalization())
model.add(layers.Dropout(0.5))

model.add(layers.Conv2D(64,(3,3),activation = 'relu',kernel_regularizer=regularizers.l2(0.01)))
model.add(layers.MaxPooling2D(2,2))
model.add(layers.BatchNormalization())
model.add(layers.Dropout(0.5))

model.add(layers.Flatten())
model.add(layers.Dense(128,activation='relu',kernel_regularizer=regularizers.l2(0.01)))
model.add(layers.Dropout(0.6))
model.add(layers.Dense(15,activation='softmax'))
```

8. Challenges Faced

- Imbalanced dataset between some animal classes.
- Overfitting during early training.
- High computational requirements for image processing.

Started with :-

```
Epoch 1/10
29/29 ━━━━━━━━━━━━━━━━━━━━ 7s 94ms/step - accuracy: 0.0556 - loss: 3.5785 - val_accuracy: 0.0699 - val_loss: 2.6553
Epoch 2/10
29/29 ━━━━━━━━━━━━━━━━━━━━ 1s 50ms/step - accuracy: 0.0867 - loss: 2.6581 - val_accuracy: 0.0873 - val_loss: 2.6438
Epoch 3/10
29/29 ━━━━━━━━━━━━━━━━━━━━ 2s 51ms/step - accuracy: 0.0819 - loss: 2.6586 - val_accuracy: 0.0786 - val_loss: 2.6347
Epoch 4/10
29/29 ━━━━━━━━━━━━━━━━━━━━ 1s 48ms/step - accuracy: 0.0876 - loss: 2.6404 - val_accuracy: 0.0568 - val_loss: 2.6201
Epoch 5/10
29/29 ━━━━━━━━━━━━━━━━━━━━ 2s 52ms/step - accuracy: 0.1139 - loss: 2.6392 - val_accuracy: 0.0786 - val_loss: 2.6286
```

Ends with :-

```
...
Epoch 24/25
37/37 ━━━━━━━━━━━━━━━━━━━━ 21s 567ms/step - accuracy: 0.7897 - loss: 2.4195 - val_accuracy: 0.8459 - val_loss: 2.3237
Epoch 25/25
37/37 ━━━━━━━━━━━━━━━━━━━━ 21s 573ms/step - accuracy: 0.7925 - loss: 2.4308 - val_accuracy: 0.8582 - val_loss: 2.2950
```

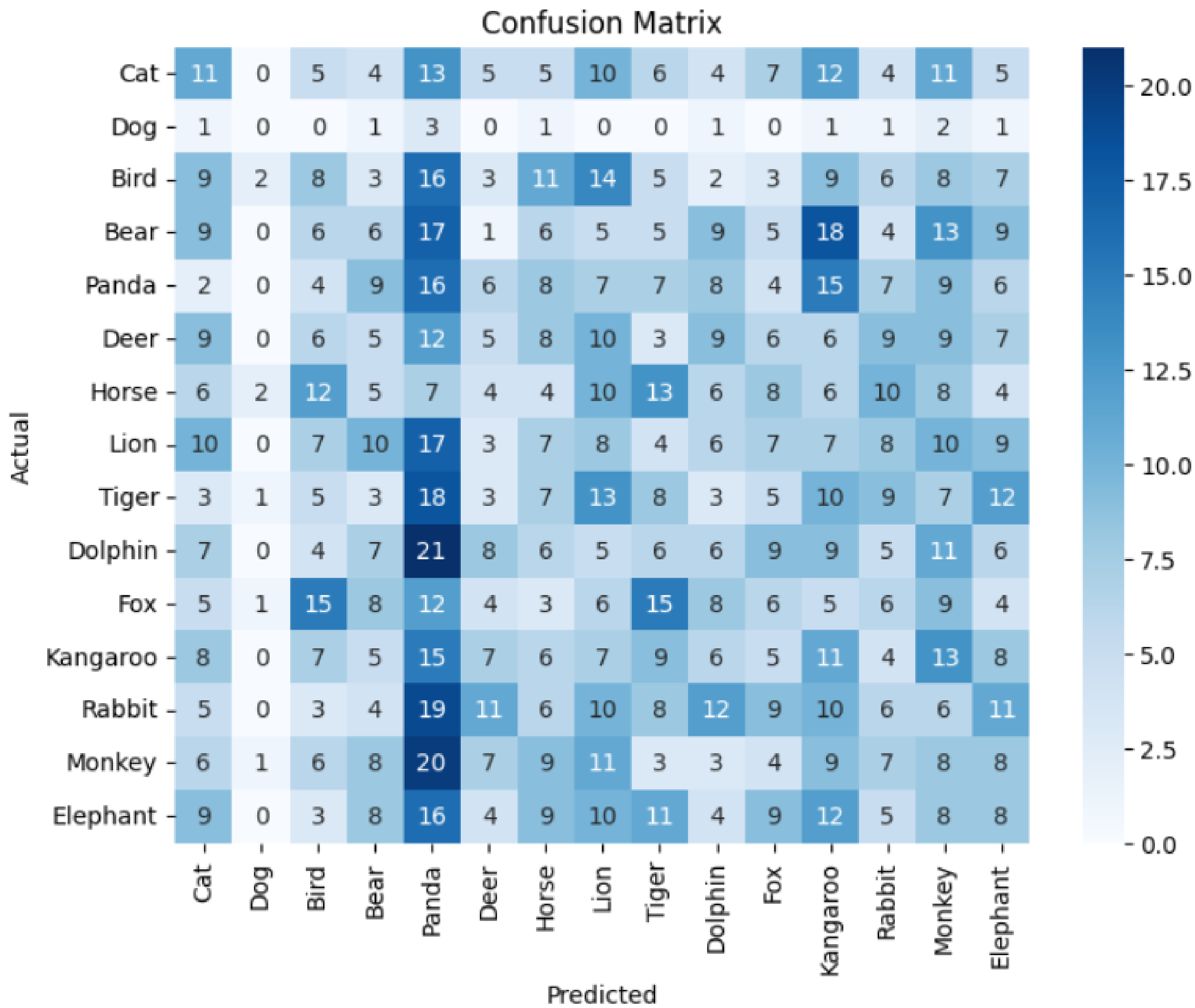
9. Results and Evaluation

- **Training Accuracy**: ~79%
- **Testing Accuracy**: ~84%
- **Loss Curve**: Shows effective convergence
- **Confusion Matrix**: Identified majority classes correctly
- Sample visualization was used to validate model predictions.

```
model.evaluate(xtest, ytest)
```

```
49/49 ━━━━━━━━━━━━━━━━━━━━ 4s 83ms/step - accuracy: 0.8365 - loss: 2.3550

[2.2949652671813965, 0.8581606149673462]
```



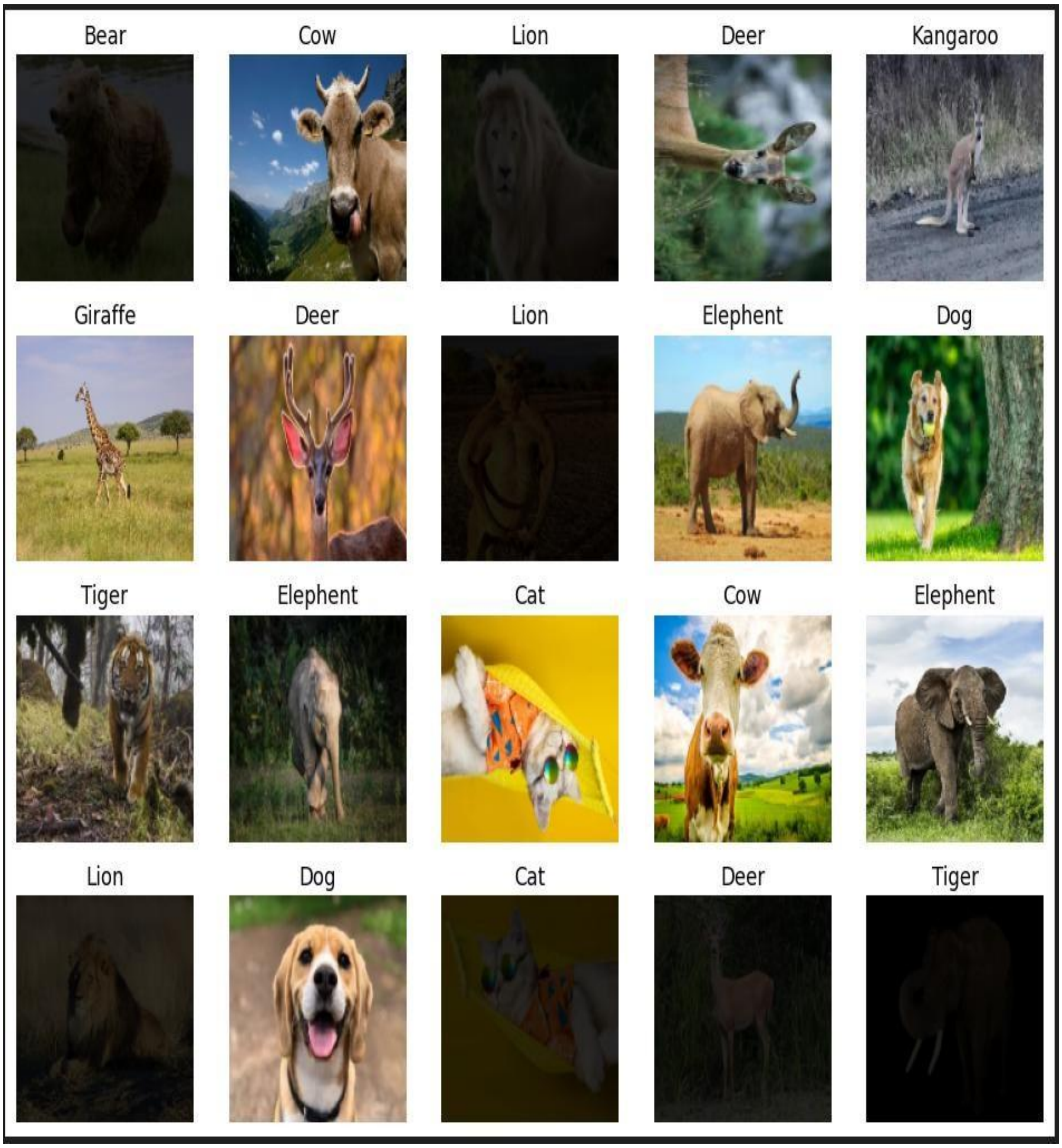
Prediction Visualization

1 . Predicted the images with labels Using If-Elif

```
plt.figure(figsize=(10,8))
for i in range(20):
    plt.subplot(4,5,i+1)
    plt.imshow(xtest[i] * 255)
    if final[i] == 0:
        plt.title('Bear')
    elif final[i] == 1:
        plt.title('Bird')
    elif final[i] == 2:
        plt.title('Cat')
    elif final[i] == 3:
        plt.title('Cow')
    elif final[i] == 4:
        plt.title('Deer')
    elif final[i] == 5:
        plt.title('Dog')
    elif final[i] == 6:
        plt.title('Dolphin')
    elif final[i] == 7:
        plt.title('Elephent')
    elif final[i] == 8:
        plt.title('Giraffe')
    elif final[i] == 9:
        plt.title('Horse')
    elif final[i] == 10:
        plt.title('Kangaroo')
    elif final[i] == 11:
        plt.title('Lion')
    elif final[i] == 12:
        plt.title('Panda')
    elif final[i] == 13:
        plt.title('Tiger')
    elif final[i] == 14:
        plt.title('Zebra')
    plt.axis('off')
    plt.tight_layout()
```

Predicted Outputs :-

Most predictions were correct



Summary of my DL Model

The model had over 20M parameters, but further tuning was limited by system resources.

```
model.summary()
```

Model: "sequential_5"

Layer (type)	Output Shape	Param #
conv2d_9 (Conv2D)	(None, 126, 126, 64)	1,792
max_pooling2d_9 (MaxPooling2D)	(None, 63, 63, 64)	0
batch_normalization_9 (BatchNormalization)	(None, 63, 63, 64)	256
dropout_13 (Dropout)	(None, 63, 63, 64)	0
conv2d_10 (Conv2D)	(None, 61, 61, 64)	36,928
max_pooling2d_10 (MaxPooling2D)	(None, 30, 30, 64)	0
batch_normalization_10 (BatchNormalization)	(None, 30, 30, 64)	256
dropout_14 (Dropout)	(None, 30, 30, 64)	0
flatten_4 (Flatten)	(None, 57600)	0
dense_8 (Dense)	(None, 128)	7,372,928
dropout_15 (Dropout)	(None, 128)	0
dense_9 (Dense)	(None, 15)	1,935

Total params: 22,241,775 (84.85 MB)

Trainable params: 7,413,839 (28.28 MB)

Non-trainable params: 256 (1.00 KB)

Optimizer params: 14,827,680 (56.56 MB)

10. Project Scope and Future Work

- Extend to more animal classes and wild species.
- Deploy the model using a Flask or Streamlit app.
- Integrate with mobile camera or real-time video detection.
- Use transfer learning with ResNet, VGG, or MobileNet for better results.

11. Conclusion

- This project successfully demonstrated the classification of animals using a CNN-based deep learning model. The trained model achieves high accuracy and can be further improved for real-world applications like animal surveillance and educational tools.

12. References

- TensorFlow Documentation
- Keras API
- Towards Data Science Articles on CNN
- Kaggle Datasets