Classification of Fish Species Using Convolutional Neural Networks (report)

Introduction

The aim of this project is to classify fish species based on image data using a Convolutional Neural Network (CNN). Accurate identification of fish species is essential for applications such as biodiversity conservation, fisheries management, and ecological research. This report outlines the process of building, training, and evaluating a CNN model for this purpose.

Data Collection and Preprocessing

The dataset comprises 3,960 images from 468 fish species, captured under three different conditions: controlled, out-of-the-water, and in-situ. The images were pre-processed and resized to a common size of 224x224 pixels. The labels were encoded using one-hot encoding.

Steps:

Image Loading: Images were loaded from the dataset directory.

Image Resizing: All images were resized to 224x224 pixels.

Label Encoding: Labels were encoded into numerical format and then converted to categorical data.

Data Splitting: The dataset was split into training (80%) and test (20%) sets.

Normalization: Pixel values were normalized to the range [0, 1].

Model Building

A Convolutional Neural Network (CNN) was built using TensorFlow and Keras. The architecture included convolutional layers, max-pooling layers, a flatten layer, dense layers, and a dropout layer to prevent overfitting.

Model Architecture:

Convolutional Layer: 32 filters, kernel size 3x3, ReLU activation

Max-Pooling Layer: Pool size 2x2

Convolutional Layer: 64 filters, kernel size 3x3, ReLU activation

Max-Pooling Layer: Pool size 2x2

Convolutional Layer: 128 filters, kernel size 3x3, ReLU activation

Max-Pooling Layer: Pool size 2x2

Flatten Layer

Dense Layer: 128 units, ReLU activation

Dropout Layer: 0.5 dropout rate

Dense Layer: Output layer with softmax activation

Model Training

The model was trained on the training dataset using the Adam optimizer, categorical cross-entropy loss function, and accuracy as the performance metric. The training process was monitored using a validation dataset.

Training Parameters:

Epochs: 20

Batch Size: 32

Optimizer: Adam

Loss Function: Categorical Cross-Entropy

Model Evaluation

The trained model was evaluated on the test dataset, achieving a test accuracy of 80.69%. This indicates that the model is effective in classifying fish species based on the provided image data.

Evaluation Metrics:

Accuracy: 80.69%

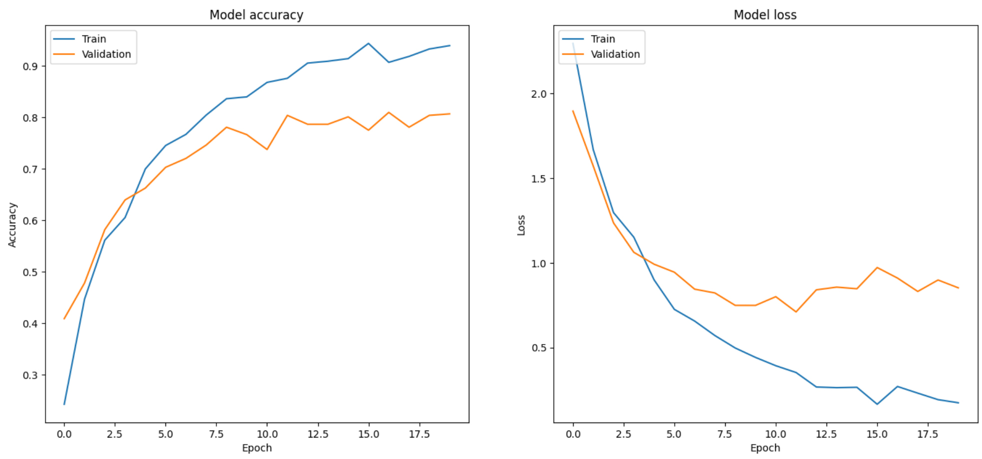

Figure 1, Training and Validation Plots

Loss: Monitored during training and validation phases

```
44/44 [==============================] - 69s 1s/step - loss: 2.2951 - accuracy: 0.2430 - val_loss: 1.8959 - val_accuracy: 0.4092
Epoch 2/20
44/44 [==============================] - 60s 1s/step - loss: 1.6688 - accuracy: 0.4470 - val_loss: 1.5722 - val_accuracy: 0.4784
Epoch 3/20
44/44 [==============================] - 66s 1s/step - loss: 1.2971 - accuracy: 0.5616 - val_loss: 1.2365 - val_accuracy: 0.5821
Epoch 4/20
44/44 [==============================] - 66s 1s/step - loss: 1.1522 - accuracy: 0.6056 - val_loss: 1.0631 - val_accuracy: 0.6398
Epoch 5/20
44/44 [==============================] - 62s 1s/step - loss: 0.9005 - accuracy: 0.7001 - val_loss: 0.9928 - val_accuracy: 0.6628
Epoch 6/20
44/44 [==============================] - 58s 1s/step - loss: 0.7264 - accuracy: 0.7455 - val_loss: 0.9455 - val_accuracy: 0.7032
Epoch 7/20
44/44 [==============================] - 59s 1s/step - loss: 0.6574 - accuracy: 0.7671 - val_loss: 0.8455 - val_accuracy: 0.7205
Epoch 8/20
44/44 [==============================] - 62s 1s/step - loss: 0.5718 - accuracy: 0.8046 - val_loss: 0.8231 - val_accuracy: 0.7464
Epoch 9/20
44/44 [==============================] - 67s 2s/step - loss: 0.4986 - accuracy: 0.8363 - val_loss: 0.7500 - val_accuracy: 0.7810
Epoch 10/20
44/44 [==============================] - 61s 1s/step - loss: 0.4431 - accuracy: 0.8399 - val_loss: 0.7499 - val_accuracy: 0.7666
Epoch 11/20
44/44 [==============================] - 60s 1s/step - loss: 0.3941 - accuracy: 0.8681 - val_loss: 0.8012 - val_accuracy: 0.7378
Epoch 12/20
44/44 [==============================] - 58s 1s/step - loss: 0.3540 - accuracy: 0.8760 - val_loss: 0.7114 - val_accuracy: 0.8040
Epoch 13/20
44/44 [==============================] - 59s 1s/step - loss: 0.2686 - accuracy: 0.9056 - val_loss: 0.8416 - val_accuracy: 0.7867
Epoch 14/20
44/44 [==============================] - 60s 1s/step - loss: 0.2644 - accuracy: 0.9092 - val_loss: 0.8575 - val_accuracy: 0.7867
Epoch 15/20
44/44 [==============================] - 58s 1s/step - loss: 0.2667 - accuracy: 0.9142 - val_loss: 0.8481 - val_accuracy: 0.8012
Epoch 16/20
44/44 [==============================] - 60s 1s/step - loss: 0.1668 - accuracy: 0.9438 - val_loss: 0.9731 - val_accuracy: 0.7752
Epoch 17/20
44/44 [==============================] - 58s 1s/step - loss: 0.2716 - accuracy: 0.9070 - val_loss: 0.9110 - val_accuracy: 0.8098
Epoch 18/20
44/44 [==============================] - 58s 1s/step - loss: 0.2323 - accuracy: 0.9185 - val_loss: 0.8321 - val_accuracy: 0.7810
Epoch 19/20
44/44 [==============================] - 59s 1s/step - loss: 0.1939 - accuracy: 0.9329 - val_loss: 0.8996 - val_accuracy: 0.8040
Epoch 20/20
44/44 [==============================] - 59s 1s/step - loss: 0.1755 - accuracy: 0.9394 - val_loss: 0.8533 - val_accuracy: 0.8069
11/11 [==============================] - 5s 359ms/step - loss: 0.8533 - accuracy: 0.8069
Test Accuracy: 80.69%
```

Figure 2, Monitored training and validation

Conclusion

This study successfully developed a CNN model capable of classifying fish species from image data with an accuracy of 80.69%. This model can be further refined and optimized for even higher accuracy and robustness, potentially aiding in environmental monitoring, fisheries management, and ecological research.

Future Work

Future improvements can include:

Experimentation with more complex model architectures

Hyperparameter tuning for better performance

Transfer learning using pre-trained models