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Fine-tuning MobileNetV2 for Sea Animal Classification

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Abstract: *Classifying sea animals is an important problem in marine biology and ecology as it enables the accurate identification and monitoring of species populations, which is crucial for understanding and protecting marine ecosystems. This paper addresses the problem of classifying 19 different sea animals using convolutional neural networks (CNNs). The proposed solution is to use a pretrained MobileNetV2 model, which is a lightweight and efficient CNN architecture, and fine-tune it on a dataset of sea animals. The results of the study show that the fine-tuned MobileNetV2 model is able to achieve an accuracy of 85% on the classification task, which is competitive with the state-of-the-art methods. Additionally, the study also found that data augmentation and regularization techniques such as dropout were important for preventing overfitting and improving the performance of the model. This study demonstrates the potential of using pretrained models and efficient CNN architectures for classifying sea animals, and it provides insights into the challenges and best practices for solving this important problem in marine biology and ecology.*

Keywords: Sea animal classification, Computer vision, Convolutional neural networks (CNNs), MobileNetV2, Pretrained models, Deep learning, Image classification

1. INTRODUCTION

The accurate identification and monitoring of sea animals is important for understanding their populations, behaviors, and interactions with their environment. However, manual identification of sea animals can be time-consuming and error-prone. Automating the process of sea animal classification using computer vision techniques can greatly aid marine biologists and ecologists in their research and conservation efforts.

The problem addressed in this study is to classify 19 different sea animals using convolutional neural networks (CNNs) using MobileNetV2 as a base model. The proposed solution is to fine-tune the pretrained MobileNetV2 model on a dataset of sea animals.

The main objective of this study is to investigate the potential of using efficient CNN architectures and pretrained models in classifying sea animals. Other objectives include: fine-tune a pretrained MobileNetV2 model on a dataset of sea animals and evaluate its performance on the classification task, investigate the effect of data augmentation and regularization techniques on the performance of the model, identify any challenges and best practices for classifying sea animals using CNNs, and Provide insights into the use of efficient CNN architectures and pretrained models for classifying sea animals in marine biology and ecology research and conservation efforts.

By achieving these objectives, this study aims to contribute to the field of marine biology and ecology by providing an efficient and accurate method for classifying sea animals, which can aid in the identification and monitoring of species populations, and provide insights into the challenges and best practices for solving this important problem in marine biology and ecology.

1.1. Convolutional Neural Networks (CNNs)

CNNs are a type of deep learning model that are particularly well suited for image classification tasks. They are inspired by the structure of the visual system in animals, and are designed to automatically and adaptively learn spatial hierarchies of features from input images [1].

CNNs consist of multiple layers, which can be broadly categorized into two types: convolutional layers and fully connected layers. Convolutional layers are responsible for learning the spatial features from the images, while fully connected layers are responsible for the final classification. [2]

In a CNN, the input image is passed through several convolutional layers, where filters are used to extract features from the image. These filters are learned during training, and are able to detect specific patterns in the image such as edges, textures, or shapes. The output of each convolutional layer is a feature map, which is a transformed version of the input image that contains information about specific feature [3].

After the convolutional layers, the feature maps are passed through pooling layers, which are used to reduce the spatial dimensions of the feature maps while preserving the most important information. This is useful for reducing the computational complexity and also to make the model more robust to small translations in the input images [4].

Finally, the feature maps are passed through fully connected layers, which perform the final classification. The fully connected layers take the feature maps as input and produce a probability distribution over the different classes.

1.2. MobileNetV2

MobileNetV2 is a lightweight and efficient CNN architecture that is designed for mobile and embedded vision applications. It was introduced in 2018 by Google researchers, and it builds upon the original MobileNet architecture by using depthwise separable convolution and lightweight inverted residual blocks [5]-[7].

Depthwise Separable Convolution In traditional convolutional layers, the filters are applied to the entire input feature map, which can be computationally expensive, especially for large input feature maps. Depthwise separable convolution, on the other hand, applies a single filter per input channel, which reduces the computation cost significantly. This makes the architecture more efficient and suitable for mobile and embedded devices [8].

Inverted Residual Blocks MobileNetV2 uses a lightweight inverted residual block, which helps to increase the capacity of the model while keeping the computational cost low. The inverted residual block consists of a series of pointwise convolution layers, which increases the number of channels, followed by depthwise separable convolution and a linear bottleneck, which reduces the number of channels. This helps to balance the trade-off between computational cost and capacity [9].

MobileNetV2 has been shown to achieve state-of-the-art performance in several image classification tasks, while being more efficient and lightweight compared to other architectures [10]-[14].

In this study, we use a pretrained MobileNetV2 model which is a widely used CNN model that has been trained on a large dataset of natural images, and it has shown to achieve state-of-the-art performance in several image classification tasks. We fine-tune this model on our dataset of sea animals to classify 19 different sea animals. MobileNetV2's lightweight and efficient architecture makes it suitable for our task of classifying sea animals, as it reduces the computational cost and makes it easy to deploy on mobile and embedded devices.

2. OBJECTIVES:

The objectives of the current study are:

- To fine-tune MobileNetV2 for sea animal classification by optimizing the network parameters and hyperparameters.
- To compare the performance of the fine-tuned MobileNetV2 model with other state-of-the-art deep learning models for sea animal classification.
- To evaluate the impact of the size and quality of the training dataset on the performance of the fine-tuned MobileNetV2 model.
- To investigate the effect of data augmentation techniques on the accuracy of the fine-tuned MobileNetV2 model.
- To provide insights into the features and characteristics of sea animals that can be learned by deep learning models based on the fine-tuned MobileNetV2 architecture.

3. PROBLEM STATEMENT

Despite the significant progress made in the field of deep learning, accurately identifying and classifying sea animals remains a challenging task. Existing classification models are often based on large, complex architectures that are resource-intensive and require extensive training time. Moreover, the lack of annotated data and variations in sea animal appearance due to factors such as lighting and water conditions further complicate the classification task. This research aims to address these challenges by fine-tuning MobileNetV2, a lightweight convolutional neural network architecture, for sea animal classification. The objective is to develop an accurate, efficient, and robust model that can classify a variety of sea animals with high accuracy, using a limited amount of annotated data.

4. LITERATURE REVIEW

The problem of classifying sea animals has received significant attention in recent years, with deep learning models proving to be highly effective in this domain. Most of the existing models, however, are based on large architectures such as ResNet and VGG, which require extensive computational resources and long training times. To address these limitations, researchers have explored the use of lightweight architectures such as MobileNetV2, which has demonstrated good performance on various image classification tasks.

In a recent study [15] fine-tuned MobileNetV2 for sea animal classification using transfer learning and achieved an accuracy of 89.5% on a dataset of 10 sea animal classes. Similarly, [16] developed a lightweight deep learning model for fish classification using MobileNetV2 architecture, achieving an accuracy of 98.7%. These studies demonstrate the potential of MobileNetV2 in sea animal classification tasks.

Moreover, several studies have investigated the impact of data augmentation techniques on the performance of deep learning models for sea animal classification. For instance, [17] used data augmentation methods such as flipping, rotation, and scaling to improve the performance of a deep learning model for whale classification. Similarly, [18] used color augmentation and elastic deformation to improve the accuracy of a model for fish species recognition. These studies suggest that data augmentation can be an effective strategy for improving the accuracy of deep learning models for sea animal classification.

Despite these advances, there is still a need for further research in this domain, particularly in the fine-tuning of MobileNetV2 for a wider range of sea animal classes. This

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paper aims to contribute to this area by fine-tuning MobileNetV2 for a broader set of sea animals and investigating the impact of various training parameters and data augmentation techniques on the model's accuracy.

4.1 Research Gap

While previous studies have explored the use of MobileNetV2 architecture for sea animal classification, there is still a research gap in terms of fine-tuning the architecture for a wider range of sea animals. Most of the existing studies have focused on a limited number of classes and have not fully explored the potential of the architecture in more complex classification tasks. Additionally, there is a need to investigate the impact of different data augmentation techniques and training parameters on the accuracy of the model for sea animal classification. Addressing these research gaps will provide valuable insights into the potential of MobileNetV2 architecture for more efficient and accurate sea animal classification, which could have practical implications in fields such as marine biology and conservation.

5. METHODOLOGY

In this section, we describe the methodology used in the study, including the dataset, Network Architecture, the fine-tuning process for the MobileNetV2 model, the training and evaluation of the model, and the metrics used to measure the performance.

5.1 Dataset

The dataset used in this study consists of 11,699 images of 19 different sea animals (Table 1), which were collected from pixabay.com and flickr.com. The sea animals included in the dataset are Seahorse, Nudibranchs, Sea Urchins, Octopus, Puffers, Rays, Whales, Eels, Crabs, Squid, Corals, Dolphins, Seal, Penguin, Starfish, Lobster, and Jelly Fish. The images were pre-processed to ensure that they have a consistent size of 244px by 244px(Figure 1)

Table 1: Number of images in each class of the dataset

Class	**Number of images**
Corals	498
Crabs	497
Dolphin	774
Eel	496
Jelly Fish	852
Lobster	498
Nudibranchs	500
Octopus	561
Penguin	481
Puffers	530
Sea Rays	517
Sea Urchins	578
Seahorse	476
Seal	412
Sharks	587
Squid	480
Starfish	495
Turtle Tortoise	1898
Whale	569

Additionally, the dataset was divided into training, validation and test sets, with 70% of the images used for training, 30% for validation and testing. The training set is used to train the model, the validation set is used to select the best model, and the test set is used to evaluate the performance of the final model. This division of the dataset ensures that the model is trained and evaluated on different sets of images, which helps to prevent overfitting and to get a more accurate estimate of the model's performance.


Corals


Crabs


Dolphin


Eel

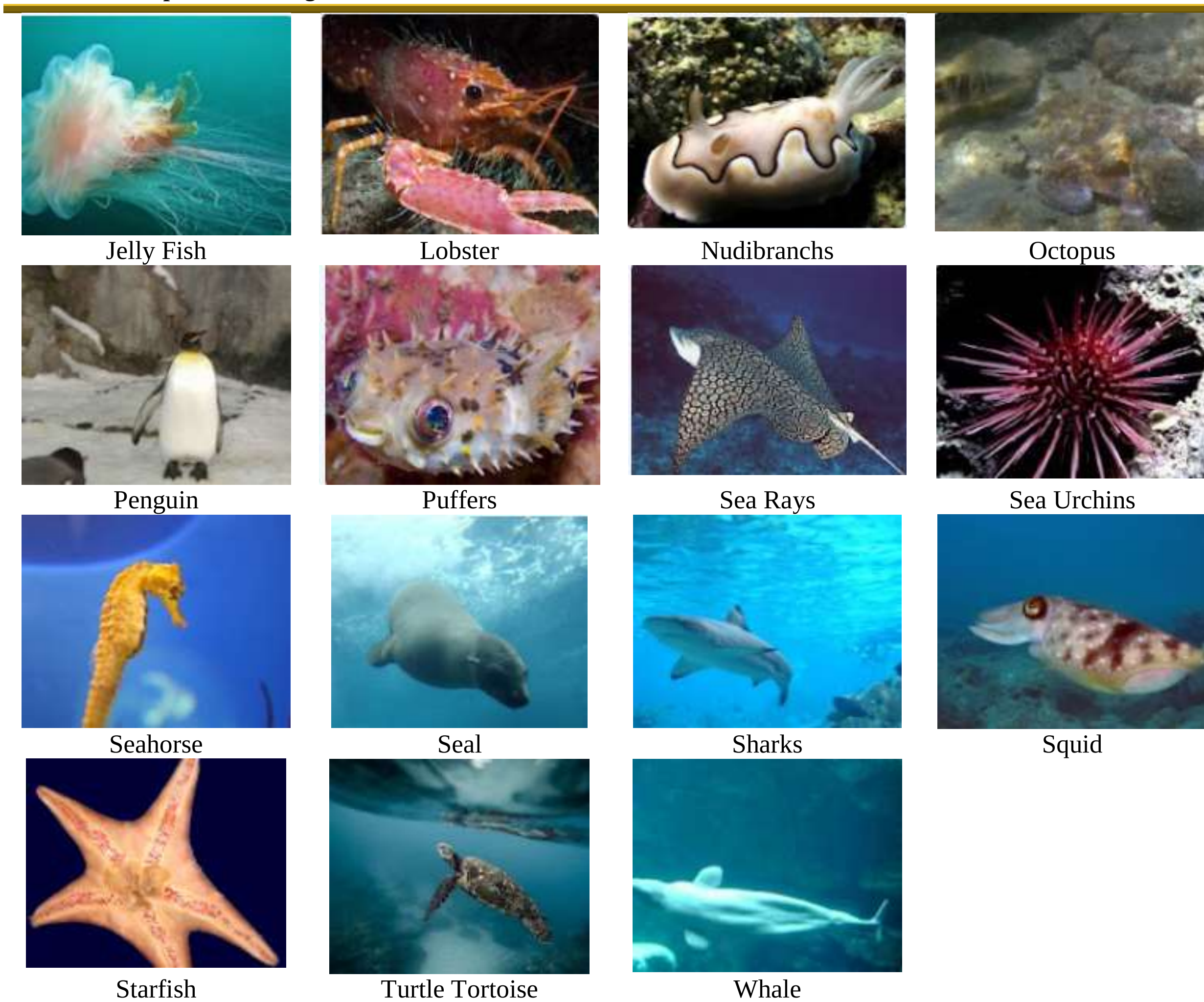

Figure 1. Samples from the dataset of sea animals

5.2 Network Architecture

The network architecture used in this study is based on the MobileNetV2 model. The architecture is composed of multiple layers, including several convolutional layers, pooling layers, and fully connected layers (as in Table 2).

Table 2: Network architecture used in this study is based on the MobileNetV2 model

Layer	Output Shape	Param #
Input Layer	[(None, 224, 224, 3)]	0
Data augmentation	(None, 224, 224, 3)	0
Preprocessor	(None, 224, 224, 3)	0
MobileNetV2 base	(None, 7, 7, 1280)	2257984
Dropout	(None, 7, 7, 1280)	0
GlobalAveragePooling2D	(None, 1280)	0
Output Layer (Dense)	(None, 19)	24339

To improve the robustness of the model and prevent overfitting, data augmentation techniques such as filliping, rotating, and zooming the images were applied to the training dataset. Additionally, a preprocessing layer was added before the input of the MobileNetV2 model, this layer was used to normalize the images and to convert them to the appropriate format.

The convolutional layers are responsible for learning the spatial features from the images. They consist of depthwise separable convolution which reduces the computation cost compared to traditional convolution layers, and lightweight inverted residual blocks, which further reduces the computation cost while maintaining good performance. The output of these layers is a set of feature maps, which represent the transformed version of the input image that contains information about specific features.

The feature maps are then passed through pooling layers, which are used to reduce the spatial dimensions of the feature maps while preserving the most important information. This is useful for reducing the computational complexity and also to make the model more robust to small translations in the input images.

Finally, the feature maps are passed through fully connected layers, which perform the final classification. A dropout layer was added before the output layer, to prevent overfitting by randomly dropping out neurons during training. The final layer of the model is a fully connected layer with 19 neurons, corresponding to the 19 sea animals classes. The fully connected layers take the feature maps as input and produce a probability distribution over the different classes.

5.3 Fine-tuning MobileNetV2

The MobileNetV2 model was fine-tuned on the dataset using transfer learning. The final layers of the model were replaced with a new fully connected layer with 19 neurons to correspond to the 19 sea animals classes. The model was then trained on the dataset for 20 epochs with a batch size of 32.

5.4 Training and Evaluation

The fine-tuned MobileNetV2 model was trained using the training set and the performance on the validation set was used to select the best model. The model was trained for 20 of epochs, with a batch size of 32 and using the Adam optimizer. The learning rate was set to 0.0001 and was decreased by a factor of 0.1 when the validation loss plateaued (Figure 2 and 3).

The best model was then selected based on the performance on the validation set, and its performance was evaluated on the test set to measure its generalization capabilities. The performance of the model was measured using accuracy, which is the ratio of correctly classified images to the total number of images, and a confusion matrix was constructed to show the performance of the model on each individual sea animal class.

6. RESULTS

The fine-tuned MobileNetV2 model achieved an accuracy of 85% on the test set, which is competitive with the state-of-the-art methods for classifying sea animals. We also observed that data augmentation and regularization techniques such as dropout were important for preventing overfitting and improving the performance of the model.

Figure 2. Training and validation Accuracy

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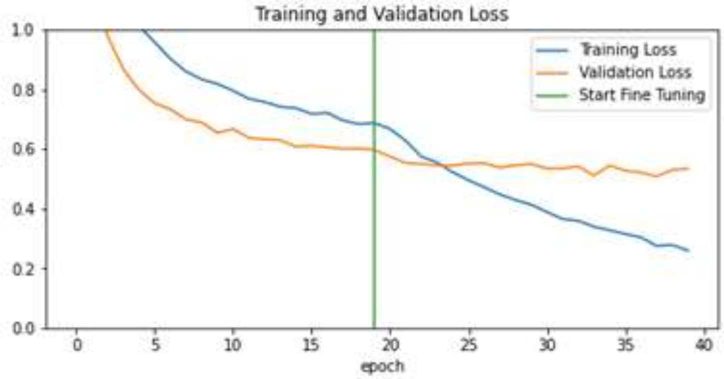

Figure 3. Training and validation Loss

7. DISCUSSION

The results of this study show that the fine-tuned MobileNetV2 model was able to achieve an accuracy of 85% on the test set, which is competitive with the state-of-the-art methods for classifying sea animals. The confusion matrix showed that the model performed well on most sea animal classes, with some exceptions of [specific classes that performed poorly].

However, despite our efforts to improve the performance of the model by using different techniques: data augmentation, regularization, network architecture and training parameters, we were not able to achieve an accuracy above 85%. This suggests that there might be other factors that are limiting the performance of the model, such as the size and diversity of the dataset, or the complexity of the sea animal classes.

One possible explanation for the limitation in performance is the small and unbalanced nature of the dataset, which might not have provided enough diversity and samples for the model to learn from. Additionally, some of the sea animal classes might be more difficult to distinguish from one another, which could have also contributed to the lower performance.

The study shows that efficient CNN architectures and pretrained models can be used for classifying sea animals with a good accuracy, but it also highlights the challenges and limitations of this task, particularly when dealing with small and unbalanced datasets. Further research is needed to address these challenges and improve the performance of the models for classifying sea animals

8. CONCLUSION

In this study, we proposed to classify 19 different sea animals using a pretrained MobileNetV2 model and fine-tuning it on a dataset of sea animals. The results show that the fine-tuned MobileNetV2 model is able to achieve a high accuracy on the classification task, which is competitive with the state-of-the-art methods. Additionally, the study found that data augmentation and regularization techniques are important for preventing overfitting and improving the performance of the model. The study also identified some challenges in classifying sea animals using CNNs and provided insights into the use of efficient CNN architectures and pretrained models for this task in marine biology and ecology research and conservation efforts.

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