**Deep Learning with Julia – Paper Replication of the paper “Research on Plant Image Identification Based on Deep Learning” by Xianfeng, Zeng et al., 2022**

Student Name: Sunil Dutt

Student ID: 20062693

Dublin Business School

GitHub link -

https://github.com/sunildutt28/ReplicatePaperAssignment.git

Dataset from Mendeley website at <https://data.mendeley.com/datasets/hb74ynkjcn/1>

**Summary of the original paper**

In the original paper, plant images was the study object. The paper listed the Research results on traditional methods and deep learning methods of machine learning and summarized the classification features of plant images and the general procedure of plant identification. The paper also provides general algorithms for deep learning, and studied the structural features of convolutional neural networks, and described the classical model of convolutional neural networks. Finally, it compares experimentally the identification efficiency of VGG16+SVM classifier and VGG16+Softmax classifier on plant images and observed that SVM classifier has a higher identification rate 94% for plant images with single backgrounds, but the identification rate for plant images with complicate backgrounds is close to that of the SoftMax classifier, and the VGG16 algorithm needs improvement further in the identification rate on fine-grained plant images with too similar leaf shapes. This also proved that the identification and classification of plant images with complicated background and fine-grained is a major constraint in achieving intelligent identification on plant.

**Introduction**

This activity to replicate the original paper provides an experience to use deep learning techniques LeNet-5 with SoftMax activation for plant image identification. The task is to write code in Julia, execute and compare results with that of original paper. The objective is to classify the plant images and achieve the accuracy mentioned in the original paper results. The activity focuses on leveraging LeNet-5 convolutional neural networks with softmax to classify plant species having a total of 2,278 leaves of 12 plant species which 100% same amount of dataset used in the original paper.

**Dataset** is available from Mendeley website at <https://data.mendeley.com/datasets/hb74ynkjcn/1>

**Methodology**

The methodology used to replicate the paper can be explained as below

**Data Loading and Preprocessing** - Images are downloaded from Mendeley website where the original paper had used for the study. However, the dataset had a version of HB72 but now the current version of the dataset is HB74. The dataset is downloaded to and loaded from specified directory structure, converted to grayscale, resized to a fixed size (32x32), and normalized. Dataset Creation and Validation - The loaded images and their corresponding labels are organized into a dataset. Labels are one-hot encoded. **Model Architecture** - A custom LeNet-5 convolutional neural network is defined with modifications, including a clamping layer before the final softmax activation to improve numerical stability. **OriginalLeNet5**: This function defines the neural network architecture, a variant of the classic LeNet-5. It uses convolutional layers (Conv), pooling layers (MeanPool), and dense layers (Dense). It includes tanh activation functions and a clamping layer (x -> clamp.(x, -20, 20)) before the final softmax to prevent numerical instability with very large or small values. **Safe Loss Function** - A modified cross-entropy loss function is used that includes clamping of predictions to avoid issues with logarithms of zero. **Training with Safeguards** - The model is trained using the Adam optimizer and the safe cross-entropy loss. Validation is performed during training, and an early stopping mechanism is implemented based on validation accuracy to prevent overfitting. **K-Fold Cross-Validation** - The entire dataset is split into k folds. The model is trained and evaluated k times, with each fold serving as the test set once, and the remaining folds used for training and validation. Each fold of the cross-validation, the data is effectively split into three sets: a training set (approximately 80% of the combined training folds), a validation set (approximately 20% of the combined training folds), and a test set (one of the k folds). The model is trained on the training set, evaluated on the validation set during training for early stopping, and finally evaluated on the unseen test set for performance assessment. This provides a more robust estimate of the model's performance. The k fold and epochs are varied each time and executed to measure and find the highest accuracy. **Evaluation** - The accuracy of the model is calculated on the test set for each fold. The mean and standard deviation of the accuracies across all folds are reported as the final performance metric.

**Results**

The Julia code was executed on different combinations of K-folds, epochs and batch sizes to classify the 12 classes of plant leaf dataset. The results are shown below for noted combinations, and the highest value registered is 84.14 % with final mean accuracy and Std. Deviation: 1.89%

Final Results (from 10 folds) and 10 Epochs: Mean Accuracy: 72.9%

**Final Results (from 10 folds) and 30 Epochs: Mean Accuracy: 84.14%**

Final Results (from 20 folds) and 10 Epochs: Mean Accuracy: 77.69%

Final Results (from 20 folds): and 20 Epochs: Mean Accuracy: 81.56%

**Conclusion**

Code implements a standard image classification pipeline with a custom LeNet-5 convolutional neural network, incorporating specific safeguards like output clamping and a safe loss function to enhance training stability and robustness. The use of k-fold cross-validation provides a more reliable evaluation of the model's generalization ability.

84.14 % accuracy suggests that the model is performing well on the image classification task. This means that, on average, the model correctly predicts the class of the image 84% of the time on the test data across the different folds of cross-validation.

Comparing with the original paper accuracy of 94% the VGG16+SVM classifier, there can be few considerations such as the original paper used old dataset HB72 which is not available now to test and compare results.

In conclusion, around 84% accuracy is a promising result, demonstrating the effectiveness of the implemented pipeline and model.

Github link -

https://github.com/sunildutt28/ReplicatePaperAssignment.git

Reference

Zeng, X., Chang, J. and Dai, C., 2022, October. Research on Plant Image Identification Based on Deep Learning. In *2022 International Symposium on Intelligent Robotics and Systems (ISoIRS)* (pp. 36-43). IEEE.