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Image-Based Nuts Detection Using Deep Learning

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Abstract: *Abstract: The classification of nuts is crucial for food security; nevertheless, accurate and swift identification continues to be a challenge in numerous areas due to insufficient infrastructure. The rise in smartphone utilization, along with advancements in computer vision driven by deep learning, has facilitated smartphone-assisted nut classification. We trained a deep convolutional neural network to categorize five distinct nut types (Chestnut, Hazelnut, Nut Forest, Nut Pecan, and Walnut) using a public dataset of 2,850 photos gathered under controlled conditions. The model attained an accuracy of 98.37% on a reserved test set, illustrating the viability of this method. This approach offers a viable avenue for large-scale smartphone-assisted nut categorization.*

Keywords: Deep Learning, Nuts, Computer Vision, Detection, Neural Network

1. INTRODUCTION

Nuts, including chestnut, hazelnut, nut forest, nut pecan, and walnut, are highly valued commodities in a variety of global regions. In addition to their substantial contribution to the global agricultural market, they also play a critical role in a variety of industries, such as healthy products and food production. The quality of these seeds is essential, as even minor blemishes or damage can significantly diminish their market value. Manual nut sifting and quality control are laborious, time-consuming, and error-prone. The income of farmers and producers is frequently affected by this manual process, which is distinguished by increased labor costs and delayed sifting times.

AI and image processing have helped automate agricultural product classification in recent years. nuts quality is assessed using color, shape, texture, and geometry. Park et al. [2] presented content-based image classification of agricultural items using texture parameters as homogeneity, entropy, and contrast. Guyer and Yang [4] used neural networks to detect cherry defects, whereas Camargo and Smith [14] used color change and image enhancement to identify banana leaf diseases.

Machine learning, especially deep learning, has changed nuts classification in agriculture. Convolutional Neural Networks (CNNs) can automatically extract important information from photos, making them useful for classifying fruits and vegetables. Plant and nuts classification studies [5], [6], [7] show that deep learning models outperform standard methods.

Even with these advances, automated nut classification is understudied. Automated nut classification solutions are needed due to rising labor costs and productivity needs. This research aims to create a deep learning-based system that can recognize and classify chestnut, hazelnut, nut forest, nut pecan, and walnut. High-resolution images will be used to extract color and texture information to classify these nuts by grade and type. Farmers and producers may scale this technology, reduce manual sorting, and improve efficiency.

2. STUDY OBJECTIV

1- Demonstrating the feasibility of using deep convolutional neural networks to classify nuts.
2- Develop a model that developers can use to create smartphone applications to detect nuts.

3. DATASET

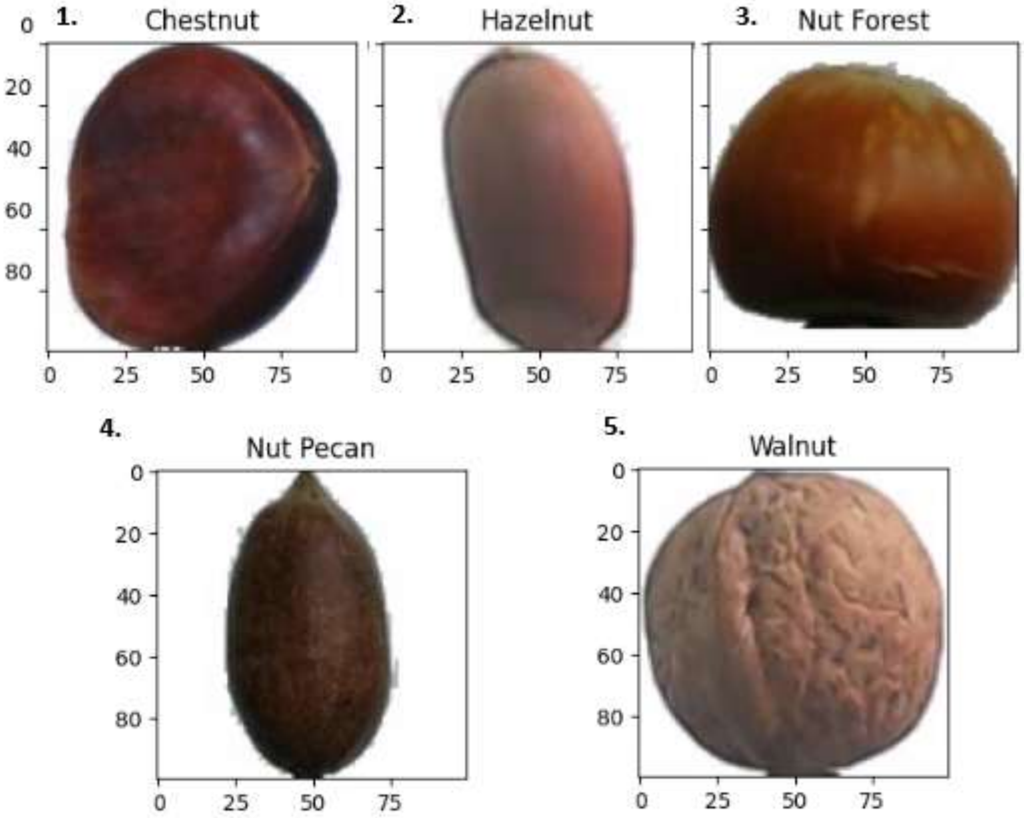

Figure 1: Dataset Samples

4. THE ARTIFICIAL CONVOLUTIONAL NEURAL

Our dataset was taken from the popular nuts dataset, which has around 2,850 pictures of five different nuts in it. We opt to utilize 2,850 images of nuts in our dataset, which comprises samples for five distinct classes of nuts that are categorized as follows [16]:

- class (0): Chestnut.
- class (1): Hazelnut.
- class (2): Nut Forest.
- class (3): Nut Pecan.
- class (4): Walnut.

The data quality hadn't been harmed, and the images were resized to 256×256 for more quickly computations

NETWORKS: AN INTRODUCTION

A Convolutional Neural Network (CNN or ConvNet) is a deep, feed-forward artificial neural network predominantly utilized for visual imagery processing in machine learning.

Convolutional Neural Networks (CNNs) utilize an adapted version of perceptrons with several layers, requiring minimal preparation. Owing to its shared-weights architecture and translation invariance characteristics, they are designated as shift-invariant or space-invariant artificial neural networks (SIANN).

Convolutional neural networks were inspired by biological processes, as the connectivity of neurons resembles the architecture of the animal visual cortex. Cortical neurons solely respond to stimuli within a restricted region of the visual field known as the receptive field. The receptive fields of different neurons demonstrate overlap, guaranteeing extensive coverage of the whole visual field.

Convolutional Neural Networks (CNNs) necessitate reduced pre-processing relative to other image classification algorithms. This signifies that the network independently acquires the filters that were conventionally crafted manually in algorithms. This independence from prior knowledge and human involvement in feature design is a considerable advantage.

They are employed in image and video recognition, recommendation systems, and natural language processing.

Design

A CNN consists of an input and an output layer, as well as multiple hidden layers. The hidden layers of a CNN typicallyconsist of convolutional layers, pooling layers, fully connected layers and normalization layers [1-5].

The process is described as a convolution in neural networks by convention. Mathematically, it is a cross-correlation rather than a convolution. This only has significance for the indices in the matrix, and thus, which weights are placed at which index.

Convolutional

Convolutional layers apply a convolution operation to the input, passing the result to the next layer. The convolution emulates the response of an individual neuron to visual stimuli.

Each convolutional neuron processes data only for its receptive field.

Although fully connected feedforward neural networks can beused to learn features as well as classify data, it is not practical to apply this architecture to images. A very high number of neurons would be necessary, even in shallow(opposite of deep) architecture, due to the very large input sizes associated with images, where each pixel is a relevant variable. For instance, a fully connected layer for a (small) image of size 100 x 100 has 10000 weights for each neuron inthe second layer. The convolution operation brings a solutionto this problem as it reduces the number of free parameters, allowing the network to be deeper with fewer parameters. Forinstance, regardless of image size, tiling regions of size 5 x 5,each with the same shared weights, requires only 25 learnableparameters. In this way, it resolves the vanishing or explodinggradients problem in training traditional multi-layer neural networks with many layers by using backpropagation[6-7].

Pooling

Convolutional networks may include local or global pooling layers[8,9,10], which combine the outputs of neuron clusters at one layer into a single neuron in the next layer. For example, max pooling uses the maximum value from each ofa cluster of neurons at the prior layer. Another example is average pooling, which uses the average value from each of acluster of neurons at the prior layer[11-15].

Fully Connected

Fully connected layers connect every neuron in one layer to every neuron in another layer. It is in principle the same as the traditional multi-layer perceptron neural network (MLP)

Receptive Field

In neural networks, each neuron receives input from some number of locations in the previous layer. In a fully connected layer, each neuron receives input from every element of the previous layer. In a convolutional layer, neurons receive input from only a restricted subarea of the previous layer. Typically the subarea is of a square shape (e.g., size 5 by 5). The input area of a neuron is called its receptive field. So, in a fully connected layer, the receptive field is the entire previous layer. In a convolutional layer, thereceptive area is smaller than the entire previous layer.

Weights

Each neuron in a neural network computes an output value byapplying some function to the input values coming from the receptive field in the previous layer. The function that is applied to the input values is specified by a vector of weightsand a bias (typically real numbers). Learning in a neural network progresses by making incremental adjustments to thebiases and weights. The vector of weights and the bias are called a filter and represents some feature of the input (e.g., aparticular shape). A distinguishing feature of CNNs is that many neurons share the same filter. This reduces memory footprint because a single bias and a single vector of weights is used across all receptive fields sharing that filter, rather than each receptive field having its own bias and vector of weights.

5. METHODS

Some methodologies discuss experiments on other plants, which may not apply to your study. Remove these and focus on how convolutional neural networks were specifically applied to nuts.

6. MODEL

Our model takes raw images as an input, so we used Convolutional Nural Networks (CNNs) to extract features, inresult the model would consist of two parts:

- The first part of the model (features extraction),which was the same for full-color approach andgray-scale approach, it consist of 4 Convolutional layers with Relu activation function, each followed by Max Pooling layer.
- The second part after the flatten layer contains two dense layers for both approaches, but in full-color the first has 256 hidden units which makes the total number of network trainable parameters 3,601,478, in the other hand gray-scale approach has 128 hidden units in the fist dense layer and 1,994,374 as total trainable parameters, we shrank the size of the gray-scale network to avoid overfitting, for the lastlayer for both has Softmax as activation and 6outputs representing the 6 classes.

Table 1: Full-Color Model Summary.

Layer (type)	Output Shape	Param #
input_layer_1 (InputLayer)	(None, 256, 256, 3)	0
block1_conv1 (Conv2D)	(None, 256, 256, 64)	1,792
block1_conv2 (Conv2D)	(None, 256, 256, 64)	36,928
block1_pool (MaxPooling2D)	(None, 128, 128, 64)	0
block2_conv1 (Conv2D)	(None, 128, 128, 128)	73,856
block2_conv2 (Conv2D)	(None, 128, 128, 128)	147,584
block2_pool (MaxPooling2D)	(None, 64, 64, 128)	0
block3_conv1 (Conv2D)	(None, 64, 64, 256)	295,168
block3_conv2 (Conv2D)	(None, 64, 64, 256)	590,080

block3_conv3 (Conv2D)	(None, 64, 64, 256)	590,080
block3_pool (MaxPooling2D)	(None, 32, 32, 256)	0
block4_conv1 (Conv2D)	(None, 32, 32, 512)	1,180,160
block4_conv2 (Conv2D)	(None, 32, 32, 512)	2,359,808
block4_conv3 (Conv2D)	(None, 32, 32, 512)	2,359,808
block4_pool (MaxPooling2D)	(None, 16, 16, 512)	0
block5_conv1 (Conv2D)	(None, 16, 16, 512)	2,359,808
block5_conv2 (Conv2D)	(None, 16, 16, 512)	2,359,808
block5_conv3 (Conv2D)	(None, 16, 16, 512)	2,359,808
block5_pool (MaxPooling2D)	(None, 8, 8, 512)	0
global_max_pooling2d_1 (GlobalMaxPooling2D)	(None, 512)	0
dense_1 (Dense	(None, 5)	(None, 5)

Total params: 14,717,253 (56.14 MB)
Trainable params: 14,717,253 (56.14 MB)
Non-trainable params: 0 (0.00 B)

7. DATA VISUALISATION

To see how the model works and what exactly learns we choose to visualize intermediate activations that consists of displaying the feature maps that are output by various convolution and pooling layers in a network, given a certain input (the output of a layer is often called its activation, the output of the activation function). This gives a view into howan input is decomposed into the different filters learned by thenetwork [16].

As shown in Figures 3 and 4, the full-color model learned how to identify the disease spots, the gray-scale method in theother hand did not learn how to locate the disease, but insteadlearned only the shape of the leaf and some patterns in the background.

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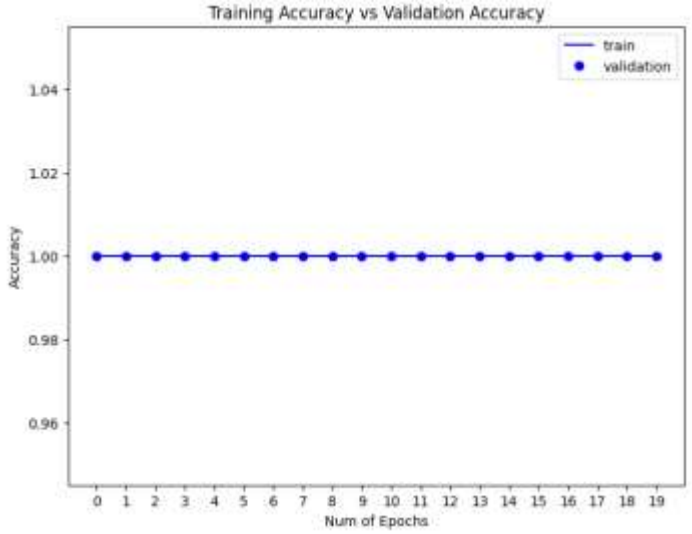	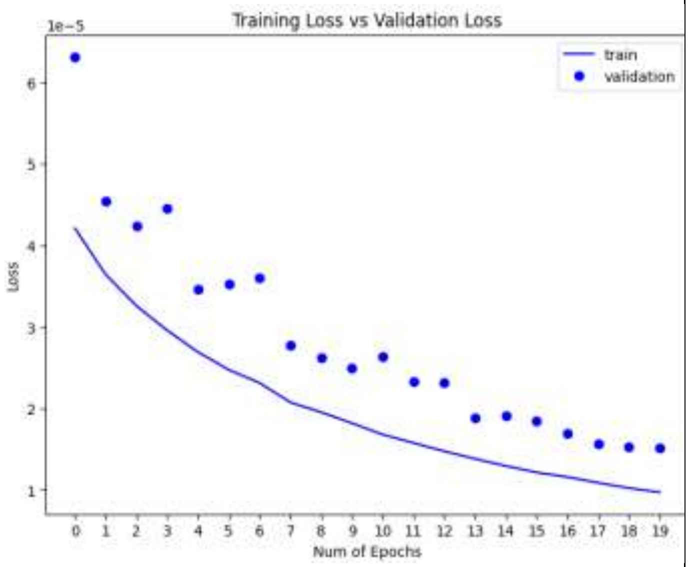
Figure 5: Training and Validation Accuracy.	**Figure 6:** Training and Validation Loss.

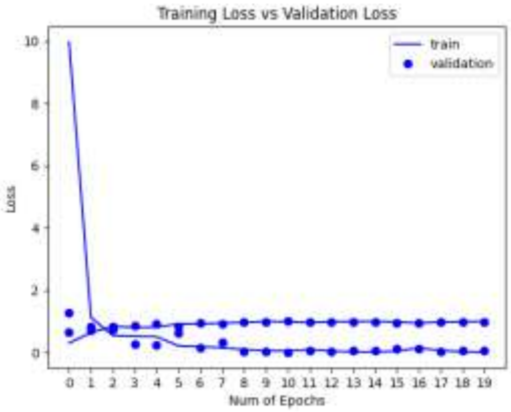

Figure 7: Full-Color Loss.

CONCLUSION

We are so proud to show that out best model (Full-Color) achieved an accuracy of 99.84% on a held-out test set, and second best model (Gray-Scale) achieved an accuracy of95.54%, Figures 5 and 6 show how the models accuracy progress over epochs (as seen in Figure5-Figure8).

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