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Comprehensive Analysis For Custard Apple Disease Detection Using CNN

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Abstract

Custard apple, a valuable tropical fruit, faces significant yield and quality challenges due to diseases such as Blank Canker, Diplopia Rot, and Mealy Bug infestations. This paper presents a comprehensive study leveraging convolutional neural networks (CNNs) for automated detection and classification of these diseases. The proposed system processes images of custard apple leaves and fruits to accurately identify disease presence, enabling timely and effective agricultural interventions.

Keywords:

Custard Apple, Disease Detection, Convolutional Neural Networks (CNN), Machine Learning, Image Classification, Agricultural Technology, Plant Diseases, Automated Detection.

1. Introduction

Custard apple (*Annona squamosa*) is susceptible to various diseases that can severely impact its cultivation. Traditional methods of disease detection are labour intensive and often subjective. Machine learning (ML), particularly convolutional neural networks (CNNs), offers a promising solution for automated and accurate disease detection. This study aims to develop a CNN-based model for detecting common custard apple diseases from images.

2. Related Works

Recent studies highlight the effectiveness of convolutional neural networks (CNNs) in plant disease detection. Zhang et al. (2018) achieved high accuracy in maize leaf disease identification with an improved CNN. Spasojevic et al. (2016) and Liu et al. (2019) demonstrated CNNs' capability to handle complex backgrounds. Mohanty et al. (2016) used transfer learning with pre-trained models like Alex Net and Google Net for improved accuracy. Ramcharan et al. (2017) developed a mobile-based system for cassava disease diagnosis using CNNs. Ferentinos (2018) compared CNN architectures, while Arsenovic et al. (2019) combined CNNs with traditional

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image processing for automated disease detection. Tables 01 summarise the conclusions and results of different investigations, providing a comprehensive overview

Table 01: List of research works with different models and various data sets used

Author(s)	Year	Model	Accuracy Obtained (%)	Dataset Used	Journal Reference
Zhang et al.	2018	Improved Deep CNN	97.35	Maize leaf images	IEEE Access, 2018
Spasojevic et al.	2016	Deep Neural Network (CNN)	96.30	Plant leaf images with complex backgrounds	Computational Intelligence and Neuroscience, 2016
Liu et al.	2019	Deep Learning with Advanced Preprocessing	98.20	Plant disease images from complex backgrounds	IEEE Access, 2019
Mohanty et al.	2016	Alex Net, Google Net (Transfer Learning)	99.35	Plant leaf images (38 classes)	Frontiers in Plant Science, 2016
Ramcharan et al.	2017	CNN Integrated in Mobile Application	93.10	Cassava leaf images	Frontiers in Plant Science, 2017
Ferentinos	2018	VGG16, ResNet50, InceptionV3	99.53	Plant leaf images (diseases of 25 different plants)	Computers and Electronics in Agriculture, 2018
Arsenovic et al.	2019	CNN and Traditional Image Processing	97.62	Large dataset of plant disease images	IEEE Transactions on Automation Science and Engineering, 2019

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3. Methodology

Detecting diseases in custard apple trees is challenging due to the complexity of factors involved. To address this challenge, the dataset must undergo pre-processing to consolidate essential features into a unified feature set. Subsequently, an appropriate deep learning algorithm will be employed for disease classification and identification. The development of the Custard Apple Disease Detection Application involves the following steps:

A. Dataset Collection and Preprocessing: A dataset comprising 5029 images of custard apple leaves and fruits was collected. The images were categorized into three classes: Blank Canker, Diplodia Rot, and Mealy Bug. The images were resized to 768x768 pixels and augmented using random flipping and rotation to enhance model generalization.

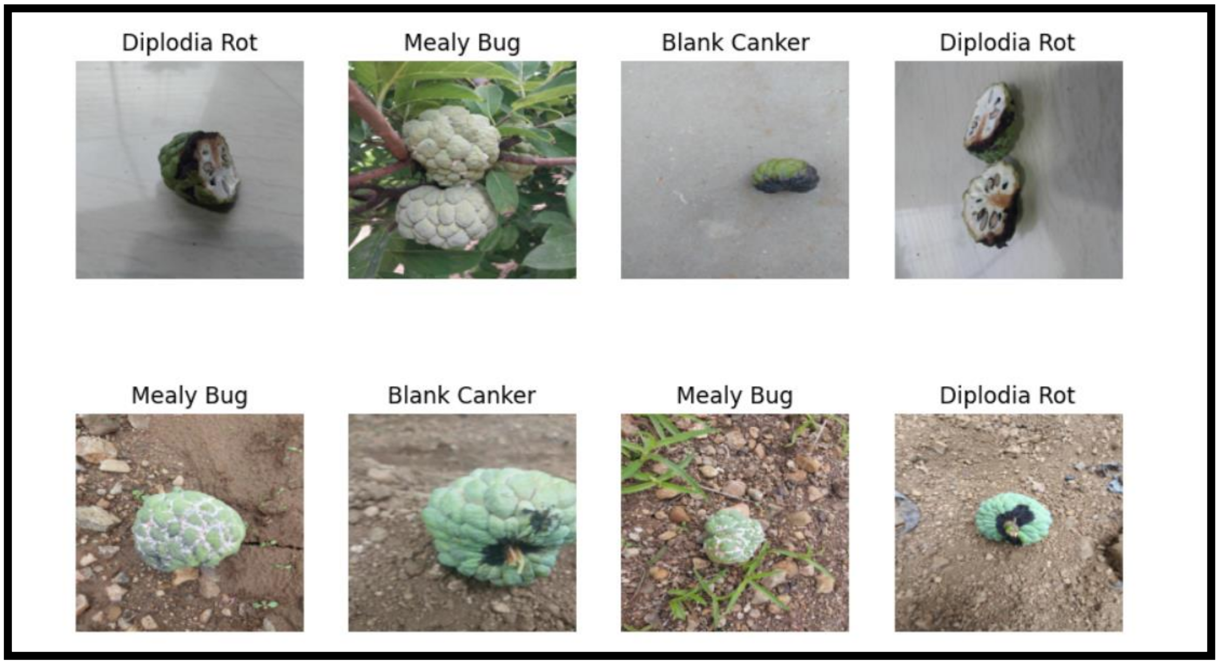

Fig.1: Dataset of Custard Apple

B. Model Architecture: A sequential CNN model was constructed with multiple convolutional layers followed by max pooling layers. The architecture aimed to extract relevant features from the images for accurate classification.

```
model = models.Sequential([
    resize_and_rescale,
    layers.Conv2D(32, kernel_size = (3,3), activation='relu', input_shape=input_shape),
    layers.MaxPooling2D((2, 2)),
    layers.Conv2D(64,  kernel_size = (3,3), activation='relu'),
    layers.MaxPooling2D((2, 2)),
    layers.Conv2D(64,  kernel_size = (3,3), activation='relu'),
    layers.MaxPooling2D((2, 2)),
    layers.Conv2D(64, (3, 3), activation='relu'),
    layers.MaxPooling2D((2, 2)),
    layers.Conv2D(64, (3, 3), activation='relu'),
    layers.MaxPooling2D((2, 2)),
    layers.Conv2D(64, (3, 3), activation='relu'),
    layers.MaxPooling2D((2, 2)),
    layers.Flatten(),
    layers.Dense(64, activation='relu'),
    layers.Dense(n_classes, activation='softmax'),
])
```

Fig.2: Model Architecture

C. Training: The model was trained using the Adam optimizer and sparse categorical cross-entropy loss for 40 epochs. The dataset was split into training (80%), validation (20%), and sets to evaluate model performance. The accuracy obtained is 97.09% on training data and 86.87% on validation data.

```
model.compile(optimizer='adam', loss='categorical_crossentropy', metrics=['accuracy'])

history = model.fit(
    train_generator,
    epochs=40,
    validation_data=val_generator
)

Epoch 30/40
40/40 ━━━━━━━━━━━━━━━━━━━━ 30s 687ms/step - accuracy: 0.9683 - loss: 0.0864 - val_accuracy: 0.8469 - val_loss: 0.4422
Epoch 31/40
40/40 ━━━━━━━━━━━━━━━━━━━━ 31s 694ms/step - accuracy: 0.9668 - loss: 0.1036 - val_accuracy: 0.9062 - val_loss: 0.3193
Epoch 32/40
40/40 ━━━━━━━━━━━━━━━━━━━━ 31s 699ms/step - accuracy: 0.9557 - loss: 0.1237 - val_accuracy: 0.8687 - val_loss: 0.4688
Epoch 33/40
40/40 ━━━━━━━━━━━━━━━━━━━━ 31s 702ms/step - accuracy: 0.9567 - loss: 0.1275 - val_accuracy: 0.9312 - val_loss: 0.2661
Epoch 34/40
40/40 ━━━━━━━━━━━━━━━━━━━━ 34s 781ms/step - accuracy: 0.9672 - loss: 0.1023 - val_accuracy: 0.9031 - val_loss: 0.2774
Epoch 35/40
40/40 ━━━━━━━━━━━━━━━━━━━━ 31s 708ms/step - accuracy: 0.9725 - loss: 0.0825 - val_accuracy: 0.8844 - val_loss: 0.3726
Epoch 36/40
40/40 ━━━━━━━━━━━━━━━━━━━━ 31s 705ms/step - accuracy: 0.9588 - loss: 0.1215 - val_accuracy: 0.8813 - val_loss: 0.3482
Epoch 37/40
40/40 ━━━━━━━━━━━━━━━━━━━━ 31s 702ms/step - accuracy: 0.9483 - loss: 0.1317 - val_accuracy: 0.8813 - val_loss: 0.3969
Epoch 38/40
40/40 ━━━━━━━━━━━━━━━━━━━━ 31s 702ms/step - accuracy: 0.9468 - loss: 0.1483 - val_accuracy: 0.8875 - val_loss: 0.3455
Epoch 39/40
40/40 ━━━━━━━━━━━━━━━━━━━━ 31s 700ms/step - accuracy: 0.9816 - loss: 0.0754 - val_accuracy: 0.8969 - val_loss: 0.4062
Epoch 40/40
40/40 ━━━━━━━━━━━━━━━━━━━━ 31s 701ms/step - accuracy: 0.9709 - loss: 0.0867 - val_accuracy: 0.8687 - val_loss: 0.5167
```

Fig. 3. Training Result.

D. Evaluation: The model achieved high accuracy on both training and validation datasets, demonstrating its effectiveness in classifying Custard Apple Diseases. Figures 1 and 2 illustrate the training and validation accuracy and loss curves, respectively.

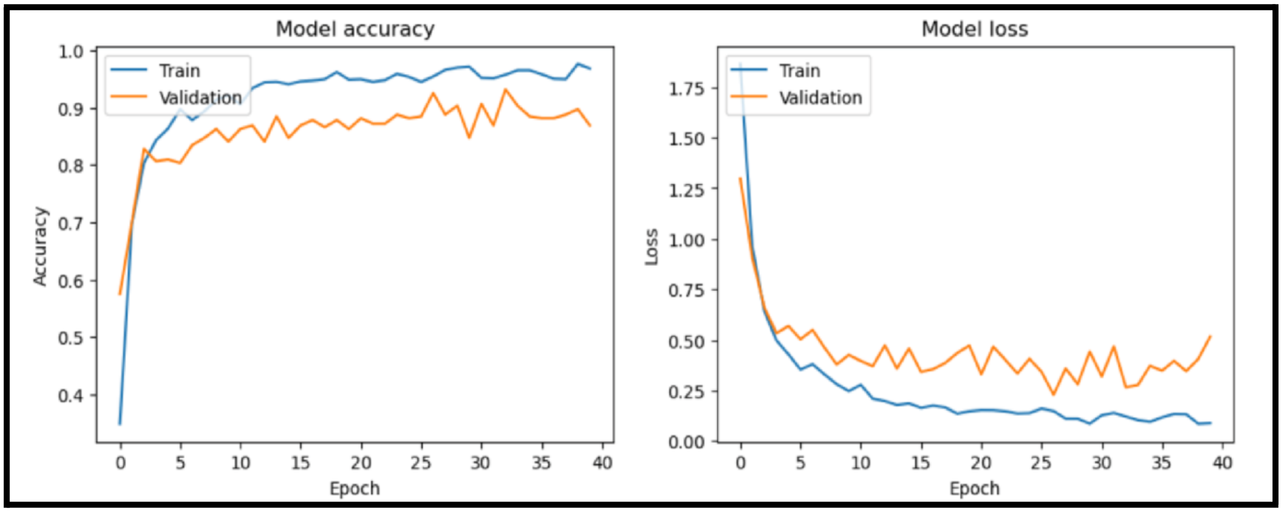

Fig4: Accuracy and Loss graph.

E. Discussion: The proposed CNN model effectively detects custard apple diseases, offering a significant improvement over traditional methods. Future work includes expanding the dataset, integrating additional augmentation techniques, and conducting field trials to validate the system under real-world conditions.

4. Conclusion and Future Scope

This study successfully implements a CNN-based system for custard apple disease detection, achieving high accuracy and robustness. It highlights the potential of machine learning in transforming agricultural practices, particularly in disease management for fruit trees like custard apples. Moving forward, future research could focus on enhancing the model by incorporating larger and more diverse datasets and integrating advanced technologies such as remote sensing and IoT devices. These efforts aim to improve disease monitoring and management, ultimately contributing to more sustainable and resilient agricultural systems and ensuring food security for farming communities.

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