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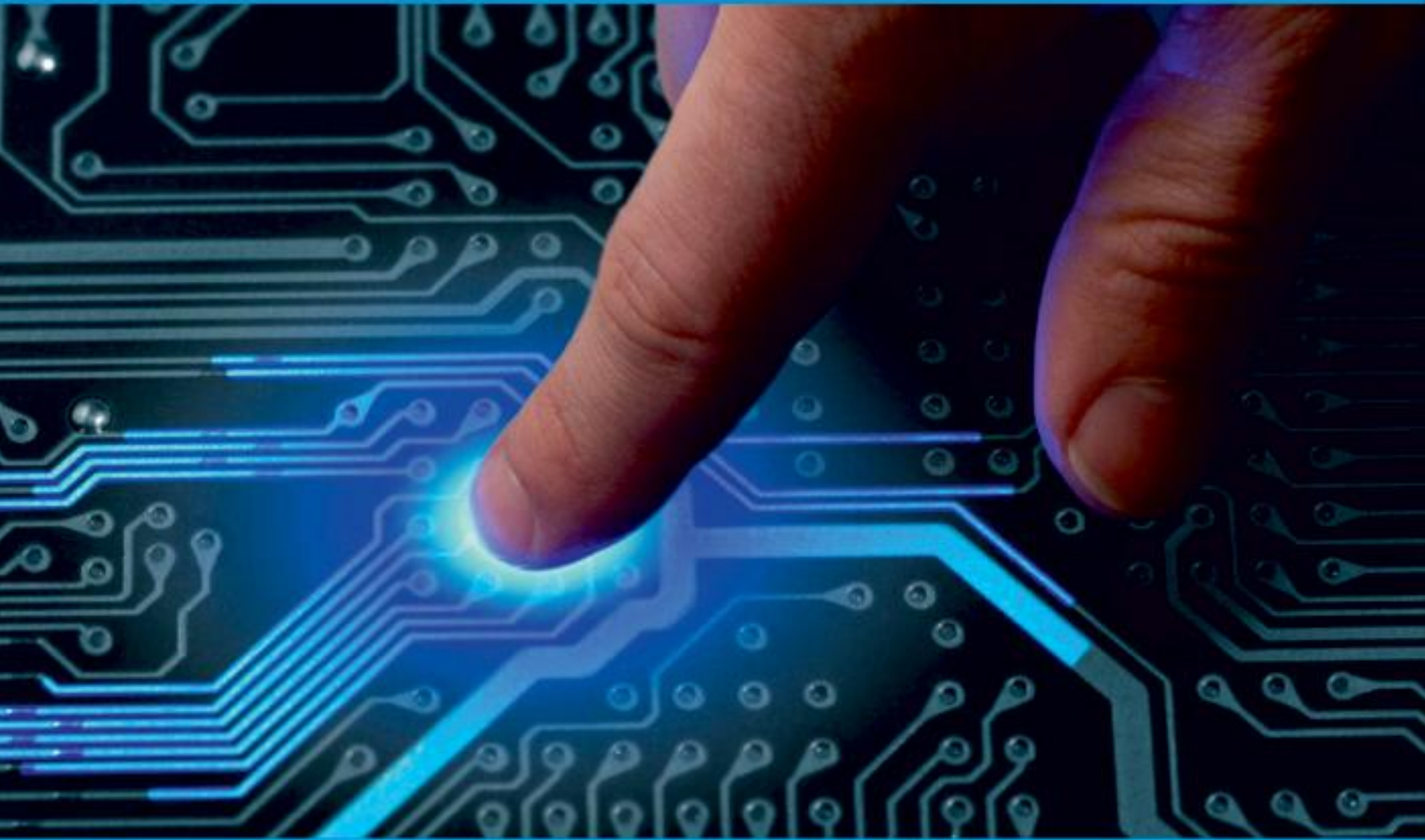

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Convolutional Neural Networks (CNNs) Implementation in Maize Plant Disease Detection

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ABSTRACT: Zimbabwe's economy is agriculture based. CNNs have been proposed to help detect and classify maize diseases. In the study, nine popular CNN architects and the authors' CNN were compared on their metrics (accuracy, precision and recall). Another comparison was made to determine if the softmax in the CNN network can classify better than the Support Vector Machine (SVM) algorithm. Train and testing were done for each CNN with softmax and then with SVM. The best metrics (accuracy 91.8%, precision 92% and recall 91.7%) were obtained from the authors' CNN using softmax.

KEYWORDS: Classification, CNN, SVM, Maize, Agriculture

I. INTRODUCTION

Maize is the staple food in Zimbabwe and thus a farming season with poor maize harvests usually translates to food insecurity, a high import bill for the country which also leads to higher food prices and farmers making losses[1]. Along with effects of climate change, pests and diseases are negatively affecting crop production.

Traditionally, agriculture research officers advise Zimbabwean farmers on detection of pests and diseases. However, at times the government fails to adequately provide resources needed by these officers and thus new methods for crop monitoring are required. The new generation of farmers mostly stay in cities away from their farms, and thus remotely manage their farming and with the increased use of mobile phones, farmers can easily assess the health of their plants by asking their farm workers to take a snap of their plants and upload them to a web application and show the healthy status of the maize plant. This calls for new measures to help farmers in their business, and thus to employ artificial intelligence (AI).

AI aims to develop and employ systems that augment and extend the efficiency and capacity of humans in various tasks with major fields in computer vision, robotics, machine learning, natural language learning and the science of cognition and reasoning [2]. This paper studied the field of computer vision whereby nineCNN architectures (VG16, VG19, Xception, InceptionV3, ResNet50, ResNet50V2, MobileNet, MobileNetV2 and Densenet121) and the author developed CNN were compared on their classification metrics as well as manipulated to use SVM for classification instead of the softmax traditionally used by the CNN. CNNs use mathematical operations to learn patterns in images through feature extraction and then use the patterns in classifying the images [3]. SVM is a popular classifier developed in the 1990s [4] and thus it's classification will be compared to the softmax function of the CNN.

II. LITERATURE SURVEY

Several authors have done researches on employing computer vision algorithms in disease identification in agriculture. Madhulatha[5] implemented AlexNet architecture to classify diseases from the Plant Village dataset. The system was developed for early detection of diseases.Basly[6] combined the CNN algorithm and SVM to for recognition of human activity by employing a CNN for feature extraction and SVM for classification. Shrestha [7] proposed a CNN architecture to detect twelve potato diseases and obtained an accuracy of 88% without any overfitting.Türkoğlu[8], using a dataset obtained in Turkey containing images of pests and diseases compared CNN architectures for future extraction and compared SVM, K-nearest neighbour (KNN), and extreme learning machine (ELM) methods algorithms for classification. The best accuracy of 97.86% was obtained using the SVM classifier and ResNet50 CNN for feature extraction. Hassan [9]

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used four CNN models (MobileNetV2, InceptionResNetV2, EfficientNetB0 and InceptionV3) on a PlantVillage dataset to classify thirty-eight classes of healthy and diseased plants and obtained the best accuracy of 99.56% using the EfficientNetB0 network.

III. METHODOLOGY / APPROACH

A dataset containing four classes (grey leaf spot, rust, healthy and blight) was obtained from https://www.kaggle.com/datasets/smaranjitghose/corn-or-maize-leaf-disease-dataset/download, which contained 840 images. To reduce overfitting, callbacks methods (EarlyStopping and ReduceLROnPlateau) were used. EarlyStopping was set to a patience of eight and ReduceLROnPlateau had a factor of 0.1 and patience of 3.Dropout was also introduced into the network to reduce overfitting the dataset. Adam was used as the optimizer.Fig 1 below summarizes the authors' model.

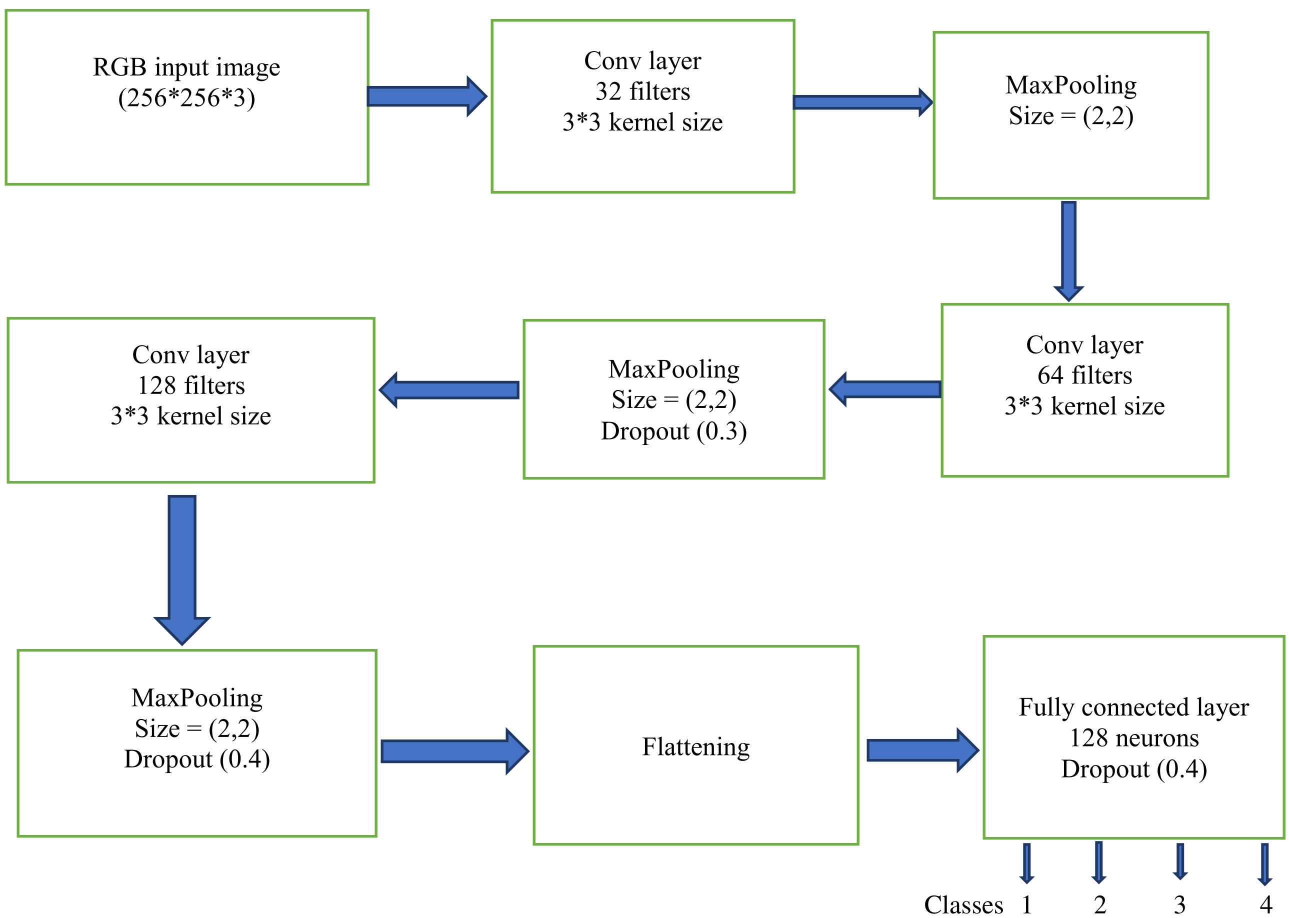

Fig 1: Showing the authors' model

At first the models implemented used the softmax for classification and then the softmax was replaced by the SVM for classification. A batch size of sixteen was used and a hundred epochs were used, but due to the callbacks used, none of the models reached hundred epochs due to the callbacks which stopped training when the model started overfitting. Classification metrics were then shown using the classification report.

PSEUDO CODE

1. Import necessary libraries or modules

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2. Create list of the CNN architectures
3. Perform data pre-processing
4. For a CNN in list of CNN architectures:
    - Use the CNN for training and testing images
    - Use softmax function for classification
    - Get the classification report for each CNN
5. Repeat step for but use the SVM algorithm for classification
6. End

IV. RESULTS & DISCUSSION

Results from the study are summarised below

Table 1: CNN architectures without SVM

Architecture	Accuracy (percentage)	Precision (percentage)	Recall (percentage)
VG-16	88.6	88.4	88.5
VG-19	88.6	88.4	88.0
Xception	87.8	87.6	87.7
Inception V3	89.1	89.0	89.0
ResNet50V2	89.9	89.9	89.8
ResNet50	60.0	60.2	59.7
MobileNet	90.8	90.9	90.8
MobileNetV2	89.9	89.9	89.8
DenseNet121	91.0	91.1	90.1
Authors' model	91.8	92.0	91.8

Table 2: CNN architectures with SVM

Architecture	Accuracy (percentage)	Precision (percentage)	Recall (percentage)
VG-16	30.2	6.6	23.3
VG-19	30.2	6.6	23.3
Xception	75.8	59.6	66.2
Inception V3	31.2	7.8	25.0
ResNet50V2	31.2	7.8	25.0
ResNet50	55.6	34.4	47.3
MobileNet	57.0	32.8	48.5
MobileNetV2	31.2	7.8	25.0
DenseNet121	31.2	7.8	25.0
Authors' model	91.0	88.9	88.6

For each respective CNN architecture, the traditional CNN without SVM outperformed the one with SVM. Below is an image showing the developed web application

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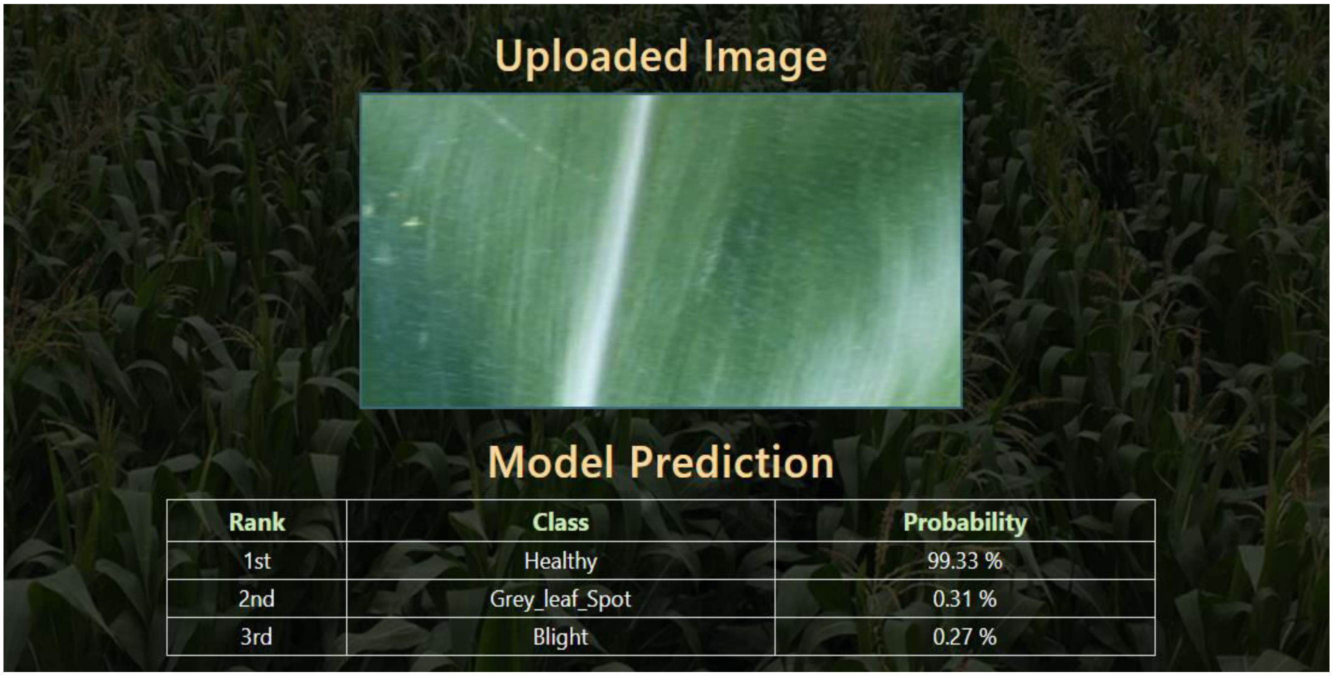

Fig 2: Showing report of an uploaded image

V. CONCLUSION

The softmax outclassed the SVM algorithm for classification and thus it had higher metrics for each CNN architecture. Deeper CNN architectures had lower metrics because a small dataset was used and they started overfitting much early. The best metrics were obtained using the authors' model (accuracy of 91.8%, precision of 92% and recall of 91.8%). For future work, there is need to increase the dataset and include more diseases and integrate the system with IoT devices for large scale remote monitoring of plants.

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