**Project Report**

1. Name of the Faculty Mentor: Mr. Atul Mishra
2. Particulars

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| S No. | Roll No. | Name |
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2. Provide a brief descriptive title of your project:

Predicting the Presence of Seedlings and the Health of Crops using Image Classification

1. In 50 words or less, please provide an abstract or summary of your project:

An efficient food production system is one major requirements in the present world. Since, majority of the food crops grow from seeds. Classic farming involves a vast amount of labor to seed and later transplant the seedlings to a low-density tray from a high-density tray for further growth. This project proposes an image classification model that would detect the presence of seedlings and also identify the health of the crops. So, we have tried to develop a Convolutional Neural Network(CNN) which would be trained on the image samples so that it could learn patterns in order to identify the seedling’s presence or absence and if present then we would like to know whether it’s healthy or not. We have used 3 Conv2d layers, 3 MaxPooling layers, 3 Activation Function layers, 1 flatten and 2 dense layers.

1. State the problem or problems that motivated or required a solution provided by this project:

Creating an efficient food production system in the most sustainable way is one of the major problems in the present world. Majority of the food crops grown in the world start from their respective seeds. The general way of growing these plants is by bulk seeding trays of soil and then later transplanting the seedlings from the high-density trays to low-density trays for further growth while avoiding weeds. This process involves a vast amount of labor and the guarantee of quality seedlings is subjective to the labor working. With this project we aim to provide an image classification model that would detect the presence of seedling. The idea behind the image classification model is that it would detect the presence of seedlings in the seed trays by contrasting the colors of the soil and the seedlings.

While the health of the crop is identified by the color or the condition of the leaves. Farmers have long done the same while deciding upon the pesticides or insecticides to use by examining the state of the crop leaves. Again, a tedious process and in a larger area of land there could be multiple patches of various diseases. The same image classification model can be used to identify healthy and unhealthy crop at various levels such as at seedling stage and pre harvest stage.

1. List the specific problem which your project is solving:

* Predicts the presence of seedlings.
* Identifies the health of the crop.

1. Provide a detailed explanation of how this project solves the problem(s).

This project proposes an image classification model that would detect the presence of seedlings and also identify the health of the crops. Therefore, one such technology which is popular in this domain is Machine Vision Technology with Convolutional Neural Networks. MVT will capture the images using video cameras and send them as inputs to our CNN model which would look for patterns in the input sent and try to predict several things which would help farmers in increasing accuracy and thus help them achieve optimum efficiency.

So, we have tried to develop a Convolutional Neural Network(CNN) which would be trained on the image samples so that it could learn patterns in order to identify the seedling’s presence or absence and if present then we would like to know whether it’s healthy or not. We have used 3 Conv2d layers, 3 MaxPooling layers, 3 Activation Function layers, 1 flatten and 2 dense layers. In order to improve the processing speed, we have tried to normalize the data. We have used 750 samples of Health and 850 samples of Seedlings dataset to evaluate our model. We improved the performance of the model by applying data augmentation. We got our optimum model with highest accuracy of 88.32% (in case of Health dataset) and 94.94% (in case of Seedlings dataset) when learning rate was 0.001 and batch size was 16 and 50 respectively. So, this CNN model is quite efficient in detecting the presence or absence of the seedlings and in identifying whether it is healthy or not.

The methodology is as follows:

1. **Datasets**

The seedling dataset consists of various species of crop such as Chickweed, Cleavers and Mayweed as this was the only available public datasets of seedlings. The leaf dataset consists of tomato crop with different kinds of diseases such as Bacterial Spot, Target Spot, Septoria Leaf Spot and Blight.

1. **Image Preprocessing**

In order to process images, we have used Binary Image Classification. We have developed a Convolutional Neural Network using a user-friendly library called Keras. A CNN is one of the types of neural network which is used in Image Classification and Natural Language Processing. A CNN is made up of various layers:

* Convolution Layer
* Max Pooling Layer
* Activation Function Layer
* Fully Connected Layer (Dense)

**Convolution layer** is the most important layer as it convolves the image by using filters. Our model uses 3 convolution layers of 32,32 and 64 nodes respectively and a filter of (2,2) matrix in each layer. Convolution is necessary as images are complex and we need to simplify it for faster processing. So, a convolution layer works by placing filters over an array of image pixels and finally creates a convolved feature map, which is of reduced dimension as compared to its original image. It’s a bit like looking an image through a window which allows you to see specific features of image which otherwise you would not have able to see. Next, we have **MaxPooling Layer** which downsizes the sample so that further non-important features get eliminated and so our model can focus only on important features. As a result, we get a Pooled feature map. In our case, we are using 3 MaxPooling Layers with filters of (2,2) dimension. There are 2 ways to get a pooled feature map:

* **Max Pooling**: it takes maximum input of particular convolved feature map.
* **Average Pooling:** it takes avg. of all inputs of particular convolved feature map.

Now, these steps involve in feature extraction & network builds up a picture of image data according to its mathematical rules. Those mathematical rules are nothing but the activation functions along with the loss functions that are used to optimize the model. So, we have used a combination of ReLU and Sigmoid functions. We have used **binary\_crossentropy** as our loss function and **Adam** as our optimizer. In order to perform classification, we need to make use of fully connected layers. So before using it we need to flatten the data because a neural network which has a complex set of connections can only process linear data.

**Binary Cross Entropy** is considered to be the first choice as a loss function for any binary classification problems. It is so because the target set has values either 0 or 1. Cross-entropy will calculate a score that summarizes the average difference between the actual and predicted probability distributions for predicting class 1 [6]. **Adam** uses individual separate learning rates for its parameters. Learning rate keeps on changing with the training steps, but every learning rate must vary between 0 and λ (lambda).

1. **Data Augmentation**

It is a strategy by which Data Scientists try to increase data samples in a dataset so that our model can train on more data and become better and better with time. So, this can be done using **ImageDataGenerator** class [7]. We have used **rotation\_range**, **width\_shift\_range, height\_shift\_range, shear\_range, zoom\_range, horizontal\_flip** as the arguments.



**Figure 3:-** Augmented Tomato Leaf Images.



**Figure 4:-** Augmented Seedling Images

1. **Training and Classification**

The model was trained on the two datasets Seedlings and Health with slight changes made in batch sizes. The Health dataset had a train set of 2263 samples and a test set of 750 samples. While the Seedlings had a train set of 1810 samples and a test set of 850 samples. The model was trained on Google Colab, a cloud service equipped with RAM of 12GB and accelerated image processing with NVIDEA TESLA V100 of 16GB. In order to improve the generalization ability of the model we applied zooming, shearing, horizontal flipping, rotation width shift and height shift transformations of ranges 0.2, 0.2, True, 0.2, 0.2 respectively on the train samples of both the datasets. The model was trained on batch-sizes equal to 16,50 and 65 respectively with epochs equal to 10 in each case.

1. Existing state-of-the-art: (Brief background of the existing knowledge.)

The existing image classification models employed either detect the presence of seedlings or identify the health state of the crop but not both. We are using the same classification model to do the both tasks.

1. List out the known ways about how others have tried to solve the same or similar problems? Indicate the disadvantages of these approaches. In addition, please identify any prior art documentation or other material that explains or provides examples of such prior art efforts.

|  |  |  |  |
| --- | --- | --- | --- |
| S. No. | Existing state of art | Drawbacks in existing state of art | Overcome |
| 1 | Predicts the presence of seedlings. | Highly specific, cannot identify the health state. | Make a general model to detect all kinds of seedlings |
| 2 | Identifies the health state of the crop | Highly specific, cannot predict seedlings presence, | Make a general model |

1. List the Technical features and Elements of the project.

* A convolutional neural network that classifies between two images.

1. Draw the block diagram of your project
2. List all the components (hardware and software used in your project)

We used the cloud environment of Google Colab for all our final code executions.

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| --- | --- | --- |
| **EXPERIMENTAL ENVIRONMENTS** | | |
| Hardware | CPU  MEMORY  GRAPHICS CARD  HARD DISK | Intel(R) Xeon(R) CPU @ 2.30GHz  12.72 GB  Tesla K80 GPU  68.40 GB |
| Software | OPERATING SYSTEM | Windows 10 Pro-64bit |
| GOOGLE COLAB |  |

1. List out the features of your project which are believed to be new and distinguish them over the closest technology.

* Able to predict the presence of seedlings as well as identify the health state of the crop.

1. Are there alternative ways of implementing your project that is different from what you have disclosed? Specifically, if someone knew of your solution to the problem you solved (Question 3), would it be easy for them to come up with an alternative solution to the same problem that did not include details of your project?

Yes, there are alternative ways to implement our project, but the technique we use to predict the seedlings is a basic one that depends on the number of leaves on the seedlings. While others could do it based on the height of the seedlings. Health state identification is not much different from what others are doing.

1. Status of your project: been built or tested or implemented? If so, please provide the particulars of the first time it was successfully built or implemented (when, where, by whom, and evidence of this event including written or on-line pointers to documentary evidence):

Our project has been built and this is the performance of our Image Classification Model:

|  |  |
| --- | --- |
| **Dataset** | **Model Loss and Accuracy** |
| Seedling | C:\Users\Kiran Kumar\Pictures\Screenshots\Screenshot (182).png |
| Health | C:\Users\Kiran Kumar\Pictures\Screenshots\Screenshot (167).png |

So, here the patterns observed in case of model loss and model accuracy on both the training and testing dataset is very similar. Thus, we have successfully reduced the biasness of our neural network on the train dataset and so the **overfitting** has reduced significantly.

1. Briefly state when and how you first conceived this idea?

We were looking at the application of machine learning in various fields that’s when we stumbled upon this agriculture problem. We went through some literature to understand the depth of the problem.

1. Please provide the names of products that your project will be used in (if any):

* Agriculture and horticulture industries
* Farmlands
* Gardens and plant nurseries

17. Additional Information:

18. References:

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