1. Crop Protection using Deep Learning

1.1. Introduction

Farming is the main occupation of India. About 70% of primary and secondary business is based on farming and it is also the backbone of our Indian economy. Crop protection is the practice of protecting crop in the farms from various harms such as plant diseases, weeds, pests, low rainfall, local animals, etc. This leads to huge losses for the farmers. It is not possible for farmers to stay in farms for whole day and protect the crops from these threats. Many of those threats need farmers attention for sure. But threat of local animals can be prevented by various different methods like electric fences, scarecrow, manual guarding, etc. But sometimes those methods fail and cause huge damage to the crops. So, the aim is to protect the crops from the local animals with the help of emerging technologies i.e. Artificial Intelligence. AI system can be developed which detects any animals entering the farms with the help of image recognition. After detecting any animals in the farm, the AI predicts which animal it is and how it can stop them by entering the farm, by playing particular ultrasonic sounds (animal repellent sounds) and forcing them to get away from that sound, which prevents the crops from damage.

1.2. Objective of Research

Agricultural lands close to protected areas often face crop raiding by wild herbivores, which can be a serious problem for farmers whose livelihoods depend on agricultural produce. In order to avoid economic loss, farmers apply a range of protective measures. They include manual guarding, various types of fences, trenches, and other devices. However, these measures often come with high associated costs and risk. Destructive measures such as traps can kill or injure animals. Highly sophisticated means such as electric fences are expensive and need continued maintenance. Although a number of measures have been developed and shown to be effective. Patterns of damages caused by different herbivores can be substantially different and estimating them using a single method may not be possible, which leads to visibly obvious damage over a measurable area. So, to protect the farmers from these losses the effective and cost-efficient methods are to be used, which leads us to develop an AI system which protects the corps from damage. Farmers were asked about the problems they faced from the establishment of the protected area. Among the total respondents, 60% claimed crop damage and livestock loss were severe problems created by the animals in the park which directly impacted their livelihoods.

1.3. Problem Statement

In agriculture, Artificial Intelligence and Machine Learning both are playing very important role in many different ways from increasing the production to

the protection of that produced product. Now both of this has become distribute technology in agriculture services as it learns and responds to different situations. The main goal of this project is to enhance farms productivity by providing them a complex technology in simple way to deal with daily problems i.e. preventing local animals from entering the farms and damaging the yield. Intelligent systems have brought artificial neural network (ANN) to become a new technology which provides assorted solutions for the complex problems in agriculture. So, by using those all systems we developed a system which detects if any animals are entering the fields, by detecting which animal it is a particular ultrasonic sound is played to stop them by entering the field and preventing the loss of yield.

2. Review of Literature

IBM is working with AI and farmers to protect crops and improve yields. The Weather Co., a subsidiary of IBM Corp., is looking to break down data silos and bring more information and artificial intelligence to farmers so they can make better decisions and improve yields. The Watson Decision Platform for Agriculture, growers have an opportunity to leverage IBM's capabilities and create a more efficient farm-to-fork ecosystem. IBM has got 13 to 14 different analytics and AI products embedded in IBM's decision platform. Technology assistance at various stages of agricultural processes can significantly enhance the crop yield. Sensor networks express a substantial improvement over traditional invasive methods of monitoring. Our proposed method is based on an animal friendly ultrasounds generator, which does not produce physical or biological harm to the animals nor sounds audible to humans. In this project, we present the system architecture for the ultrasound repelled device.

3. Data Collection

For building the effective model, the dataset is prepared which consist of different classes i.e. birds, cows, and goats, both for training and testing. Training set of each class consist of 800 images and 200 images for testing of .jpg format. The dataset is gathered from different sources from Google image search. Training set is used for training the model whereas test set is used for testing the accuracy of the model after modeling. Both training and test set are further divided into independent and dependent variables (input and output parameters). Depending on independent and dependent variables the activation function is decided for hidden layer, and output layer of Neural Network.

Directory Structure of dataset:

```
dataset : ├────test_set
          │   ├────birds
          │   ├────cow
          │   └────goat
          └────training_set
          ├────birds
          ├────cow
          └────goat
```

4. Methodology

4.1. Explanatory Data Analysis

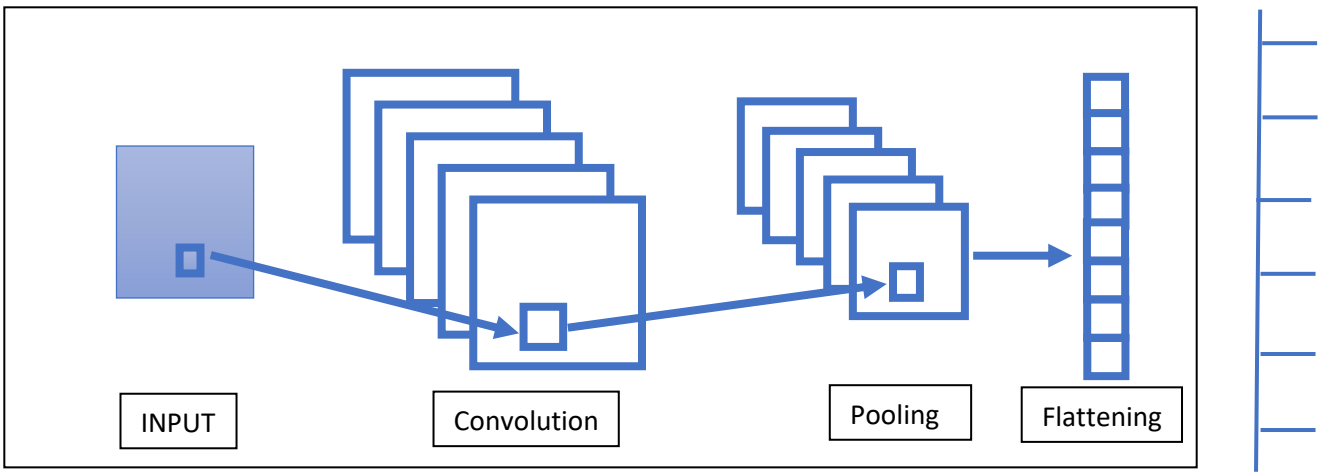
- Neural network consists of neurons that have weights and biases. These weights and biases are tuned during the training process to come up with a good model.
- Each neuron receives a set of inputs, processes it in some way, and then outputs a value.
- Images are 2D structures and we know that the spatial arrangement of pixels has lot of hidden information. This information cannot be ignored, as we will be losing a lot of underlying patterns. This is where Convolution Neural Networks (CNNs) come into picture. CNNs take the 2D structure of the images into account when they process them.
- A Convolutional Neural Network (CNN) is a multilayered neural network with a special architecture to detect complex features in data. CNNs have been used in image recognition, powering vision in robots, and for self-driving vehicles.
- CNN capable of classifying images.
- Once a CNN is built, it can be used to classify the contents of different images.
- All we have to do is feed those images into the model.
- Just like ANNs, CNNs are inspired by the workings of the human brain.
- CNNs are able to classify images by detecting features, similar to how the human brain detects features to identify objects.

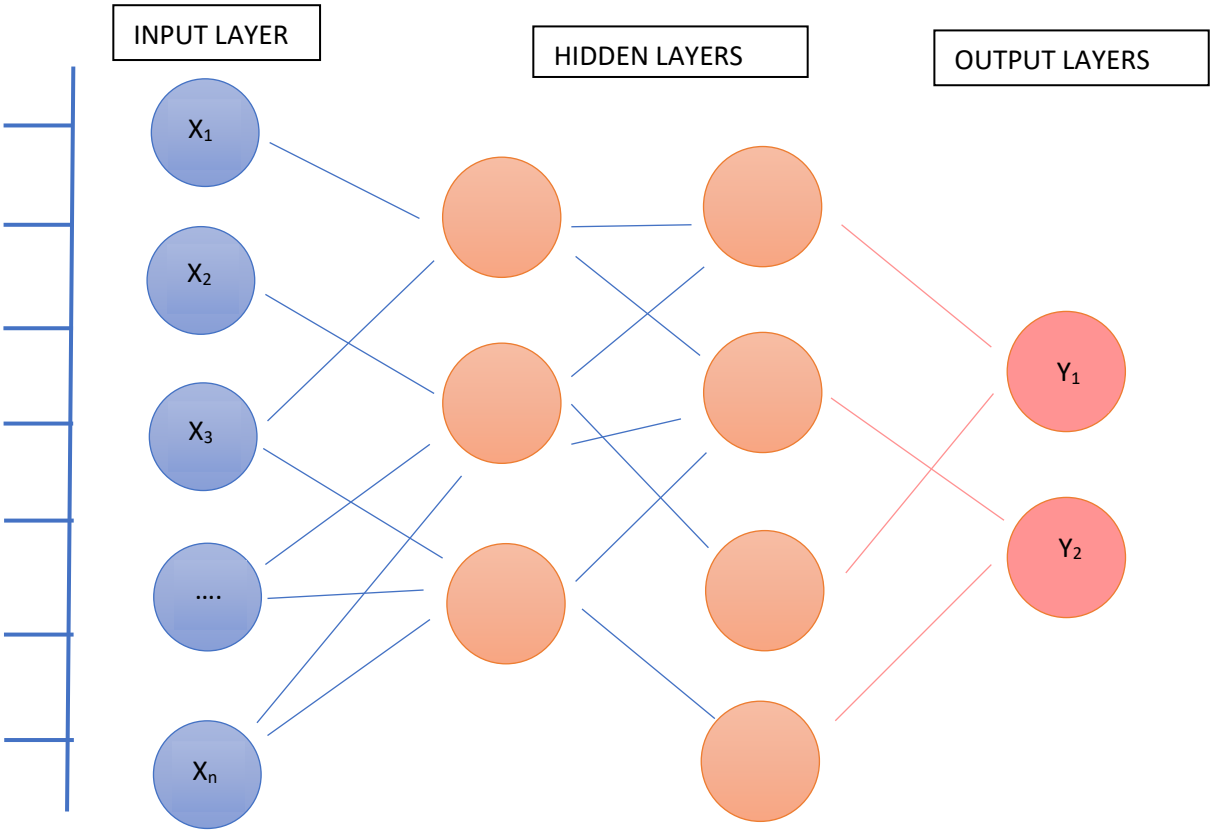
Types of layers in a CNN

- **Input Layer**: This layer takes the raw image data as it is.
- **Convolutional Layer:** This layer computes the convolutions between the neurons and the various patches in the input. The convolutional layer basically computes the dot products between the weights and a small patch in the output of the previous layer.
- **Rectifier Linear Unit Layer:** This layer applies an activation function to the output of the previous layer. This function is usually something like $max(0, x)$. This layer is need to add non-linearity to the network so that it can generalize well to any type of function.
- **Pooling Layer:** This layer samples the output of the previous layer resulting in a structure with smaller dimensions. Pooling helps us to keep only the prominent parts as we progress in the network. Max pooling is frequently used in the pooling layer where we pick the maximum value in a given KxK window.
- **Fully Connected Layer:** This layer computes the output scores in the last layer. The resulting output is of the size 1x1xL, where L is the number of classes in the training dataset.

As we go from the input layer to the output layer in the network, the input image gets transformed from pixel values to the final class scores. Many different architectures for CNNs have been proposed and its an active area of research. The accuracy and robustness of a model depends on many factors, the type of layers, depth of the network, the arrangement of various types of layers within the network, the function chosen for each layer, training data, and so on.

4.1.1. Figures


INPUT
Convolution
Pooling
Flattening


INPUT LAYER
HIDDEN LAYERS
OUTPUT LAYERS
X1
X2
X3
....
Xn
Y1
Y2

4.2. Statistical methods

- **Problem Framing**: Requires the use of exploratory data analysis and data mining.
- **Data Understanding**: Requires the use of summary statistics and data visualization.
- **Data Cleaning**. Requires the use of outlier detection, imputation and more.
- **Data Selection**. Requires the use of data sampling and feature selection methods.
- **Data Preparation**. Requires the use of data transforms, scaling, encoding and much more.
- **Model Evaluation**. Requires experimental design and resampling methods.
- **Model Configuration**. Requires the use of statistical hypothesis tests and estimation statistics.
- **Model Selection**. Requires the use of statistical hypothesis tests and estimation statistics.
- **Model Presentation**. Requires the use of estimation statistics such as confidence intervals.
- **Model Predictions**. Requires the use of estimation statistics such as prediction intervals.

4.3. Data Modeling

Steps in Convolution Neural Networks

1.Convolution

2.Max pooling

3.Flattening

4.Full Connection

- **Step 1: Convolution**

  Convolution is done to an image using feature detector when input image is convolved with the feature detector then we get a feature map by applying convolution operation size of the image is reduced so we may lose some information. but features detector is one which stores the features and unwanted features are removed. We will apply number of feature detectors(filter) to a single image so we will be getting number of features maps. So, using number of feature detectors we get max number of features in an image so we will be getting number of feature maps. Group of feature map

```
model.add(Conv2D( , , , input_shape = ( , , ), activation=' '))
```

  is called convolution layer.

- **Step 2: Max pooling**

  Types of pooling-Max pooling - Mean Pooling, Sum pooing. Max Pooling. By applying max pooling, we are neglecting 75% of unwanted features and we are reducing special invariance this will avoid over fitting of the data.

```
model.add(MaxPooling2D(pool_size = ( , )))
```

- **Step3: Flattening**

  Fattening is converting n dimension to 1 dimension and applying ANN to that 1-dimension array which just acts like inputs to the neurons.
  When output is not correct then in the backward propagation along with the weights feature detector(filter) is also optimized.

```
model.add(Flatten())
```

- **Step 4: Full Connection**

  Full connection is dense layers. The flattened feature map is passed through a neural network. This step is made up of the input layer, the fully connected layer, and the output layer. The fully connected layer is similar to the hidden layer in ANNs but in this case it's fully connected. The output layer is where we get the predicted classes. The information is passed through the network and the error of prediction is calculated. The error is then backpropagated through the system to improve the

```
model.add(Dense(output_dim = ,activation = ' ', init = 'random_uniform'))
```

  prediction.
  The final figures produced by the neural network don't usually add up to one. However, it is important that these figures are brought down to numbers between zero and one, which represent the probability of each class. This is the role of the Softmax function.

$$\sigma : \mathbb{R}^K \to (0,1)^K$$
$$\sigma(\mathbf{z})_j = \frac{e^{z_j}}{\sum_{k=1}^{K} e^{z_k}} \quad \text{for } j = 1, \ldots, K.$$

```
model.add(Dense(output_dim = , activation = ' ', init = 'random_uniform'))
```

Compiling CNN

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

Fitting the CNN

```
model.fit_generator(x_train, samples_per_epoch = , epochs =  , validation_data = x_test
,nb_val_samples =  )
```

5. Findings and Suggestions

Though Artificial Intelligence offers vast opportunities for application in agriculture, there still exists a lack of familiarity with high tech machine learning solutions in farms across most parts of the world. AI systems also need a lot of data to train machines and to make precise predictions. Since the data infrastructure takes time to mature, it requires a significant amount of time to build a robust machine learning model. In case of vast agricultural land, though spatial data can be gathered easily, temporal data is hard to get. Aside from the aforementioned strategies, some farmers rely on scarecrows, crackers, bright lights, re, beating drums, and dogs. Along with practicing certain crop protection measures, the most successful farmers will monitor their field as often as possible. After all, constant monitoring is the best way to make sure that everything on the field goes as planned. In an attempt to ensure maximum crop protection, some farmers will combine a few crop protection strategies. Furthermore, modern farm technology researchers are working on new technological solutions. These solutions involve the use of cameras, computers, and even robots to protect plants from wild animals. While waiting for advanced technology to become available, farmers can do all their best and practice some of the above-mentioned strategies to protect their crops.

6. Conclusion

The damage to field crops caused by wild animals has been a highly topical issue and also one that has been discussed publicly. Although different means were used to prevent crop damage, most of the means were only temporarily effective as animals were only driven away for few minutes to be expected to come back at nights where the model needs to be trained with infrared images as only infrared images can be captured at nights. AI-driven technologies are emerging to help improve efficiency and to address challenges facing the industry including, crop yield. Though Artificial Intelligence offers vast opportunities for application in agriculture, there still exists a lack of familiarity with high tech machine learning solutions in farms across most parts of the world. Exposure of farming to external factors like weather conditions. Making available this AI system to all the farmers is the main objective to reduce the loss of farmers caused my animals.

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