CLASSIFICATION OF INSECTS USING IMAGE PROCESSING AND MACHINE LEARNING

A THESIS SUBMITTED TO THE GRADUATE SCHOOL OF APPLIED SCIENCE OF NEAR EAST UNIVERSITY

By

AMENAH ZAKARIYA

In Partial Fulfillment of the Requirements for the Degree of Master of Science

in

Computer Engineering

NICOSIA, 2021

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Amenah Faiz Hashim ZAKARIYA: CLASSIFICATION OF INSECTS USING IMAGE PROCESSING AND MACHINE LEARNING

Approval of Director of Graduate School of Applied Sciences

Prof Dr K. Hüsnü Can Başer

We certify this thesis is satisfactory for the award of the degree of Master of Science of Computer Engineering

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I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

Name, last name: Amenah Zakariya

Signature: 

Date: 27-05-2021

To my family…

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ABSTRACT

One of the biggest challenges to food security worldwide is insect pest attacks. It also has adverse effects on the economies of nations that depend on the export of cash crops. These pests naturally attack crops, mostly on the field, but sometimes also in storage facilities, causing damage to crops, either reducing their quality or making them useless.

Many approaches, such as setting traps and the use of GMO seeds have been used to try and solve this problem, but unfortunately, the fastest and cheapest method for pest control, which is the administration of pesticides can also be detrimental to the environment and health of the surrounding population. In cases of large scale commercial farming, these adverse effects are more evident and more dangerous.

This thesis, puts forth a system that could help in the now developing practice of Integrated Pest Management, which is a practice that combines methods or approaches to pest control in a more sustainable and even more effective effort. I have developed the key functionality of a pest identification system that can be used to detect insect pests on the field, thus aiding the early detection and control of these pests before an outbreak. In my work, I use transfer learning approach on the VGG16 classification model, using it for feature extraction and pairing it with an SVM to perform the classification task.

This work is done with the aim to aid in more targeted use of pesticides, to increase effectiveness, while reducing the amount of pesticides needed for pest control. With this, we can achieve lower Environmental Impact Quotients and still ensure food security through the preservation of farm produce.

Keywords: Machine Learning; Insect Detection; Integrated Pest Management; CNN; VGG16, Support Vector Machines

ÖZET

Dünya çapında gıda güvenliğinin önündeki en büyük zorluklardan biri haşere saldırılarıdır. Aynı zamanda, nakit mahsul ihracatına bağlı olan ülkelerin ekonomileri üzerinde de olumsuz etkileri vardır. Bu haşereler, çoğunlukla tarlada, bazen de depolama tesislerinde mahsullere doğal olarak saldırarak mahsullere zarar verir, ya kalitelerini düşürür ya da işe yaramaz hale getirir.

Bu sorunu denemek ve çözmek için tuzak kurmak ve GDO tohumlarının kullanılması gibi birçok yaklaşım kullanıldı, ancak ne yazık ki haşere kontrolünün en hızlı ve en ucuz yöntemi olan pestisitlerin yönetimi de çevreye ve sağlığa zararlı olabilir. çevreleyen nüfusun. Büyük ölçekli ticari çiftçilik durumlarında, bu olumsuz etkiler daha belirgindir ve daha tehlikelidir.

Bu tez, haşere kontrolüne yönelik yöntemleri veya yaklaşımları daha sürdürülebilir ve daha etkili bir çabayla birleştiren bir uygulama olan Entegre Zararlı Yönetimi uygulamasına yardımcı olabilecek bir sistem ortaya koymaktadır. Sahadaki böcek zararlılarını tespit etmek için kullanılabilecek bir haşere tanımlama sisteminin temel işlevini geliştirdim, böylece bu zararlıların bir salgından önce erken tespitine ve kontrolüne yardımcı oldum. Çalışmamda, VGG16 sınıflandırma modelinde transfer öğrenme yaklaşımını kullanıyorum, bunu özellik çıkarımı için kullanıyorum ve sınıflandırma görevini gerçekleştirmek için bir SVM ile eşleştiriyorum.

Bu çalışma, pestisitlerin daha hedefli kullanımına yardımcı olmak, etkinliği artırmak ve haşere kontrolü için gereken pestisit miktarını azaltmak amacıyla yapılır. Bununla, daha düşük Çevresel Etki Bölümleri elde edebilir ve yine de çiftlik ürünlerinin korunması yoluyla gıda güvenliğini sağlayabiliriz.

Anahtar Kelimeler: Makine Öğrenimi; Böcek Algılama; Entegre Zararlı Yönetimi; CNN; VGG16, Destek Vektör Makineleri

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LIST OF ABBREVIATIONS

GMO:	Genetically Modified Organisms
EU:	European Union
IPM:	Integrated Pest Management
FAO:	Food and Agriculture Organization
EIQ:	Environmental Impact Quotient
NLP:	Natural Language Processing
CNN:	Convolutional Neural Network
RNN:	Recurrent Neural Network
GAN:	Generative Adversarial Network
SOM:	Self Organizing Maps
RBFN:	Radial Basis Function Network
LSTM:	Long Short Term Memory
DBN:	Deep Belief Network
RBM:	Restricted Boltzmann Machine
SVM:	Support Vector Machine
VGG16:	Visual Geometry Group 16
ILSVRC:	ImageNet Large Scale Visual Recognition Challenge
API:	Application Programmer Interface

CHAPTER 1

INTRODUCTION

Machine learning has had many applications within a wide variety of categories. It is in fact now considered to be the foundation for the future of technological development. It has been used for very important and sensitive tasks such as medical diagnosis, and also for more casual applications such as recommendation systems in social media and even in games. Most of these tasks have been categorized within the scope of machine learning as object detection, natural language processing, classification tasks, among others.

Machine learning basically provides an way to automate the processes involved in these tasks as well as adding a computational advantage to increase efficiency and eliminating human error to provide accuracy. Essentially, it allows us to do more, over extended periods of time, and with more accuracy. For this reason, it has been applied to a wide range of applications and tasks.

The agricultural sector is one of such areas where machine learning has been applied. It has been used in tasks to increase yield, reduce loss or wastage and ultimately increase food security. A major challenge to this goal is insect pests. They pose a serious threat to commercial agriculture interests, causing large scale destruction which can be very difficult to control. According to one study, the potential loss of cash crops, wheat and cotton globally due to pest infestation is about 50% and 80% respectively, with other crops such as rice and soya beans having potential losses as high as 37% and 29% respectively (Popp et al., 2012). Pests hold the lead now as the biggest cause of food loss in the world.

Measures that are already used to solve this problem include the use of chemical pesticides to kill and repel the pests as well as transgenic planting, which involves genetically modifying the crop plants (Estruch et al., 1997). Transgenic planting, though effective, has come under scrutiny from the public as well as agencies and institutions against GMO (Genetically modified organisms) foods for their perceived dangers and effects on the human body.

Regarding the sue of pesticides, the European Union (EU) put forth some guidelines in the *Directive 2009/128/EC* aimed at ensuring the sustainable use of pesticides in commercial agriculture. The Directive had the simple purpose of ensuring that pesticides were used in a way that would reduce the negative effects it had on the environment and on people.

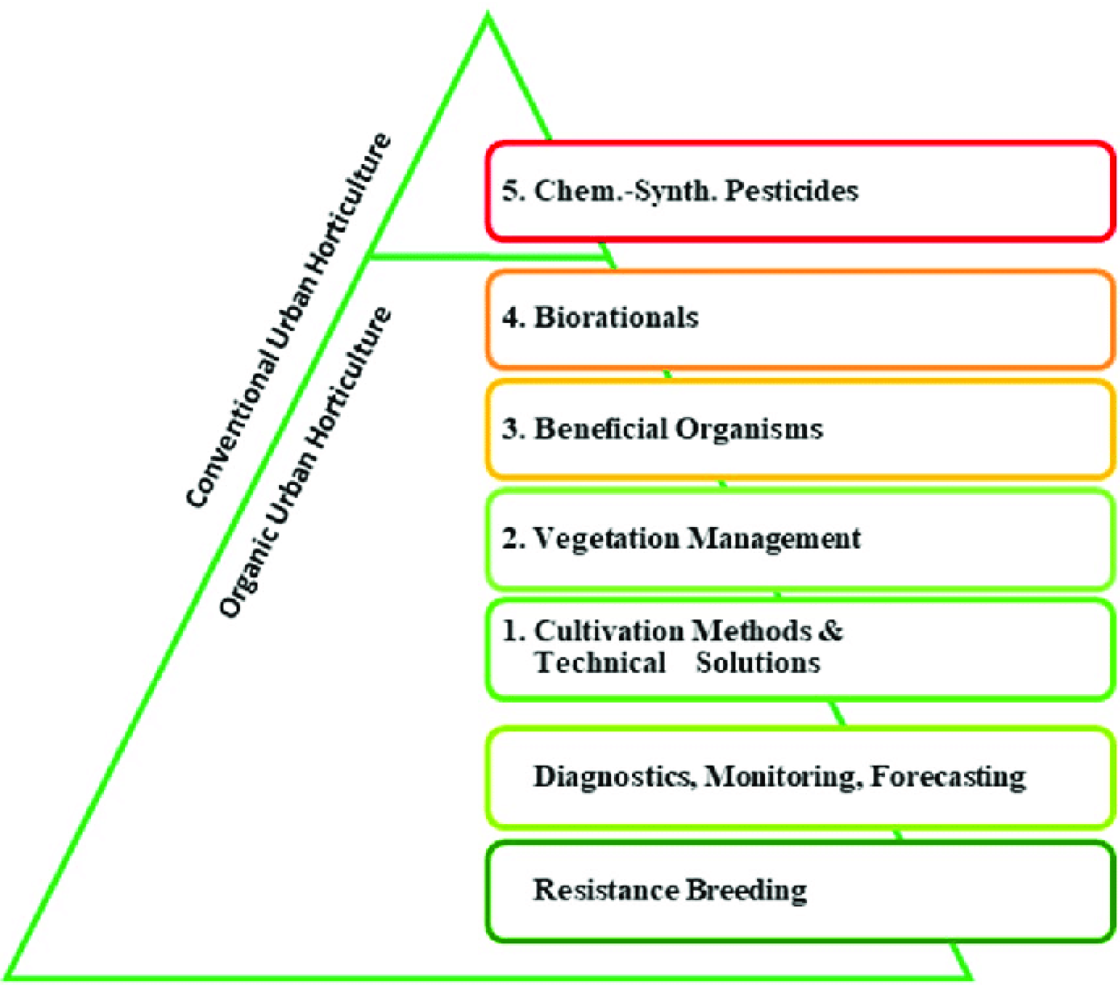

Figure 2.1 Integrated Pest Management According to *Directive 2009/128/EC*

Some of the guidelines involved in the directive included IPM (Integrated pest management), revision of the chemical contents of chemical based pesticides, and techniques that would ensure the responsible and controlled use of pesticides such as stopping aerial spraying or crop dusting. The use of pesticides is one of the most effective and common methods of pest control adopted by commercial farmers, and it has been very helpful to solve this problem, however, the indiscriminate use of these pesticides generates a series of new problems of their own that equally needs to be solved.

1.1 Problem Definition

There are a number of problems that surface from the indiscriminate use of pesticides. They include, environmental pollution, poisoning of water bodies caused by the washing of these chemicals into rivers and streams during rain, severe ailments to farmers and workers due to exposure, among others.

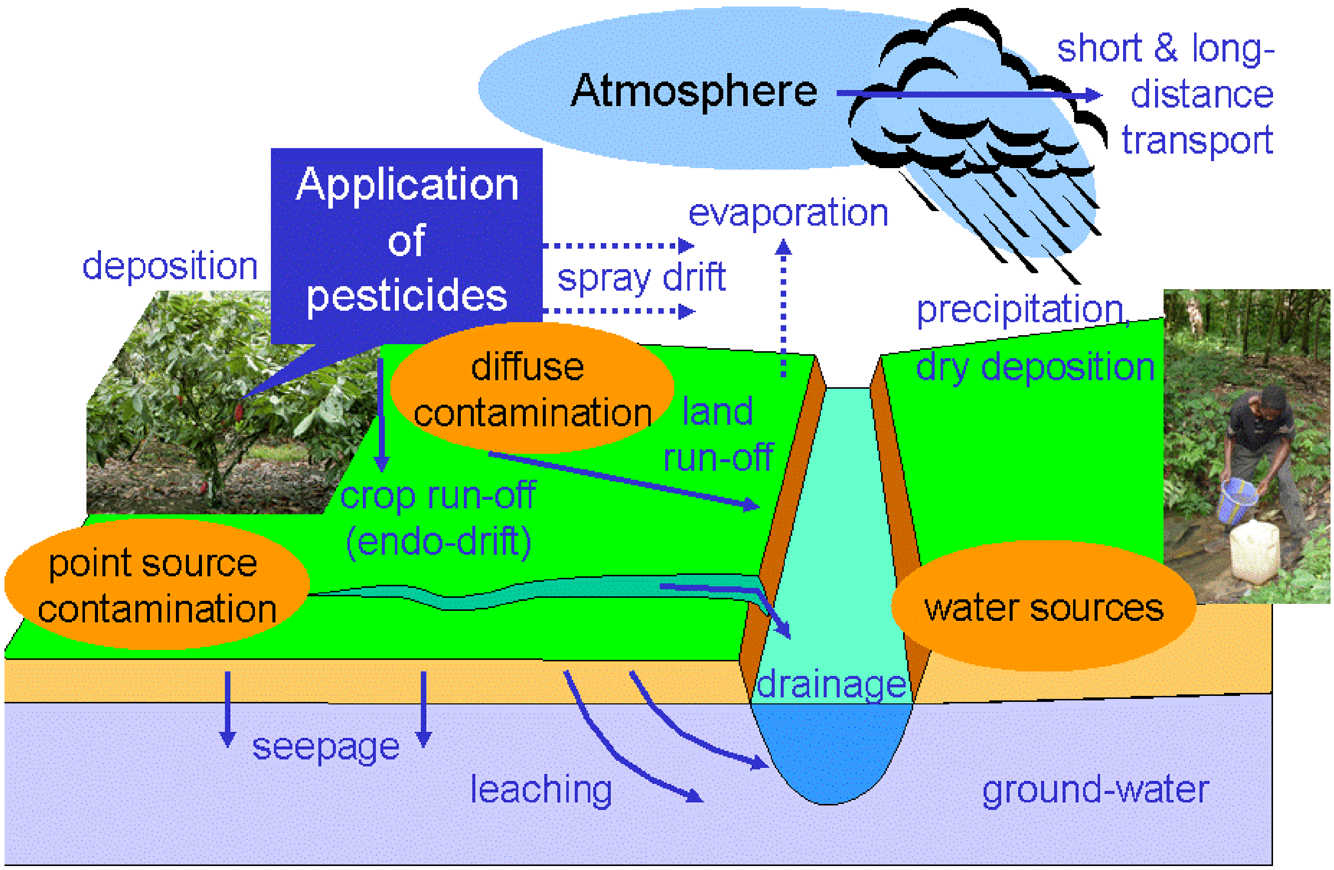

Figure 1.2 Environmental contamination caused by pesticides

One of the most popular methods of pesticide application is aerial spraying or crop dusting. This is a methods where the pesticides are administered from an aircraft, by spraying over the general area of the farm. It is one of the most common in large scale commercial agriculture, as it saves time, is easier to do, and requires little human labor. Another method is the use of air blast sprayers, which use wind power to blow pesticide droplets across a general area of crops. This is usually using in vineyards and orchards as the aerial spray method would only reach the top cover of the vegetation. The alternative to these approaches would be to have groups of laborers move across the farm area and apply the pesticides to the crops individually. This would require more human labor, time, effort and cost. These methods of application are also preferred because detection of pests on these large farm lands can be very difficult, and most times, the pests are detected when it is already too late and the pests have reproduced beyond control.

This has created a problem where the most efficient ways to kill pests and reduce crop loss, consequently boosting food security also causes damage to the health of the workers and the population, as well as to the environment.

1.2 Aim of the Thesis

This thesis is intended to propose a solution to a two fold problem. First of all, to help develop a method of pest management that is sustainable, and to make sure that pesticides are used strategically and only when absolutely necessary. It would also ensure that when they are used, the most value is gotten from them.

In these thesis, we theorize that if we can ensure early detection of pests before they reproduce and get out of control, we can employ more sustainable methods of pest control, such as using of traps, or target the use of the pesticides to only the affected areas of the farmland. In an analysis of pest control measures, it was estimated that early detection of pests could reduce the use of pesticides to as low as 8% (Galphat et al., 2019). In this thesis, I propose a machine learning model for detecting insect pest on the field. It would be trained on images with actual vegetation backgrounds as some of these insects are adapted with green coloration or camouflaging capabilities to make them difficult to identify on the field.

This project would constitute the detection aspect of a number of integrated pest management systems. It could be connected to a trap which would be activated when an insect pest is detected or necessary agents or workers could be notified accordingly, so that they can take the necessary preventive measures. This project would focus on insect detection with deep learning, using the Tensor Flow python machine learning library. The system would detect the pests and set a bounding box around them.

1.3 Importance of the Thesis

Pest outbreaks are a very dangerous challenge to agriculture that has the potential of destabilizing the way of life of small and large scale farmers as well as entire economies of countries that are dependent on certain crops. An example is the recent outbreak of pink boll worms affecting the cotton production of Maharashtra, India. This has had Economic implications on India, which is currently the biggest cotton producer in the world. The Food and Agriculture Organization of the United Nations (FAO) has also stated that due to a number of factors such as globalization, and trade, among others, pest attacks can now more easily get out of control, even reaching epidemic levels.

On the other hand, the most popular solution to the pest problem, pesticides, has had very adverse effects on the environment and on human health. In figure 1.2, we see how environmental contamination can be caused by the use of pesticides. In some cases, they get carried in the atmosphere over short to long distances and can settle in places where their presence is dangerous. In some cases, they seep into the ground, go through the soil and get mixed up with the ground water. As most of these pesticides are not biodegradable, they maintain their harmful chemical composition during the seepage process. In some other cases, they get carried with run off water during erosion and get into water bodies. Pesticides are now quite notorious for poisoning water bodies and the population who depend on it, as well as posing a danger to the wildlife in these water bodies and affecting the livelihood of people who depend on fishing in such areas.

1.4 Limitations of the Study

An initial challenge for this work was getting a data viable data set for the development of the machine learning model. Initial searches only turned up pests for specific crops such as rice. Fortunately, I was able to find a dataset of 4,449 images spanning 5 classes. This is the dataset used in this work.

Also, due to limited computation power at my disposal, I could not use the entire 4,449 images available in the dataset. There was also the concern of over fitting in my model. For these reasons, I had to select 50 images that I believe would best emulate the real life conditions on farmlands.

I also was not able to actually test the system in a real life situation on farmlands. For this reason, I made sure that my selections from the data set closely resembled real life situations. This was a very important problem to solve, because most of these insect pests are genetically equipped to blend in with their environment, with some having the same color as the surrounding vegetation like shown in Figure 1.3, or even having the textures of their anatomy look exactly like the surrounding vegetation.

Figure 1.3 An insect pest with coloration that blends in with its surrounding environment

1.5 Overview of the Thesis

Having defined my aim and highlighted the importance of this work, I would be proceeding with a literature review in the second chapter where I would discuss already existing work on the topic. I would also be discussing already existing methods of insect detection, discussing the techniques used in them and also pointing out the limitations to these approaches.

In the third chapter, I would be discussing the machine learning approach of deep learning. I would give a brief introduction into what deep learning entails and explain why I chose it as the best approach to solve the problem.

In the fourth chapter, I would discuss my design of the system and the software tools I employed in my development process. I would give explanations for the software tools and explain why I chose these tools.

In the fifth chapter, I would explain my development process and explain what I did in each step. I would also, also explain the problems I encountered and how I solved these problems. This chapter would serve as a walk through of my development process.

In the sixth chapter, I would be discussing my results and discussing what these results mean. I would also be comparing this with some already existing systems and discussing how they measure up.

Finally, in chapter 7 I would be drawing and discussing my conclusions from the study. I would discuss what I have learnt and how this work could help in real life situations. I would also be discussing some improvements that could be done to make the system more efficient and useful.

CHAPTER 2

LITERATURE REVIEW

As discussed in the previous chapter, pests are the biggest cause of crop loss in the world. Other challenges such a drought and diseases have been easier to solve. Improved irrigation methods have helped farmers to even grow crops in dry seasons. Genetic modification has also helped in making disease resistant crops. In the case of pests, the most used solution to this problem is pesticides. In recent times, the dangers of indiscriminate use of pesticides has become more obvious. Also, with the growth of commercial agriculture, the use of these pesticides has grown rapidly, with some farms using hundreds of liters of pesticides if not thousands.

There are different kinds of pests, and in some cases, farmers have to take into consideration more than one pest family.

2.1 Insect Pests

This is the most popular pest class as they form the majority of what are generally referred to as pests. They are categorized into 3 groups mainly (Schellman, 2015).

- Suckers: These types of insect suck the sap from the plants, drying them up and in some cases spreading diseases. They usually leave behind a sticky residue on the plants and sometimes, ants that feed on these residue might also be present. Examples of these pests are Aphids and White flies.

Figure 2.1 An Aphid sucking sap from a leaf

- Borers: These types of insects bore holes into the twigs and stems of the plant damaging the plants and most times killing them. They usually lay eggs in the holes they bore. Examples of these insects are Beetles and Sawflies.

Figure 2.2 A Sawfly

- Chewers: These are types of insects that simply chew off parts of leaves or stems or damage entire plants. Examples of chewers are Caterpillars and Grasshoppers.

Figure 2.3 Caterpillars causing damage to a plants leaf

2.2 Bird Pests

Bird pests generally refer to birds that cause damage to agricultural produce, contaminate foodstuff, or transmit diseases. Species of bird pests include Pigeons, Crows, Starlings, etc

Figure 2.4 Bird feeding on grapes in a vineyard

Some methods used to manage bed pests include scare tactics to deter them such as man shaped tubes and hawk shaped kites (Steensma et al., 2016), and other methods such as the use of avicides. Avicides are substances that kill, repel , or reduce the rate of reproduction of birds. Examples of avicides are Avitrol and Strychnine.

2.3 Pest Control

The need to maintain and even increase agricultural yield has made it very important to put in place pest control methods. Taking into consideration the dependence of nations economies and the livelihood of farmers on agriculture, there have been even desperate move to handle this problem. As a result, governments and agencies often have to regulate these measure adopted by the farmers. The easiest solution to this problem, saving time, labor effort and cost to the farmers, especially in large scale commercial farming is the use of insecticides. However, the adverse effects of insecticides on the environment, workers health and the health of the surrounding population has become more clear in recent years. As a result, new methods that are sustainable and do not cause as much damage are very necessary to get the best results at the least possible cost, and years of research has come up with some findings to make this possible.

2.4 Sustainable Pest Control

Several methods of pest control have been as a result of research into pest control in agriculture. In this section, I would discuss the main methodologies used globally.

2.4.1 Integrated Pest Management

Integrated pest management is a concept that was officially put forward by Stern et al., in 1959, after experiments with the Spotted Alfalfa Aphid in California, although it is believed to have already been practiced long before, in the United States and in Peru (Soberón et al., 2016). Integrated Pest Management essentially refers to a collection of pest control measures to reduce the loss of produce caused by pests. The measures employed in this case could include the introduction of natural predators, like in the case of bird abatement falconry, where birds of prey, such as a falcon are trained to hunt and kill bird pest within the area of the farm. Another method could be to use sticky traps to trap insects. In some cases, special methods of cultivation could be employed to reduce the effects of pests on crop yield.

The methods to be employed in cases of integrated pest management are usually preceded by research and analysis. This research could be to study the effect of the pests on the crop yield at the time, to determine if the cost of pest control is greater than the cost of damaged crops, or to measure the environmental or health impact of their use of pesticides. One of such methods was created by Cornell University's College of Agriculture and Life Sciences, where a parameter known as EIQ (Environmental Impact Quotient) is used to measure the effects of the pesticides to be used on the environment and health of the surrounding population (Cornell University, 2014). The EIQ parameter was first introduced by Kovach, et al. In 1992 as a way to help farmers analyze their pesticides based on its content and active agents and make informed decisions on their usage.

2.4.2 GMO Crops

GMO (Genetically Modified Organisms) crops are crops that have been genetically modified. Their DNA has been modified or altered to create some form of resistance or to make them unpalatable to the pests. In some cases even, the crops are modified to make them produce their own pesticides that poison and kill pests. Cotton and Maize are two major successes of the application of genetic engineering to pest control. Most of the corn grown in the United States as of now is genetically modified.

While GMO crops have been a major solution to the pest problem, researchers are still divided on the topic. There is a groups of researchers and scientists who believe that GMO crops are the solution to plants diseases and pests, as well as a way to create better improved versions of crops and foods, consequently increasing food security. There is also the group of researchers and scientists who believe that GMO foods could be a major risk to the environment and food security. There is the belief that GMO foods could also lead to the development of antibiotic resistant diseases and super pests that would adapt to become immune to the dangers posed by these GMO crops. An example is the Diamond back moth, or cabbage moth. It is a very destructive pest originating in Europe, but now spread to southeast Asia, New Zealand, Australia, and America. It has now developed resistance to some pesticides, and even survives the cold temperatures of winter (Dann, 2017).

2.4.3 Precision Agriculture

Precision agriculture involves complex technological input for analysis and research to make well informed and very specific decisions. These decisions are designed to increase value while reducing cost. It consists of smart farming techniques to gather data from the field in real-time or near real-time, process the data and make specific decisions.

In this area, Machine learning has become very handy. It has been used for other aspects of the cultivation process such as fruit detection for automatic harvesting and fruit sorting like with Amazon Fresh (Staff, 2019), analysis of soil fertility, differentiation between weed and crops based on their color properties (Zwiggelaar, 1998), detection of pests from aerial imagery (Carroll et al., 2008), weed control (Dimililer & Kiani, 2017), among many others. Precision agriculture ensures that resources are only spent when necessary, and that right amounts are used so as to ensure the best value is gotten and that there are no diminishing returns. Pest detection is a major way that precision agriculture can be used to reduce the use of pesticides and maintain crop yield. This would also preserve the environment, avoid contamination of water bodies and protect the health of the surrounding population.

The work in this thesis involves using machine learning's object detection ability to find pests on the field. In this work, I would be using Googles Tensor flow framework because it gives access to already existing machine learning modules such as the VGG16 module that would be used within this thesis. Furthermore, it is open source which means that it sees a lot of development and contribution from many developers worldwide making it one of the most sophisticated machine learning libraries available.

2.5 Pest Detection

In line with the idea of precision agriculture, pest detection serves as a way to take advantages of the opportunities and efficiency provided by technology to reduce the use of pesticides to a tolerable minimum. As a study showed, Early pest detection could reduce the amount of pesticides needed by 92% (Galphat et al., 2019). Applications already exist that use specific approaches, such as back propagation (Dimililer & Zarrouk, 2017) for insect detection.

2.5.1 Pest Detection Approaches

The approaches used in pest detection could either involve the detection and elimination of the pests or just the detection as a subsystem of the general approach to pest control. The detection system could also be fully automated or be a part of a broader system of pest control.

A common approach is the use of cameras, maybe on ground attached to a rover to traverse the farmland, or attached to a drone or aircraft (Carroll et al., 2008) to give aerial footage of the farm land. Image enhancement techniques can then be used to process the image data. Some image enhancement techniques such as the application of a median filter.

CHAPTER 3

DEEP LEARNING

Deep learning is a branch of machine learning that uses artificial neural networks to solve complex problems. These could include tasks like object detection, NLP (Natural Language Processing), genomics, among others. Artificial neural networks are computational systems that model the way the human brain works. Figure 3.1 and figure 3.2 show the biological neural unit and the artificial neural unit respectively. This ideology was first experimented in 1943 by a Neurophysiologist named Warren McCulloch and a mathematician named Walter Pitts. In their experiments, they developed an electrical model of a neural network to model the functions of the neurons of a human brain. More work was later done in this line by Donald Hebb in 1949 and he defined most of the popular concepts of Neural Networks in his book titled *The Organization of Behavior*. Deep learning takes this ideology of neural networks and uses it as a building block to make a more complex and sophistoicated model that can be used to process large amounts of data.

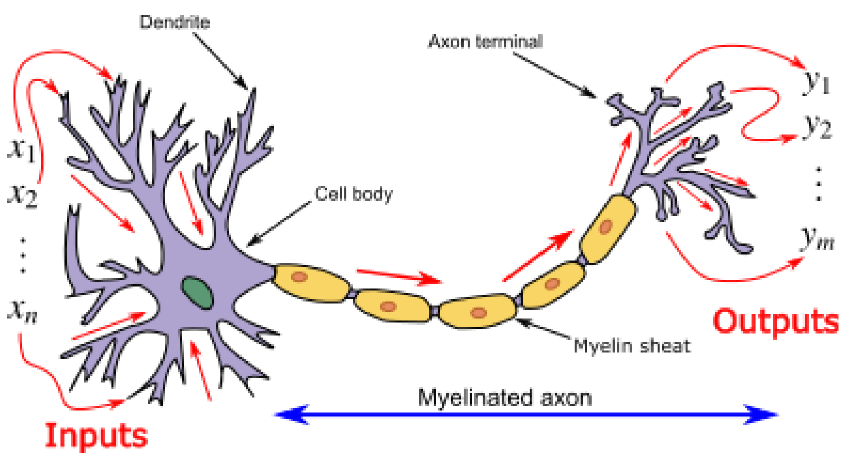

Figure 3.1 Biological neural unit (neuron)

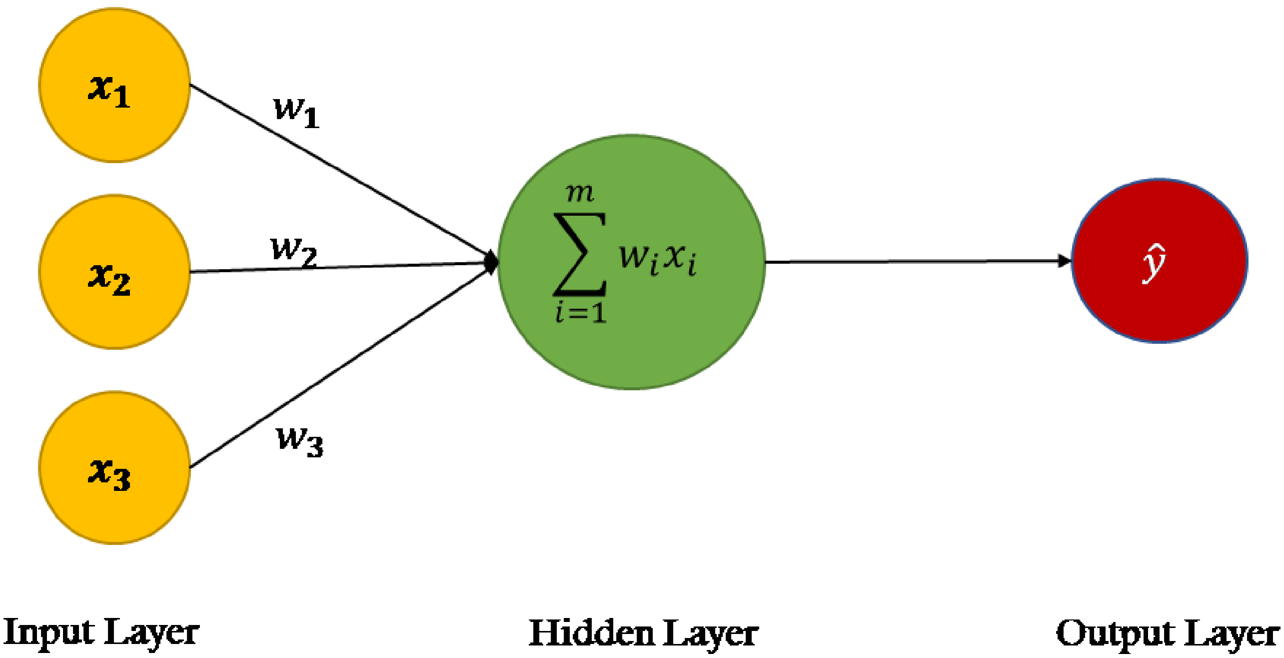

Figure 3.2 Model of the artificial neural unit (Node)

A major distinguishing factor for deep learning is its lack of feature extraction (Lecun et al., 2015). In ordinary machine learning applications, the data that the model is trained on usually has to go through a pre-processing process called feature extraction, where the relevant data to the model is first extracted before training can begin. This feature extraction process normally involves selecting what parts of the data are necessary, and deciding on how the data is to be represented. This allows the data to be trained easily on a model with low computational complexity. It also avoids the curse of dimensionality.

In deep learning, the model is capable of feature learning or representation learning. This is a concept where the model is able to learn which features are necessary and to structure them in a heirarchy based on the relevance to the task. This makes it possible for the model to map the raw input directly to the output and be able to solve much complex problems with more dimensionality to the input. This eliminates the chances of the curse of dimensionality in deep learning. This also allows deep learning to be able tro work with almost any kind of data.

3.1 The Curse of Dimensionality

The curse of dimensionality is a situation where the dimensions of the training data are too much to be handled by the model. This makes the model more prone to error. This is more concisely described by Hughes, 1968, where it is stated that with the same number of fixed samples in a data set, the accuracy of a classifier or regression model increases as the number of dimensions increases up until a certain level of dimensionality is reached, and starts to fall if the dimensionality is increased any further.

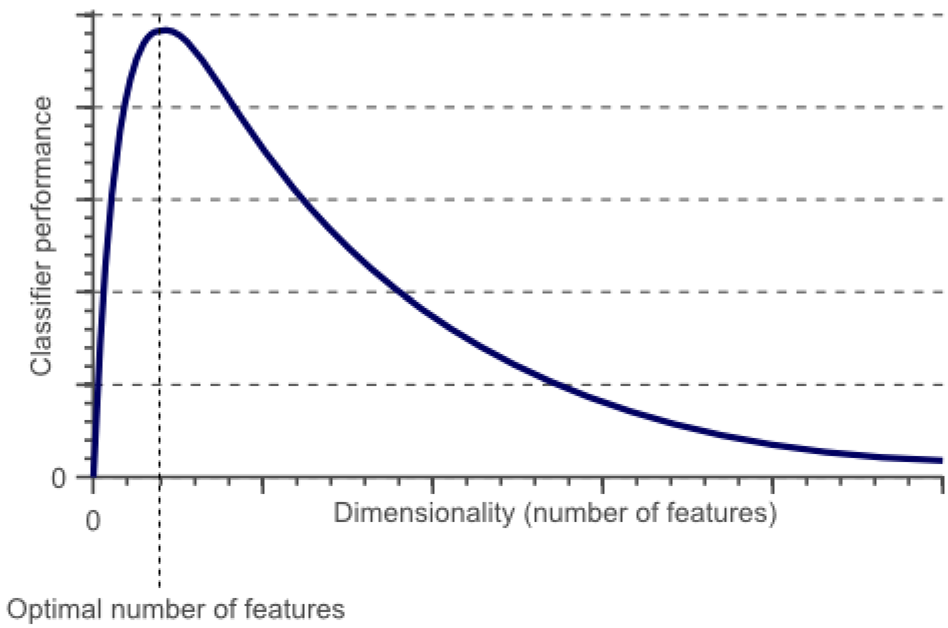

Figure 3.3 Graphical representation of the Curse of Dimensionality

This is also sometimes referred to as the Hughes phenomenon for the contribution of Gordon Hughes to the description of the concept (Hughes, 1968).

3.2 Deep Learning Approaches

In deep learning applications different types of algorithms or approaches are used to solve different kinds of tasks. There is no perfect one-size-fits all approach, so its important to understand the approaches and see how they apply to the tasks to be carried out (Biswal, 2020). I would be giving brief introductions into some of the most popular algorithms that have been applied for deep learning below.

3.2.1 Convolutional Neural Networks (CNN)

Convolutional Neural Networks are neural networks with an input layer, an output layer and multiple hidden layers. The first convolutional neural network, the LeNet was created by Yann LeCun and was published in his 1989 paper. The LeNet-5 as it was called, was used for recognition of handwritten zipcodes. It consisted of 3 convolutional layers stacked alternatively with 2 pooling layers and finished off with a fully connected layer. The imput data was minimally preprocessed. This was the earliest development of a convolutional neural network.

The average convolutional neural network consists of one input layer, and output layer, and hidden layers. The hidden layers can be any of the following types:

- **Convolutional Layer:** This layer serves the purpose of feature extraction. These layers, known as convolution kernels are essentially matrices that represent specific features of the input. They are created by convolving the said input with the specified activation functions. The most popular activation function used in image classification and recognition tasks is *ReLu*. ReLu is a simple linear activation function that outputs the input if it is positive and outputs zero otherwise. Having more convolution layers increases accuracy, because more features are extracted, but this also increases the computational complexity (Brownlee, 2019).

- **Pooling Layer:** The pooling layer is a layer that naturally follows a convolution layer. It downsizes the feature map, taking the activated features in the previous convolution layer as input.

- **Fully Connected Layer:** The fully connected layer takes as its input the flattened matrix from the previous layer, which must be a pooling layer. This flattening entails taking the 2 dimensinal matrix and converting it to a linear series.

The output layer is fed its input from the fully connected layer and has its own activation function. The most popular activation function used in image classification and object detection tasks is the Softmax activation function. It translates its input, whether zero or a positive or negative value into a result between 1 and 0, and puts this result forth as a probability to show levels of conviction on the output.

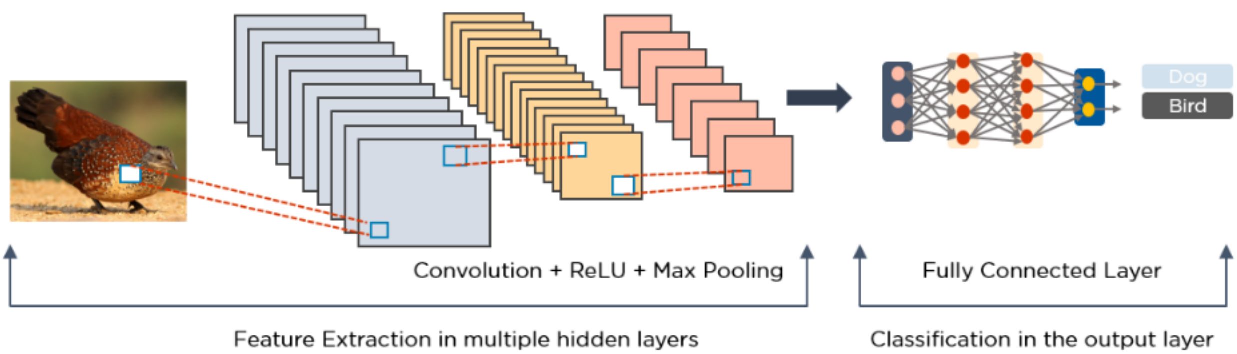

Figure 3.4 Architecture of a convolutional neural network

3.2.2 Recurrent Neural Networks (RNN)

Recurrent neural networks have the ability to take input in the form of a series unlike normal neural networks which can only take inputs of a fixed size. This gives it an advantage over regular neural networks in cases where the input is served in a continuous stream over time. Recurrent neural networks are able to learn from new input that comes in in the series and can adjust its past results based on the new learned features, as all the input in the series are related in some way. In recurrent neural networks, the results of the output is not only affected by the weights of the connections between nodes, but also by a state vector. This state vector influences the input and serves the purpose of providing some form of context for the previous outputs. This allows the network model to learn more and can sometimes cause similar inputs to give different outputs based on the input series that precedes them.

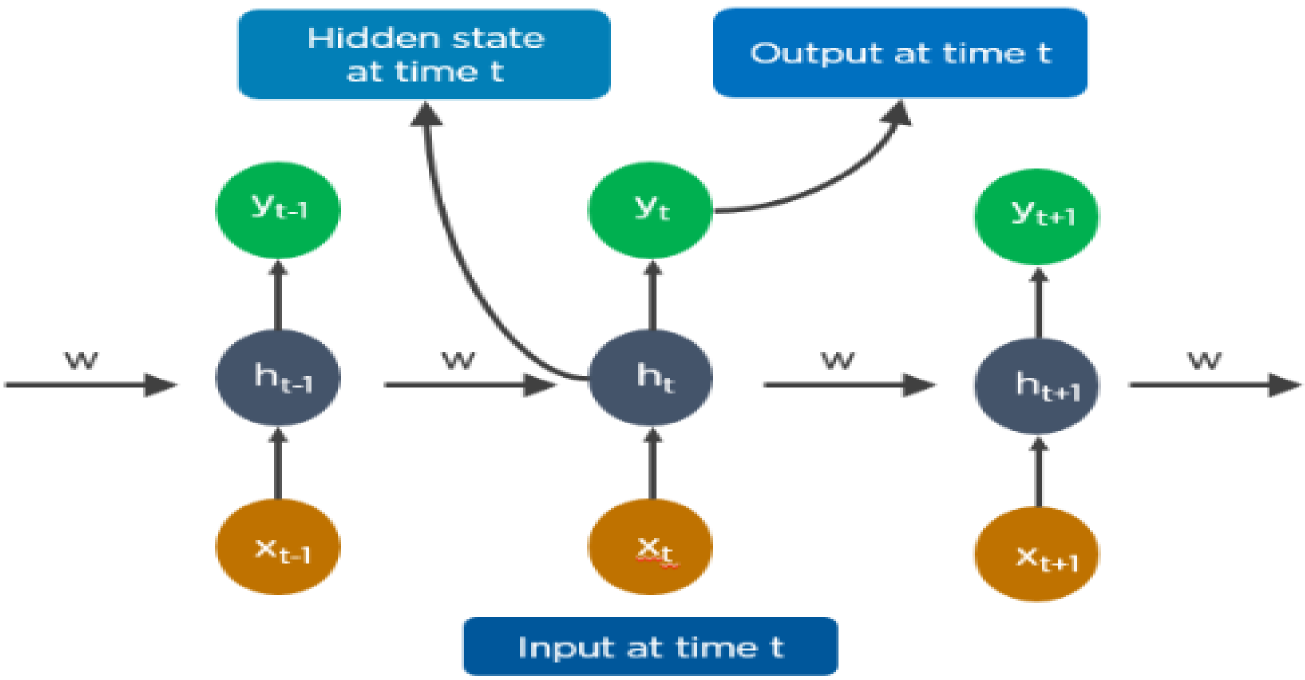

Figure 3.5 A recurrent neural network showing how the hidden layers state vector of a previous connection can affect the output of the next input in the series

Recurrent neural networks can take in input series of any length without having to increase the size of the model. Recurrent neural networks are mostly used in Natural Language Processing (NLP), time-series analysis, machine translation, among others. Recurrent neural networks are used by google in their search engine to auto complete search terms.

3.2.3 Generative Adversarial Networks (GAN)

Generative adversarial networks are networks that generate sample data that is similar to the data that is entered as input for training. They can been used for image enhancement, like in cases where low resolution images and textures are improved to high resolution images. They have also been used to generate samples for simulations in cases of research where enough data is not available for study like in astronomical research (Schawinski et al., 2017) among others.

Generative Adversarial Networks consist of a generator, which creates new data with features similar to those in the input data, and a discriminator that learns the difference from the newly generated data and the real data. The output of a Generative Adversarial Network is a binary definition of if the data is the real data entered or a fake generated data. The objective of the network is there fore to improve the generative and discriminating aspects of the network with each iteration till the discriminator is unable to differentiate between the generated data and the real data. This by essence increases the generative power of the network.

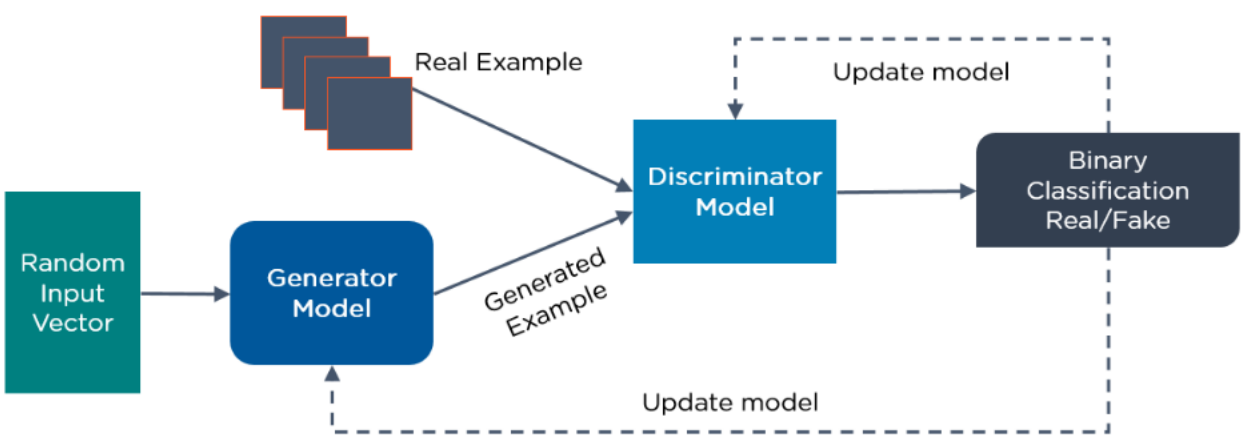

Figure 3.6 Structure of a Generative adversarial network

3.2.4 Multi Layer Perceptrons

Multi Layer Perceptrons is an improvement on the popular binary classifier used in supervised learning, the Perceptron. Multi layer perceptrons consist of one input layer, one fully connected output layer, and multiple hidden layers.

Multi layer perceptrons take the input through the input layer, then feed forward to the hidden layers, processing with the weights and activation functions and firing the nodes accordingly. Multi layer perceptrons simply map inputs to outputs. Multiple layers can bee added in the hidden layer to make the network deeper. This is the most basic application of the deep learning technology.

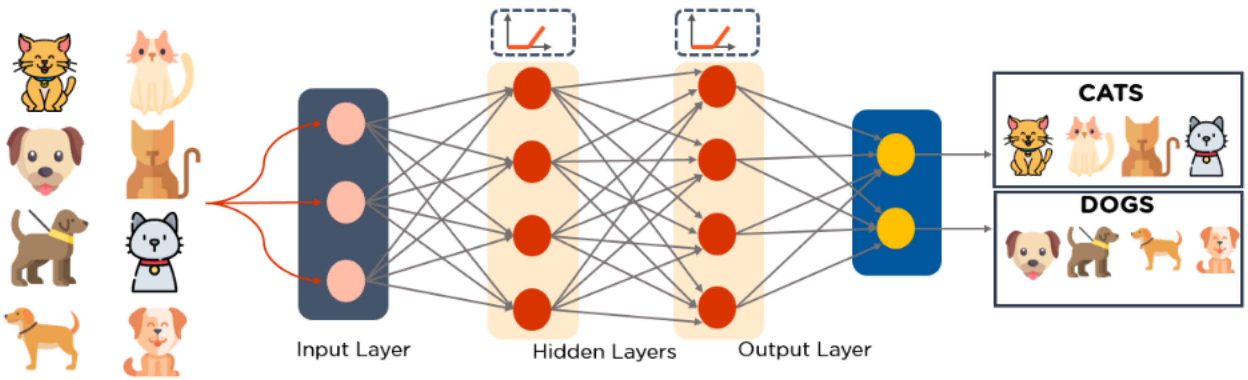

Figure 3.7 An application of multi layer perceptron to classify images into classes of cats and dogs using the ReLu activation function

Other algorithms used in deep learning applications include Self Organizing Maps (SOM), Radial Basis Function Networks (RBFN), Long Short Term Memory Networks (LSTM), Deep Belief Networks (DBN), Restricted Boltzmann Machines (RBM), and Auto encoders.

CHAPTER 4

SYSTEM DESIGN

For most classification or object detection problems the go to approach has been convolutional neural networks. This is because of the complex nature of its computations and its similarity to the way vision works in humans. Its multiple layers of convolution and pooling allow convolving of multiple features extracted from large amounts of images. This process can be quite laborious, time consuming and require high computation power. They require large amounts of pictures to attain high levels of accuracy and so can be challenging to use in cases where datasets are not available or are difficult to acquire.

4.1 Design and Development Approach

For the development of this system, I wanted to take advantage of the power and accuracy provided by convolutional neural networks but I was limited by way of computational power and access to extensive datasets. Some of the most sophisticated CNN models were trained for days with multiple graphic processing units on millions of data samples. With this, for some applications accuracy levels that surpassed even human capabilities were achieved. For this reason, I decided to use an approach known as transfer learning.

4.1.1 Transfer Learning

Transfer learning is an approach to machine learning where knowledge gained from training a model for a given task is stored and reapplied or improved on and then used in another problem. This way, the training process does not start from scratch, and a higher performance is achieved at a faster rate.

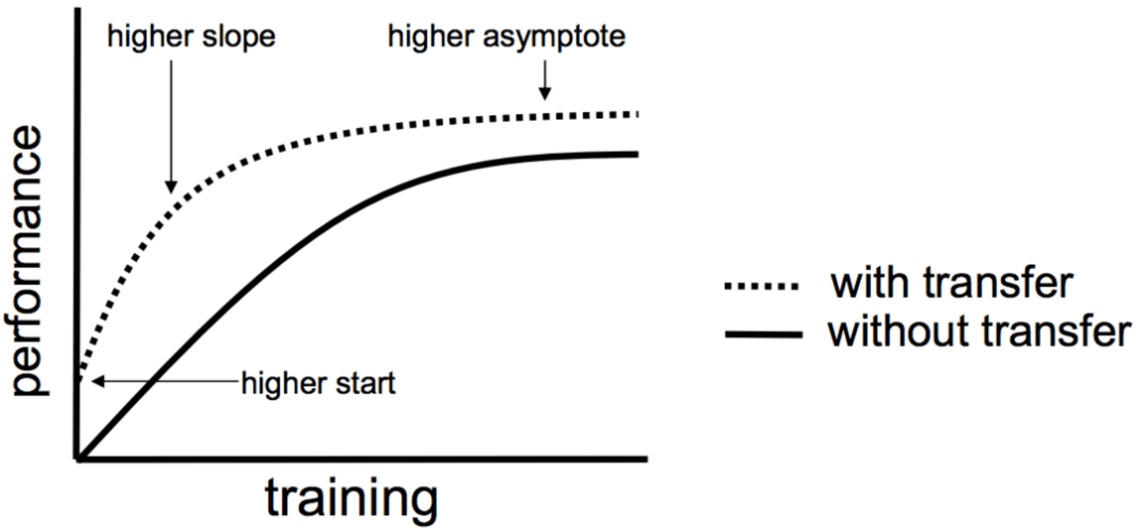

Figure 4.1 Illustration of how transfer learning boosts the performance of a model

With this approach, the already pre-trained model serves as a foundation on which improvement is made. For this work, I used transfer learning approach with VGG16 for feature extraction and SVM for classification. This way, I hope to achieve accuracy levels superior to the regular VGG16 model.

4.1.2 VGG16

VGG16 (Visual Geometry Group 16) is a convolutional neural network designed by Karen Simonyan and Andrew Zisserman in 2014. It was first featured in their paper titled "Very Deep Convolutional Netwroks for Large-Scale Image Recognition". It was entered for the ILSVRC challenge in 2014 and came out as one of the best performing models. It was second position for the classification task, with a top-5 accuracy of 92.7% and a top-

1 accuracy of 71.3% on ImageNet which is a dataset of 14,197,122 images in 1000 classes. It also came first in the localization task with a localization error of 25.32%.

The VGG16 network contains 16 layers with about 134 million parameters. It has an input layer with a fixed size of 224 x 224 x 3 representing an RGB image of size 224 x 224, and convolution layers with kernel sizes of 3 x 3 (Hassan, 2021). Figure 4.2 shows the summary of the structure of the VGG16 with five blocks of convolution layers and max pooling layers.

Layer (type)	Output Shape	Param #
conv2d_1 (Conv2D)	(None, 224, 224, 64)	1792
conv2d_2 (Conv2D)	(None, 224, 224, 64)	36928
max_pooling2d_1 (MaxPooling2	(None, 112, 112, 64)	0
conv2d_3 (Conv2D)	(None, 112, 112, 128)	73856
conv2d_4 (Conv2D)	(None, 112, 112, 128)	147584
max_pooling2d_2 (MaxPooling2	(None, 56, 56, 128)	0
conv2d_5 (Conv2D)	(None, 56, 56, 256)	295168
conv2d_6 (Conv2D)	(None, 56, 56, 256)	590080
conv2d_7 (Conv2D)	(None, 56, 56, 256)	590080
max_pooling2d_3 (MaxPooling2	(None, 28, 28, 256)	0
conv2d_8 (Conv2D)	(None, 28, 28, 512)	1180160
conv2d_9 (Conv2D)	(None, 28, 28, 512)	2359808
conv2d_10 (Conv2D)	(None, 28, 28, 512)	2359808
max_pooling2d_4 (MaxPooling2	(None, 14, 14, 512)	0
conv2d_11 (Conv2D)	(None, 14, 14, 512)	2359808
conv2d_12 (Conv2D)	(None, 14, 14, 512)	2359808
conv2d_13 (Conv2D)	(None, 14, 14, 512)	2359808
max_pooling2d_5 (MaxPooling2	(None, 7, 7, 512)	0
flatten_1 (Flatten)	(None, 25088)	0
dense_1 (Dense)	(None, 4096)	102764544
dropout_1 (Dropout)	(None, 4096)	0
dense_2 (Dense)	(None, 4096)	16781312
dropout_2 (Dropout)	(None, 4096)	0
dense_3 (Dense)	(None, 2)	8194

Total params: 134,268,738
Trainable params: 134,268,738
Non-trainable params: 0

Figure 4.2 Architecture of the VGG16 CNN

The VGG19 is only a bit improvement on the VGG16 with 19 layers as opposed to the 16 layers of the VGG16. Although the VGG19 has a top-5 accuracy of about 93%, it has the same top-1 accuracy of 71.3% as VGG16 and requires more memory than the VGG16. This makes the VGG16 to still be the prudent choice between the two considering the cost to performance ratio. This is why I have chosen the VGG16 for this work.

In this work, the VGG16 convolution neural network is used for feature extraction, and then the features are used as input for the support vector machine which would perform the classification task.

4.2 Software Tools

In this work, a few software development tools were used to help with the process. Firstly, the programming language used in this work was python programming language, because of its ease of use and the availability of libraries, modules and tools that help make thinsg easier in implementation. In this section, I would be giving an exposition into the main software development tools I used in this work and how they are applied in machine learning applications.

4.2.1 TensorFlow

TensorFlow is an open source python library for machine learning applications. It can be applied to many of the machine learning and artificial intelligence tasks, but it has a focus on the development of neural networks. It has high level APIs that allow quick, easy, and modular development and debugging. It also contains a number of pretrained models, such as the VGG16 which is used in this work. This allows for quick and easy integration.

The APIs available in TensorFlow are set up in a modular way that allows quick development and testing. The APIs also allow different levels of accessibility so that the models can be restructured and set up to any specification that the developer wants. This allows fast prototyping and control of the architecture of the model and has made it a go to choice for developers for small projects and production level applications alike. Figure 4.3 shows the API levels of the TensorFlow platform.

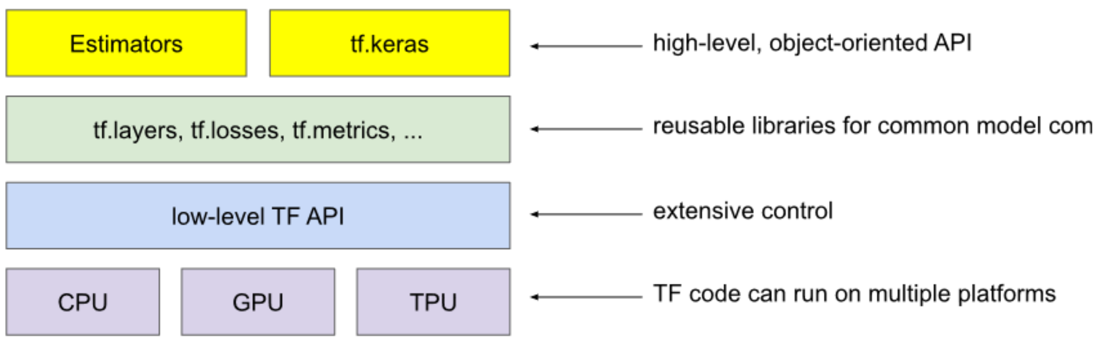

Figure 4.3 The API levels of the TensorFlow platform

4.2.2 Keras

Keras is one of the high level APIs of the TensorFlow platform and is the easiest and most modular level to interface with. It was preceded by the Estimator which was capable of four major actions namely evaluation, training, prediction and exporting of a model.

Keras is easily extendable and has a large array of modules and libraries that makes it easy to use and provides a number of powerful tools that would aid in the easy development of powerful neural network models.

4.2.3 Matplotlib

Matplotlib is a python library that provides graphing and representational tools to be used in machine learning and data science applications. Matplotlib is used to represent data graphically as scatter plots, 3D plots and line plots. It can also be easily integrated into applications in a modular way due to its high level object oriented API.

4.2.4 Scikit-learn

Scikit-learn is an open source python machine learning library that is used for machine learning applications and predictive data analysis. It can be used for classification tasks, regression tasks, clustering, dimensionality reduction, model selection, and preprocessing. It features algorithms that can be used for the aforementioned tasks. It is built on NumPy, SciPy and matplotlib.

CHAPTER 5

DEVELOPMENT PROCESS

Considering the computationally intensive nature of the work, I had to convert my python code to a python notebook so that I could run it on Google colab and take advantage of the virtual computation it provides. With Google colab, I can run code on a virtual computer and use its CPU and storage space online. This way, the computational and memory load is taken off my computer and is run online making my code to still run fast as it would if I had a more sophisticated computer at my disposal.

5.1 Obtaining the Dataset

The dataset used in this project was obtained from Kaggle. It contained 4,449 images over 5 classes namely Butterfly, Dragonfly, Grasshopper, Ladybird, and Mosquito. For the sake of relevance to the application and to downsize so that the model could train much quickly, I selected about 25 images each from the Butterfly and Dragonfly classes to make a total of 50 images.

I downloaded the dataset from Kaggle, and selected the images I needed into folders named for the classes that they belonged to and put these folders in a folder named "images".

5.2 Importing the Modules and Libraries

In this step, I imported the libraries and modules to be used in the development process.

Numpy is used to handle arrays and allow mathematical and mapping operations to be performed on the arrays. Considering the fact that CNNs handle their input as arrays and have filter kernels as arrays, the numpy library is used to handle these arrays.

sklearn.svm is used to load the support vector machine algorithm from sklearn so that it can be used after the feature extraction for the classification task.

Sklearn.metrics contains the *accuracy_score* module to be used to compute the accuracy of the classification process of the model.

Sklearn.model_selection library contains the *StratifiedKFold* module which is used to heklp split the dataset for training and testing at a fixed proportion

Sequential and *Model* are both imported from *keras.models* are used to build the VGG16 model and help make any adjustments we may need.

From *keras.preprocessing.image*, the *ImageDataGenerator* module is imported to be used for data augmentation such as shifting, zooming, flipping, and so on.

The *GlobalAveragePooling2D* layer is imported from the *keras.layers* library to be used in in the VGG16 CNN in place of the flatten layer.

Finally, from *keras.applications*, we import the pretrained VGG16 model.

5.3 Saving the Extracted Features

Here, the parameters are given as arguments for the function and features are extracted after every Global average pooling layer for which the max pooling layers have been switched out. The model is defined as VGG16 and the weights are set to those for the training on the ImageNet dataset. All extracted features are saved in a newly created folder called “features”.

Still within the *save_all_features* function, the *ImageDataGenerator* is used to rescale the image. The saved features are written back as binary files with the .npy NumPy file type and saved in the features folder.

5.4 Running the SVM with the Extracted Features

The next step was to define the Support vector machine and run it on the extracted features, get a prediction, and calculate the accuracy with each iteration.

5.5 Loading the Features and Evaluation

After the function to run the SVM was defined, a final function called evaluate was defined to load the features first and feed them to the *kfoldSVM_on_features* function.

CHAPTER 6

RESULTS AND DISCUSSIONS

After the functions have all been defined, the evaluate function is called with the features and input size as arguments.

The process runs smoothly, and at the end of the evaluation, an accuracy of 96% is obtained.

```
fused features across all conv blocks
without normalization
Accuracy score averaged across 10 kfolds 94.00% (+/- 2.00%)
with square root normalization
Accuracy score averaged across 10 kfolds 96.00% (+/- 4.00%)
```

Figure 6.1 The accuracy obtained after the evaluation

6.1 Comparison to the Regular VGG16 Model

The results for my implementation of transfer learning in comparison to the VGG16 shows that my implementation was indeed an improvement on the already existing model for the specific task of insect detection. Where the VGG16 model had a top-1 accuracy of 71.3%, my implementation of transfer learning of the VGG16 for feature extraction coupled with SVM implementation for classification had an accuracy of 96%

6.2 Limitations of the Study

There were a lot of challenges in the course of this study, mostly relating to compatibility issues with the new version of TensorFlow. There was also the initial challenge with finding the dataset. The dataset I was able to obtain from Kaggle also had a few irrelevant images, so I had to go through them to clean them and select the best ones to serve my purpose.

CHAPTER 7

CONCLUSION AND FUTURE WORK

7.1 Conclusion

The results were as expected, based on the ideology of transfer learning. This serves as a way to further simplify the process of developing a machine learning model, and could also help developers easily extend or improve on their already existing models.

Also, the fact that some of these already existing machine learning models have shown expertise that in some cases supercedes that of humans means we could take this pretrained artificial brains and reapply them to other tasks where the advantages provided by machine learning could be well utilized.

In this work, we already see how machine learning could be applied to ensure food security and help protect the economy. Other areas and fields could also benefit from this cross platform capability made possible by transfer learning.

7.2 Future Work

Transfer learning's ideology could be used to also transfer the knowledge base of other well know and sophisticated neural networks and help develope production level systems with much ease. This means that organisations or research facilities with the resources and know-how to develop strong systems like with VGG16 can do this and make them available for others to use in different related applications.

For the field of insect detection, considering the large variety of insect pests that there are, it would be a very welcome improvement to have a larger and possibly regulated dataset created.

In other areas, transfer learning offers the promise of machine learning to a wide range of applications, and because of the cross compatible nature of these models, they can be reapplied to any arbitrary task.

REFERENCES

Bengio, Y. (2009). Learning Deep Architectures for AI. https://doi.org/10.1561/9781601982957

Biswal, A. (2020, October 14). Top 10 Deep Learning Algorithms You Should Know in (2020). *Simplilearn.com. https://www.simplilearn.com/tutorials/deep-learning-tutorial/deep-learning-algorithm.*

Brownlee, J. (2019). Deep Learning for Computer Vision: Image Classification, Object Detection, and Face Recognition in Python. *Machine Learning Mastery.*

Carroll, M. W., Glaser, J. A., Hellmich, R. L., Hunt, T. E., Sappington, T. W., Calvin, D., … Fridgen, J. (2008). Use of Spectral Vegetation Indices Derived from Airborne Hyperspectral Imagery for Detection of European Corn Borer Infestation in Iowa Corn Plots. *Journal of Economic Entomology*, *101*(5), 1614–1623. https://doi.org/10.1093/jee/101.5.1614

Cornell University. (2014). *A Method to Measure the Environmental Impact of Pesticides*. Cornell University College of Agriculture and Life Sciences. https://nysipm.cornell.edu/eiq/.

Dann, L. (2017, November 21). *Insecticide-resistant 'super-pest' now surviving winter*. Farmers Weekly. https://www.fwi.co.uk/arable/crop-management/pests/insecticide-resistant-super-pest-surviving-winter.

Dimililer, K., & Zarrouk, S. (2017). ICSPI: Intelligent Classification System of Pest Insects Based on Image Processing and Neural Arbitration. *Applied Engineering in Agriculture*, *33*(4), 453–460. https://doi.org/10.13031/aea.12161

Dimililer, K., & Kiani, E. (2017). Application of back propagation neural networks on maize plant detection. *Procedia Computer Science*, *120*, 376–381. https://doi.org/10.1016/j.procs.2017.11.253

Estruch, J. J., Carozzi, N. B., Desai, N., Duck, N. B., Warren, G. W., & Koziel, M. G. (1997). Transgenic plants: An emerging approach to pest control. *Nature Biotechnology*, *15*(2), 137-141. doi:10.1038/nbt0297-137

Food and Agriculture Organization of the United Nations (FAO). *Plant pests and diseases.* Plant pests and diseases : FAO in Emergencies.

Galphat, Y., Patange, V. R., Talreja, P., & Singh, S. (2019). Survey and Analysis of Pest Detection in Agricultural Field. Lecture Notes on Data Engineering and Communications Technologies Proceeding of the International Conference on Computer Networks, Big Data and IoT (ICCBI - 2018), 976–983. https://doi.org/10.1007/978-3-030-24643-3_116

Hassan, M. U. (2021, February 24). VGG16 - Convolutional Network for Classification and Detection. https://neurohive.io/en/popular-networks/vgg16/.

Hughes, G. (1968). On the mean accuracy of statistical pattern recognizers. *IEEE Transactions on Information Theory, 14(1),* 55–63. https://doi.org/10.1109/tit.1968.1054102

Kovach, J., Petzoldt, C., Degni, J., & Tette, J. (1992). A Method to Measure the Environmental Impact of Pesticides.

Lecun, Y., Bengio, Y., & Hinton, G. (2015). Deep learning. *Nature, 521(7553),* 436–444. https://doi.org/10.1038/nature14539

LeCun, Y., Boser, B., Denker, J. S., Henderson, D., Howard, R. E., Hubbard, W., & Jackel, L. D. (1989). Backpropagation applied to handwritten zip code recognition. *Neural computation,* 1(4), 541-551.

Lima, M. C. F., Maria Elisa Damascena De Almeida Leandro, Valero, C., Coronel, L. C. P., & Bazzo, C. O. G. (2020). Automatic Detection and Monitoring of Insect Pests—A Review. *Agriculture,* *10*(5), 161. https://doi.org/10.3390/agriculture10050161

Popp, J., Pető, K., & Nagy, J. (2012). Pesticide productivity and food security. A review. *Agronomy for Sustainable Development*, *33*(1), 243–255. https://doi.org/10.1007/s13593-012-0105-x

Schawinski, K., Zhang, C., Zhang, H., Fowler, L., & Santhanam, G. K. (2017). Generative adversarial networks recover features in astrophysical images of galaxies beyond the deconvolution limit. *Monthly Notices of the Royal Astronomical Society: Letters*, 467(1), L110-L114.

Schellman, A. (2015, October 29). *Insect Pests*. Anne of Green Gardens. https://www.anneofgreengardens.com/gardening-topics/plant-problems/insect-pests/.

Soberón, M., Bravo, A., & Blanco, C. A. (2016). Strategies to Reduce Insecticide Use in Agricultural Production. *Reference Module in Food Science*. https://doi.org/10.1016/b978-0-08-100596-5.03063-8

Staff, A. A. (2019, July 30). *Machine Learning: Using Algorithms to Sort Fruit*. UK About Amazon. https://www.aboutamazon.co.uk/innovation/machine-learning-using-algorithms-to-sort-fruit.

Steensma, K., Lindell, C., Leigh, D., Burrows, C., Wieferich, S., & Zwamborn, E. (2016). Bird Damage to Fruit Crops: A Comparison of Several Deterrent Techniques. *Proceedings of the Vertebrate Pest Conference*, *27*. https://doi.org/10.5070/v427110693

Stern, V. M., Smith, R. F., Bosch, R. V. D., & Hagen, K. S. (1959). The integration of chemical and biological control of the spotted alfalfa aphid: The integrated control concept. *Hilgardia*, *29*(2), 81–101. https://doi.org/10.3733/hilg.v29n02p081

Wu, X., Zhan, C., Lai, Y., Cheng, M., & Yang, J. (2019). IP102: A Large-Scale Benchmark Dataset for Insect Pest Recognition. *2019 IEEE/CVF Conference on Computer Vision and Pattern Recognition (CVPR)*. doi:10.1109/cvpr.2019.00899

Zwiggelaar, R. (1998). A review of spectral properties of plants and their potential use for crop/weed discrimination in row-crops. *Crop Protection*, *17*(3), 189–206. https://doi.org/10.1016/s0261-2194(98)00009-x

APPENDICES

APPENDIX 1

Model Structure and Parameters of VGG16

Layer (type)	Output Shape	Param #
conv2d_1 (Conv2D)	(None, 224, 224, 64)	1792
conv2d_2 (Conv2D)	(None, 224, 224, 64)	36928
max_pooling2d_1 (MaxPooling2	(None, 112, 112, 64)	0
conv2d_3 (Conv2D)	(None, 112, 112, 128)	73856
conv2d_4 (Conv2D)	(None, 112, 112, 128)	147584
max_pooling2d_2 (MaxPooling2	(None, 56, 56, 128)	0
conv2d_5 (Conv2D)	(None, 56, 56, 256)	295168
conv2d_6 (Conv2D)	(None, 56, 56, 256)	590080
conv2d_7 (Conv2D)	(None, 56, 56, 256)	590080
max_pooling2d_3 (MaxPooling2	(None, 28, 28, 256)	0
conv2d_8 (Conv2D)	(None, 28, 28, 512)	1180160

```
conv2d_9 (Conv2D)            (None, 28, 28, 512)       2359808
_________________________________________________________________
conv2d_10 (Conv2D)           (None, 28, 28, 512)       2359808
_________________________________________________________________
max_pooling2d_4 (MaxPooling2 (None, 14, 14, 512)       0
_________________________________________________________________
conv2d_11 (Conv2D)           (None, 14, 14, 512)       2359808
_________________________________________________________________
conv2d_12 (Conv2D)           (None, 14, 14, 512)       2359808
_________________________________________________________________
conv2d_13 (Conv2D)           (None, 14, 14, 512)       2359808
_________________________________________________________________
max_pooling2d_5 (MaxPooling2 (None, 7, 7, 512)         0
_________________________________________________________________
flatten_1 (Flatten)          (None, 25088)             0
_________________________________________________________________
dense_1 (Dense)              (None, 4096)              102764544
_________________________________________________________________
dense_2 (Dense)              (None, 4096)              16781312
_________________________________________________________________
dense_3 (Dense)              (None, 2)                 8194
===============================================================
==
Total params: 134,268,738
Trainable params: 134,268,738
Non-trainable params: 0
_________________________________________________________________
```

APPENDIX 2: Ethical Approval Letter

NEAR EAST UNIVERSITY

ETHICAL APPROVAL DOCUMENT

Date:03/06/2021

To the Institute of Graduate Studies

For the thesis project entitled as "Classification of insects using Image processing and Machinelearning", the researchers declare that they did not collect any data from human/animal or any other subjects. Therefore, this project does not need to go through the ethics committee evaluation.

Title: Classification of insects using Image processing and

Machine learning

Name Surname: Assoc. Prof. Dr.Kamil Dimililer

Signature:

Role in the Research Project: Supervisor

APPENDIX 3

Similarity

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