Abstract

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CHAPTER ONE

INTRODUCTION

1 Background Information

The use of computer and computing devices, in the recent decade has seen greater development more than any known time in history. This cuts across all spheres of endeavour. This is seen in the use of different and diverse computer-vision and artificial intelligence based tools in all works of life. According (Ghazal et al., 2024), Vision-based intelligent systems have made way to practically every aspect of modern human life. These systems combine computer vision, artificial intelligence (AI), and machine learning technologies and allow machines to mimic human visual and cognitive abilities to make informed decisions about the task at hand. Computer vision technology is used to process and interpret visual information from the surrounding environment while the artificial intelligence (AI) technologies along with machine learning algorithms are used for recognizing patterns and predicting actions.

According to (Vullaganti et al., 2025) Precision agriculture is one such practice, which uses advanced technologies and data-driven approaches to aid decision making and optimize crop production. For crop growth, nutrients are the most crucial and most used inputs. SSNM is an effective precision agriculture practice for efficient application of nutrients. This involves identifying the spatio-temporal variability of nutrient status and deficiencies in agricultural fields and applying fertilizers accordingly at variable rates. Principles and practices of SSNM are aided by the 4 R nutrient stewardship concept, namely,

1. Using the right fertilizer,
2. Applying at the right time
3. Using the right source, and
4. Adopting the right method

Early identification of the pathogen type of plant infection is of high significance for disease control. Various methods are used to diagnose pathogens of disease on plant. This article discusses the review of the literature data on traditional methods for diagnosis of plant pathogens, such as visual observation, microscopy, mycological analysis, and biological diagnostics or the use of indicator plants. Rapid and reliable detection of plant disease and identification of its pathogen is the first and most important stage in disease control. Early identification of the cause of the disease

allows timely selection of the proper protection method and ensures prevention of crop losses. There are a number of traditional methods for identifying plant diseases, however, in order to ensure the promptness and reliability of diagnostics, as well as to eliminate the shortcomings inherent in traditional diagnostics, in recent years, new means and technologies for identifying pathogens have been developed and introduced into practice. As well as the article provides information on such innovative methods of diagnosis of diseases and identification of their pathogens, which are used widely in the world today, such as immunodiagnostics, molecular-genetic (and phylogenetic) identification, mass spectrometry. (Khakimov et al., 2022)

Artificial intelligence algorithms are trained on large datasets of image or other data forms related to the plant diseases. Artificial intelligence algorithms learn to understand and recognize patterns and features associated with the differing diseases, making it possible for the Artificial Intelligence models to predict the presence and severity of disease in new, unseen data.

There are many types of ML algorithms that can be employed for Ugu disease detection. These include image processing technique, deep learning modelss (like Convolutional Neural Networks - CNNs), and other classifiers. In this, work it is intended to you deep learning and or image processing techniques.

Faster detection: ML algorithms can process images and data rapidly, enabling early disease detection and timely interventions, according to ResearchGate Improved accuracy: ML models can often outperform traditional methods in terms of accuracy, reducing the risk of misdiagnosis and enabling more precise interventions, according to ResearchGate. Increased production: By enabling early and accurate disease detection, ML can help farmers take timely action to prevent crop loses and increase productivity.

Data availability: Training ML models requires large and diverse datasets of plant disease images or data, which may be challenging to obtain. Data quality: The quality of the data used to train ML models can significantly impact their performance, and poor quality data can lead to inaccurate predictions. Generalisation: ML models may struggle to generalise to new or unseen conditions, such as different plant species or environmental factors, according to **Diva Portal**

Early disease detection: ML can be used to identity disease symptoms at their earliest stages, allowing for timely interventions and preventing the spread of diseases. Disease classification: ML models can be trained to classify different types of plant diseases, aiding in accurate diagnosis and targeted treatment. Disease severity assessment: ML can be used to assess the severity of plant diseases, helping farmers determine the approximate treatment strategies. Predicting disease outbreaks: By analysing historical data and environmental factors. ML can be used to predict the likelihood of disease outbreaks, allowing for proactive measures to be taken, according to ResearchGate.

Image-based detection: ML algorithm can analyse images of plant leaves to identify disease symptoms, such as lesions, discolouration and other visual clues.

Pumpkin is the name given to a group of plant species in the genus Cucurbita, including Cucurbita pepo, Cucurbita mixta, Cucurbita maxima, and Cucurbita moschata. It is grown primarily as a vegetable or ornamental plant. Pumpkins have long-running, bristled stems, large deeply-lobed leaves often containing white blotches, and yellow or orange flowers separated into male and female types on the same plant. The fruit (for the group) is variable in shape and color but is often white [see][] THREE.1, cream, or green, containing about 70% flesh and several large white seeds.

Ugu (fluted pumpkin) is a member of pumpkin family. And according to (Pum, b), Pumpkin plants are short-lived annual or perennial vines with branching tendrils and broad lobed leaves.

(IFY, 2024) said these about Ugu, fluted pumpkin. Fluted pumpkin, also known as "ugu" leaves, originates from West Africa, particularly Nigeria. Its scientific name is Telfairia occidentalis. This leafy vegetable is a staple in Nigerian cuisine and is widely cultivated for its culinary and nutritional benefits.

The nature of fluted pumpkin is characterized by its distinctive fluted stem, large dark green leaves, and tendrils. It is a climbing plant that thrives in tropical climates, and its cultivation involves providing adequate sunlight and well-drained soil.

The importance of fluted pumpkin, or ugu leaves, lies in its nutritional richness. It is a good source of essential vitamins such as A and C, calcium, iron, and other micronutrients. The leaves are commonly used in soups, stews, and various local dishes, contributing both flavor and nutritional value to the diet.

Beyond its culinary uses, fluted pumpkin holds cultural significance and is often used in traditional medicine for its perceived health benefits. Additionally, the cultivation and trade of ugu leaves contribute to the economic well-being of farmers in the region.

Some Facts and Nutritional Benefits of Fluted Pumpkin Leaves or Vegetables include;

Good Source of Dietary Fibre: Fluted pumpkin leaves are a source of dietary fiber that helps maintain the digestive system's health. It plays an essential role in improving digestion, thereby reducing health conditions like irritable bowel movement, constipation, and those caused by indigestion problems like ulcers and gastroparesis.

Maintains the Body Tissues: The vitamin contents in this vegetable help maintain healthy tissues, cells, membranes, and skin and treat wounds in the case of vitamin C. The protein in fluted pumpkin leaves alsoleaves also helps improve and maintain the body tissues, which include the connective tissues, muscles, and nervous systems.

Rich in Antioxidants: They are rich in alkaloids, resins, hydrocyanic acid, tannins, and flavonoids, powerful antioxidants that offer some immune system and anti-inflammatory benefits. Foods rich in antioxidants are known to be effective in preventing cancer and other associated health conditions like ulcers due to their ability to avoid the damages that oxidative stress should have caused in the body.

Balances the Hormones: Vegetable is known to have high protein content. Ugu contains the protein needed for hormone balancing; tissue repairs and regulates the acidities of body cells and organs. Consuming fluted pumpkin leaves is essential, as their protein content will also help improve the body cells and replace broken ones.

Serve as an Anti-Diabetic Agent: It has an anti-diabetic effect, which means it can treat diabetes mellitus by reducing glucose in the blood. It is possible due to the content of polysaccharides and ethyl acetate, which have effectively lowered blood sugar levels. They also effectively promote glucose tolerance and serum insulin. The extract of Ugu leaves has proved effective in this case, and it has been used as an anti-diabetic agent to regulate the blood glucose level.

Improves Blood Production: Fluted pumpkin leaves are always recommended for patients who suffer from a shortage of blood due to certain illnesses; the presence of iron and other essential minerals contributes to boosting blood in the body system and prevents anemia. For the effectiveness of helping boost blood production, it is recommended to be pounded, then strain the mashed vegetable to collect the liquid/juice.

Improves the Bones and Teeth: Fluted pumpkin vegetables contain a good amount of calcium needed to maintain healthy bones and teeth and keep the skeletal systems functioning normally. It also contains magnesium, which is vital in making the bone firm and strong. It might be surprising to say that calcium is almost ineffective to bones without magnesium as it helps the adequate absorption of calcium by the bones. Ugu also has potassium as one of the minerals it contains, which also helps maintain bone mineral density, which helps to make the calcium content in the bones intact, avoiding the leaching of the mineral. It helps to prevent osteoporosis, which affects the bones, especially in the aged.

Treat Convulsion: Ugu leaves have been found effective in treating convulsions in children. It becomes medicinal when sliced and mixed with coconut water and a small amount of salt. Scientifically, there might be no proof of this, but it was used hundreds of years ago to treat high fever and convulsion and remedy many other health conditions.

Effective for Weight Loss: Foods that help in weight loss are recommended for their effectiveness in weight management. Vegetables such as fluted pumpkin leaves contain a high amount of dietary fiber, which can help you lose weight as it makes you fuller and lowers your appetite. It contains little or no calories, eliminating the chances of storing more calories in the body.

Promotes Fertility: Fluted Pumpkin leaves have been used locally to treat infertility issues in both men and women. Its content of many vital nutrients and compounds has proven effective in its use to boost/improve sperm count in men and the overall functioning of their testicles. It boosts fertility in women and improves post-pregnancy health as it helps the nursing mother adequately feed their babies by increasing breast milk production.

Can Improve Memory: Fluted pumpkin leaves, just like most green leafy vegetables, contain certain compounds that help to improve memory. It also contains vital nutrients such as vitamins and magnesium, which aid in improving and normal functioning of the brain and nervous system. It can help to Improve cognitive reasoning, memory loss (Dementia), and other health conditions associated with memory health, such as Alzheimer's disease.

Ugu leaf has a lot of benefit to the healthy leaving of man. I personally have heard of recovered eye-sight case by constant consumption of Ugu leaf and nturukpa (another leaf common to the eastern Nigeria). According to , (Olagunju, 2016)

> Igbos in South East Nigeria call it Ugu and can barely live without it. But why should they when it has numerous health benefits? Telfairia occidentalis, as it is scientifically called is a tropical vine grown in West Africa as a leaf vegetable and for its edible seeds. Common names for the plant include fluted gourd, fluted pumpkin, and ugu and it is mainly cultivated in Nigeria. Ugu is used primarily in soups and herbal medicines though its fruits are edible, its seeds produced by the gourd, are high in protein and fat, and can, therefore contribute to a well-balanced diet. However, recently, nutritionists have been hammering on the wonders of juicing and how it benefits the body. Thus, more health conscious people are tilting towards juicing now more than before with the claim that anything can be juiced and juices are easier absorbed into the body system than solid foods. So, "while most of us have been using our ugu leaves in varieties of soups, some people have been juicing it for direct maximum nourishments," nutritionist Efemena Okeze says.
>
> As the name suggests, pumpkin juice is an extract from fresh pumpkin leaves and has several health benefits. And as such, it can be used as a healthy substitute for carbonated drinks.
>
> According to Grace Tinkola, an undergraduate at a South-West University, "I grew up drinking ugu juice sweetened with malt drink because of my mother. Then, I thought mother was just singing its praises to get us to drink it. But now that I am grown, I keep thanking my mom for forcing my siblings and me to make it a habit. It is a very healthy way of life but now I take it without the malt drink."
>
> Fluted pumpkin leaves are rich in potassium, calcium, iron and some Folic acid. They also contain a healthy amount of Vitamin A, Vitamin C, Vitamin E, Thiamin, Niacin, vitamin B6, Folate, Iron, magnesium and phosphorus, and are a very good source of dietary fibre, riboflavin, Copper and Manganese.
>
> The anti-oxidants such as alpha-carotene and Beta–carotene contained in the leaves help to slow down ageing process and also help to eliminate free radicals which are responsible for growth of cancer. The iron contained in the leaves helps to improve blood levels as well as prevent anaemia. This means that the leaves are good for people with heavy menstrual periods, pregnant women or people with poor absorption due to gut diseases such as, coeliac disease and Crohn's disease. Those who eat poor or restricted diets, those with red blood cell problems such as thalassaemia, sickle cell anaemia and those with bone marrow problems and leukaemia will benefit from it as well.

Vitamin C in the leaves helps to heal wounds, form scar tissue, and maintain healthy bones, skin, and teeth. It is rich in vitamin E, which promotes a healthier skin and in turn slows down the aging of the skin.

Carotene, which converts to vitamin A in the body is present in the leaves and aside from the vision benefits in Vitamin A that the leaves provide, there are also numerous skin benefits.

Taiwo Olayinka, a beautician and owner of pretty concepts studio, explains the importance of the vitamins C, E and beta-carotene on the skin thus: "Vitamin C, also known as ascorbic acid, is important for the production of collagen, a protein that aids in the growth of cells and blood vessels and gives the skin its firmness and strength; helps to create scar tissue and ligaments; and aids in skin repair.

"Vitamin C is an antioxidant and slows the rate of free-radical damage to collagen that can contribute to dry skin, fine lines and wrinkles. Vitamin E is an antioxidant that protects and repairs your skin and can help prevent premature ageing of your skin and damage to your DNA."

The Journal of Investigative Dermatology reported in February 2005 that people who take vitamins C and E in the long term reduced their sunburns from exposure to UVB radiation. Further, researchers saw a reduction of factors linked to DNA damage within skin cells.

Beta-carotene according to nutritionists is a strongly coloured pigment that imparts the yellow and orange fruits and vegetables their rich hues. Once ingested, it gets converted into vitamin A (retinol) which performs several biological functions within the body. Vitamin A also acts as an antioxidant that protects cells from the damaging effects of harmful free radicals.

Ugu leaf (Talifairia occidentalis) is such an amazing gift to humanity that many people have different testimonies about it. Credit to (7Am), the following are the leaf, gourd and seed of Ugu leaf (fluted pumpkin):

Figure ONE.1: Ike Ugu or Ugu gourd

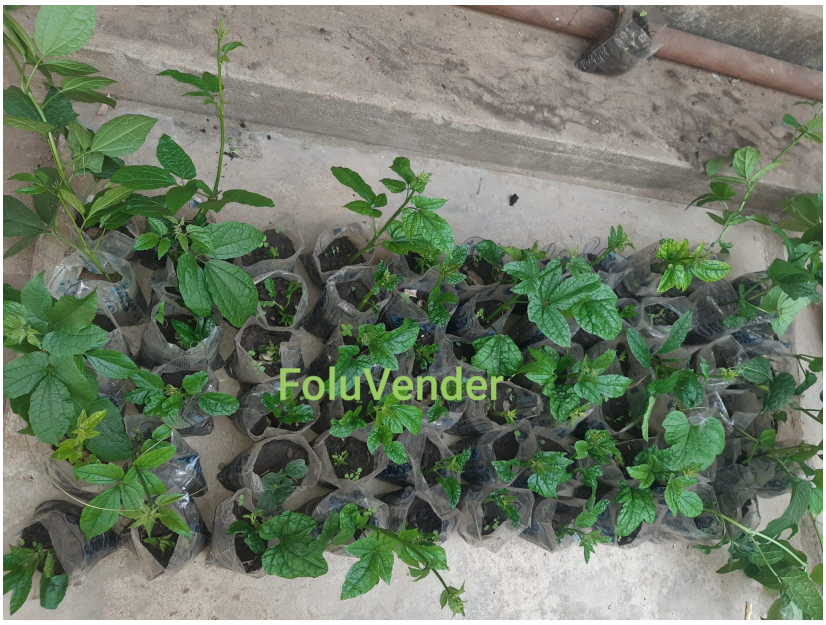

Figure ONE.2: Ugu leaf. Credit: farmsquare.ng

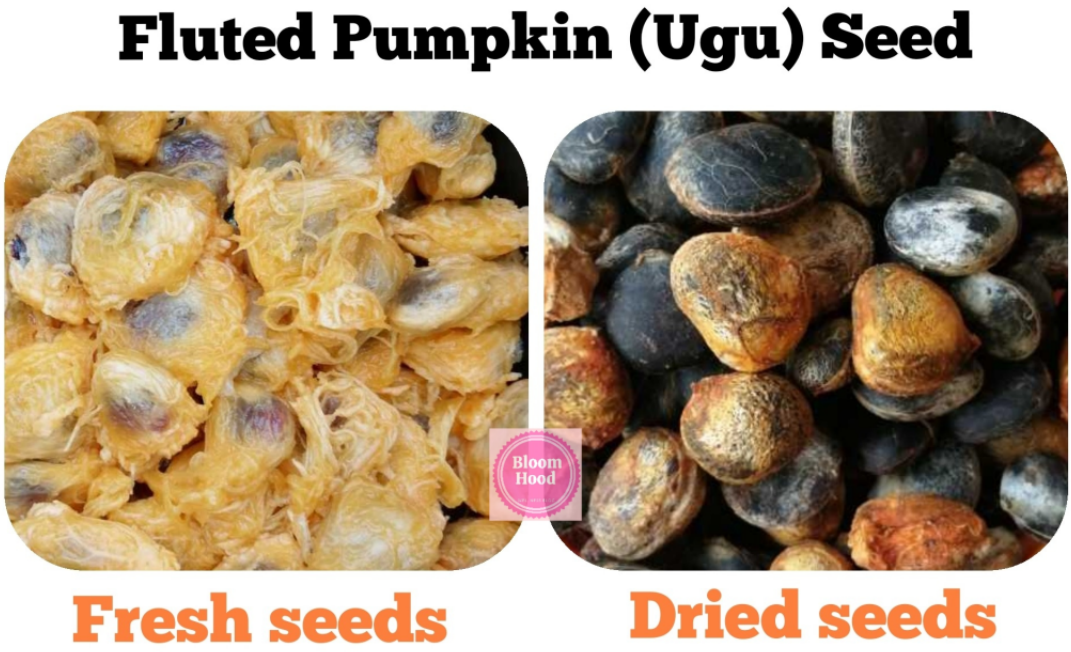

Figure ONE.3: Ugu seed. Credit: farmsquare.ng

2 Problem Statement

Develop an ML/AI based system for the early and accurate detection of various Ugu leaf diseases as listed in section 6, leveraging diverse image datasets, and advanced algorithms to improve farm production efficiency and better crop yield.

3 Objectives

The objectives of the study is primarily to develop an accurate, efficient and robust system for identifying the diseases mentioned in 6 particularly in its early stage. This early detection is very important for prompt management intervention and control and can assist in reduction of crop losses and prevent the spread of the disease(s).

4 Research Questions

- What is the accuracy of using image processing to identify and classify different Ugu leaf diseases?
- How does image processing and classification compare to traditional methods of Ugu leaf disease detection?

5 Justification of the Study

- Existing methods for vegetables, fruits and other plant's leaf diseases identification suffer from low accuracy, posing a huge challenge for precise classification.
- To proffer suitable solutions to identified Ugu (leaf) disease.
- The importance of the study is to find an easier and prompt method of disease detection in the farm. This will reduce loss due to disease in the farm as the cosmetic and pharmaceutical industries have standard qualities they look out for and purchase.

6 Scope of The Study

The scope of the study is to find out how ML/AI (machine learning / artificial intelligence) can be used for only disease detection and classification and treatment suggestion / recommendation in a large scale Ugu farm of the following diseases of fluted pumpkin

- **Downy mildew**
- **Powdery disease**
- **Mosaic disease**
- **Bacterial leaf spot**

CHAPTER TWO

LITERATURE REVIEW

Modern agriculture has to cope with several challenges, including the increasing call for food, as a consequence of the global explosion of earth's population, climate changes, natural resources depletion, alteration of dietary choices, as well as safety and health concerns. As a means of addressing the above issues, placing pressure on the agricultural sector, there exists an urgent necessity for optimizing the effectiveness of agricultural practices by, simultaneously, lessening the environmental burden. In particular, these two essentials have driven the transformation of agriculture into precision agriculture. This modernization of farming has a great potential to assure sustainability, maximal productivity, and a safe environment. In general, smart farming is based on four key pillars in order to deal with the increasing needs; (a) optimal natural resources' management, (b) conservation of the ecosystem, (c) development of adequate services, and (d) utilization of modern technologies. An essential prerequisite of modern agriculture is, definitely, the adoption of Information and Communication Technology (ICT), which is promoted by policy-makers around the world. ICT can indicatively include farm management information systems, humidity and soil sensors, accelerometers, wireless sensor networks, cameras, drones, low-cost satellites, online services, and automated guided vehicles.
(Benos et al., 2021)

Ugu disease pose a very high severe threat in the planting and production of this highly cherished vegetable. Hence, it very pertinent for the Ugu farmers to effectively deal with Ugu disease and early detection of these diseases is key. This is very easy to handle in very small to medium scale production. But this is a very herculean task as the size of the farm grows into acres of land, most especially for very harmful crop diseases.

Site selection: Squash and pumpkin are best grown on sandly loam or silt loam soils with a pH of 6 to 7. Growth on acidic and or poorly drained soils often results in increased incidence of root, crown and fruit rots. Late plantings should not be situated near earlier plantings where a disease already existed. (John and Lynn)

Sanitation: Old crop debris provides a site were many plant pathogens overwinter and survive between crops. Crop debris shuld be removed or incorporated into the soil to hasten its decomposition as soon as possible after harvest. Care should be taken to avoid contaminating planting areas with soil, diseased culls or diseased plant materials. (John and Lynn)

Disease resistant varieties: Disease-resistant varieties of squash (virus diseases and powdery mildew) and pumpkin (powdery mildew) are available and should

be planted where possible. Resistance is the most effective and economical means of disease control. For diseases such mosaic virus, resistance is the only effective control. (John and Lynn)

Pathogen-free seed and transplants: Some diseases may be seedborne or introduced into fields on infected transplants. Efforts should be taken to obtain high-quality seed and transplants. Only transplants that appear healthy should be used.(John and Lynn)

Irrigation: Frequent application of sprinkler irrigation with small amounts of water favour the spread and development of many diseases. Overhead irrigation produces splashing and runoff, which promotes movement of plant pathogens and increases the duration of leaf wetness - a condition that favours infection. Drip irrigation helps reduce diseases by not wetting foliage and by reducing pathogen spread from overhead sprinkler splashing or water run off. (John and Lynn)

Chemical control: Spray programs with fungicide or bactericide (copper compounds) sprays may be needed for effective management of foliar diseases. Consult the latest edition of the E-832, OSU Extension Agent's Handbook of Insect, Plant Disease adn Weed Control for a list of suggested treatments for specific diseases. Generally, spray programs are most effective when applied on a regular (seven to fourteen days) preventive schedule. Organic growers have fewer spray options than conventional growers, but many copper compounds and sulfur can be used in organic production.(John and Lynn)

Scouting: Plantings should be scouted regularly - at least once per week - for insect pests and diseases. Scouting allows for early pest detection so timely management practices can be implemented. (John and Lynn)

Disease identification: Correct disease identification is key to effective management. Incorrect identification can lead to the implementation of an ineffective management practice and crop failure. For example, disease caused by bacteria or viruses are not controlled with most fungicides. Furthermore, some fungicides will control one fungal disease, but not another. Squash and pumpkin growers shuld learn to recognise the more common diseases by their symptoms and have sufficient knowledge of disease development to select appropriate management practices. Some diseases are easy to identify in the field, while others are more difficult. The following descriptions will aid in disease identification and if needed, the OSU Plant Disease and Insect Diagnoses Laboratory offers disease diagnosis as a service to commercial growers and residential gardeners. Samples can be submitted to the laboratory through local county OSU Extension offices. (John and Lynn)

1 Types of Ugu Leaf Diseases and Causal Agents

Traditionally, there are several types of crop disease: abiotic (also known as non–infectious) and biotic (infectious). Unfavourable environmental conditions often generate non-communicable diseases. Examples are low or high temperature, excess or lack of moisture. Also, diseases are usually caused by harmful impurities in the air. They can accumulate due to the presence of nearby chemical or metallurgical plants. Usually, the unhealthy physicochemical composition of the soil is the disease source. The latter factor is often the result of poor-quality treatment of fields with some herbicides. These examples prove the importance of sustainable agriculture

[using AI and other supporting technologies] not only for protecting the environment but also for a profitable [Ugu cultivation and other dependent-to-be industries of the future] businesses. (Vasyl)

According to (John and Lynn), squash and pumpkin are vegetable crops in the cucurbit family grown both on commercial farms and in residential gardens. This means that both vegetables would be affected by the same diseases mostly.

(John and Lynn), went further to say the following: Integrated pest management (IPM) involves the use of several different strategies and the judicious use of pesticides for management of diseases and other cucurbit pests. Both conventional and organic growers should practice IPM. More effective and less costly control is usually achieved when IPM is practised, compared to reliance on a single management practice, such as pesticide application. Management strategies that are components of an effective IPM system include: Crop rotation: Fungi, bacteria and nematodes that cause soil-borne and foliar disease often survive in the soil or on old crop debris and build up to damaging levels with repeated cropping. To reduce pathogen survival and disease carry-over a three-to-four-year rotation with non-cucurbit crops is recommended.

2 Ugu Diseases and Symptoms

According to (Mir, 2024), the following are the common diseases of Ugu leaf with symptoms.

- **Downy Mildew**: Downy mildew is a potentially devastating disease of cucurbit crops which is caused by the fungus-like water mould Pseudoperonospora cubensis. Once established in a region, the disease can spread rapidly, causing significant loss of fruit quality and yield.

  It infects squash, pumpkins, melons, gourds, and cucumber, with cucumbers being the most susceptible crop to this pathogen.

  The downy mildew pathogen majorly infects the leaves, resulting in decreased photosynthesis, and during favourable environmental conditions it can defoliate plants and destroy entire fields within a short time.

  The fruits of infected plants are usually undersized and misshapen. They are also more likely to develop sun scald, which further reduces their quality. (**?**)

  According to (**?**) Optimal conditions for cucurbit downy mildew include at least 6 hours of 100% relative humidity at the leaf surface for the production of sporangia, which are the structure that makes and releases spores. According to the Compendium of Cucurbit Diseases, the optimum temperature for sporangia production is 59–68°F. When higher levels of spores are present, the disease can successfully penetrate if free moisture is present for as little as 2 hours. The spores are dispersed by air currents, which is why the disease is tracked as it moves from south to north.

  Symptoms of downy mildew on cucumber are angular yellow lesions on leaves delineated by leaf veins. Spots on cantaloupe are more irregular and may resemble angular leaf spot at first glance. However, since downy mildew is a water mold and produces spores, you may observe gray-purplish sporulation

on the underside of leaves infected with downy mildew. Angular leaf spot is bacterial and does not produce spores. To further test suspicious leaves, place a few in a plastic bag with a moist paper towel and let sit on the countertop overnight. The next day, observe leaf undersides for spores. A hand lens with at least 10x power is helpful when looking for spores.

- **Powdery Mildew**: According to (Opara and Okoronkwo), Powdery mildew is caused by the fungus Fusarium moniliforme. This fungus forms a dry powdery mass of mycelia on the fruits of fluted pumpkin. Symptom is also observed as greyish powdery areas on older leaves; leaf drop may cause sunburn First seen on the lower leaf surface powdery mildew is a white "powdery" covering of spores hat move upper, eventually defoliating the pumpkin plants.

  According to (Abdulridha et al.) Early disease detection is necessary for optimal PM management to control and prevent the spread of the disease throughout the field. In addition to early detection, two main issues have to be addressed for an efficient PM management: i) determining the progression of the disease, and ii) determining the location and severity of the disease of the outbreak. Frequent spray applications with large amounts of chemicals such as fungicides contribute to the accumulation of chemical waste in soil and water, increase environmental pollution and contamination of edible products

- **Mosaid Disease**: Many biological constraints, particularly diseases of the virus origin have become potent threats to existence of the plant and thus of utmpst importance is Telfaira mosaic virus (TeMV), genus Poty virus followed by Pepper veinal mottle virus (PVMV), genus Poty virus. Common virus symptoms observed on plants in the filed includes mosaic, mottling and leaf size reduction. Mosaic symptoms on leaves were most common (25%), followed by leaf sizee reduction (17%) and leaf necrosis were least (2%). Telfaira mosaic virus (TeMV), causes mottling of the leaves and low leaf yield; it also causes chlorosis and it therefore transmitted from generation to generation by mere planting.(Opara and Okoronkwo)

- **Bacterial Leaf Spot**: (Opara and Okoronkwo) said Bacterial leaf spot is caused by Xanthomonas cucurbitae (syn = X, campestris pv. cucurbitae). Lesions appear first on the underside of the leaves as small, water soaked yellow dots on the upper of the leaf. Lesions are especially small in pumpkin, winter squash and gourd leaves. A s lesions enlarge, they can coalesce and look like Angular

3 Literature Gap

From our research so far, little has been done. The little that is done is done for the Cucurbitae family of vegetables and in this family, very many other members are not common in Nigeria, may be West Africa. They are not consumed as much as Ugu leaf (Talfaira occidentalis). Given that the amount of all other vegetables put together, does not reach half the quantity of Ugu leaf consumed in say Eastern Nigeria, predominated by the Igbo tribe. Is seems nothing has been done in the immediate environment of the researcher. Hence this research is expected to help

the producers of this super-vegetable to cut cost and improve produce yield. And this research is most needed at this time more than ever.

4 Summary

From say the last three decades, the popularity of Ugu leaf has been on the rise. Initially, it was juiced and mixed with malt drink. Today that continues and other varieties like mixing with ginger is also noticed.

And this research is needed most in this time more than ever, also as the usefulness of this vegetable is gradually finding its way into the manufacturing industry as it is being used to make cosmetics produce for skin see figure THREE.3 and hair care see figure THREE.2. It is also *expected* to have been used by the pharmaceutical industry in the production of multivitamin (this we can not prove yet as it is a classified information).

CHAPTER THREE

METHODOLOGY

It is a common and know fact that CNN models are best suited for object recognition and classification with image datasets. In spite of the advantages CNN has, the challenges are still there and they include long duration of training time and the large datasets requirement. Deep CNN models are required to extract the low-level and complex features from the images and then, this increases the complexity of the model training. Transfer learning approaches are capable of addressing the above mentioned challenges. Transfer learning uses pre-trained networks, where model parameters learned on a particular dataset can be used for other problems. The following methodologies are the methodologies being considered for this work.

1 Multi-Class Classification

Plant diseases datasets hold multiple images including both infect and healthy plant leaf samples, with each sample mapped to a particular class. For instance, using the *Ugu leaf* plant as class, then all the images of healthy and infected samples of *Ugu leaf* plant will be mapped to that specific class. Now, the classification of the target image is purely based on the features extracted from the source image. Considering the sample example of the *Ugu plant / leaf*, the Ugu class has four set of diseases, names: downy mildew, powdry mildew, mosaic disease and bacteria leaf spot (Agricincome, 2024) and (Pum, a). When a sample of one particular disease is fetched as input after training with all four set of disease samples under the *Ugu plant / leaf* class, the testing phase output will classify the exact label of the disease from among the four categories mapped under that particular class. Thus, multi-class classification is mutually exclusive, wheras, the multi-label classification, each category inside a class is itself considered a different class. Suppose we have N classes, then we can refer to N multi-classes, and if the N classes have M categories, then each category inside each of the N classes is itself considered a class.

2 Transfer Learning Approach

Generally, it takes several days or weeks to train and tune most state-of-the-art models, even if the model is trained on high-end GPU machines. Training and building a model from scratch is time-consuming. A convolution neural network, CNN model built from scratch with a publicly available plant disease dataset seemed

to attain 25% accuracy in 200 epoch, whereas using a pre-trained CNN model using a transfer learning approach is expected to attain 60% plus accuracy in almost half the number of iterations (over 100 epochs). Transfer learning methods include several approaches, the choice of which depends on the choice of the pre-trained network model for classification and the particular nature of the dataset.

3 ResNet-50

ResNeet-50 is a convolutional neural network that has about 50 deep layers. The model has five stages, with convolution and identity blocks. These residual networkss act as a backbone for computer vision tasks. ResNet (He et al., 2015) introduces the concept of stacking convolution layers one above the other. Besides stacking the convolution layers, they also have several skip connections, which bypass the original input to reach the output of the convolutional neural network. Furthermore, the skip connection can be placed before the activation function to mitigate the vanishing gradient issue. Thsu, deeper models end up with more errors, to resolve these issues, skip connections in the resident neural network were introduced. These shortcuts connections are simply based on identity mapping. Let us consider x as the input iamge, F(x) as the nonlinear layers fitting mappings, and H(x) as the residual mapping. Thus, the function for residual mapping becomes: H(x) = F(x) + x

ResNet-50 has convolution as an identity block. Each identity block has three convolutional layers and over 24M trainable parameters. Input x and shortcut x are the twow matrices, and they can only be added if the output dimension from a shortcut and the convolution layer after the convolution and batch normalization are the same. Otherwise, shortcut x must go throguh a convolution layer and batch normalization to match the dimension.

Figures Used

Figure THREE.1: Example fluted pumpkin fruit shape. Credit to IFY MGBEMENA

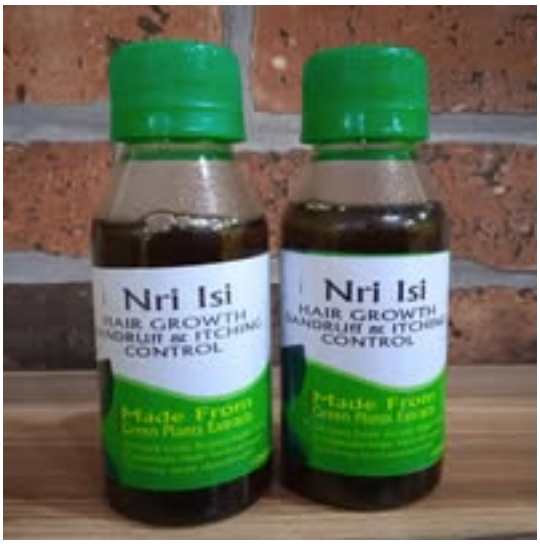

Figure THREE.2: Example hair care product made from Ugu leaf

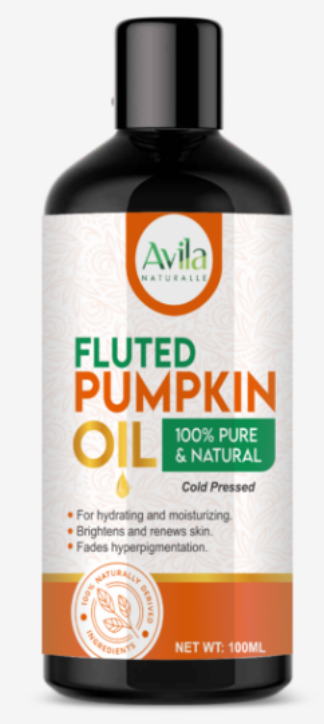

Figure THREE.3: Example skin care product made from Ugu leaf

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