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Guava Leaf Disease Detection Using Colour Region Segmentation and Circularity Value Techniques

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Abstract: Workers in the agricultural sector face various dangers that affect human society's food security, such as climate change, animal grazing, plant diseases, and other hazards that are well known. Plant disease is one of the most serious problems since it not only causes massive waste of plants for human consumption, but it also has a significant impact on human society's health and the lives of farmers whose primary source of income is the production of healthy crops. If infections are not diagnosed early, it can spread disease, like Alga Leaf Spot, Rust, and Whitefly, which can infect the entire farm. This project aims to implement the Image Processing Technique, for plant disease detection on guava leaves in early stage. First, the Histogram Equalization is used to improves the image contrast and quality. Then the Colour Segmentation Technique was applied to detect the disease area on the leaf based on its disease-type colour. Next, the Circularity Value Technique was applied to detect the shape of the disease on the leaf. Finally, the disease will be detected and classify based on its colour and shape. From the analysis, it is found that the disease colour is 100% correct detected, 53.33% detected its correct shape, 53.33% detected the correct disease.

Keywords: Guava Leaves, Disease, Image processing, MATLAB Software

1. Introduction

A large segment of the county's workforce is employed in agriculture. In Malaysia, agriculture is essential to the country's growth and not only for food and raw materials for industry [1]. In today's agriculture production, the fruit industry plays a significant role. Guava is one of the popular fruits that is commercially cultivated in many countries because it is rich in vitamins, minerals, and nutrients. Other than that, it can also be used for some therapeutic properties. However, Guava's quality and quantity production has dropped due to several diseases [2]. Plants affected with a disease frequently have visible markings or lesions on their leaves, stems, flowers, or fruits.

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Consequently, each disease or pest scenario has a unique visual pattern that can be used to identify issues. The major source for identifying plant diseases is plant leaves, and most disease symptoms may initially manifest on the leaves [3]. Microorganisms like fungi, bacteria, and viruses usually cause diseases in Guava Plants. The significant conditions that occur in these plants are Alga Leaf Spot, Bacterial Leaf Blight, Rust, Wilt and Whitefly. These kinds of diseases happen in the leaf, affecting the overall plant life cycle. Normally farmers use chemical pesticides to protect the plants from diseases. By doing this, it would be affected human health and also economically [4].

Other than that, some farmers are observed independently without using technologies to identify the symptoms of the diseases in plants. Therefore, it would be less accurate if farmers used this technique [5]. Besides that, some countries need proper facilities to identify the symptoms of diseases in the plant. To avoid this kind of problem, the Image Processing Technique is the best method to detect the condition in the Guava Leaves. By identifying the disease in its early stage, the Guava Plant can be protected and control the disease from great loss.

1.1 Problem statement

Plant disease normally occurs due to environmental issues such as temperature, pH, humidity, and moisture. The improper care of agriculture would seriously affect the product quality and quantity. Besides, plant disease can also cause financial losses for farmers and agricultural industries. Due to some lack of knowledge on those diseases, farmers faced difficulties identifying the disease and could not take precautions on those plants. When the leaf diseases are not identified properly, farmers use pesticides that are not related to that particular disease [6]. Even though plant disease poses a danger to agricultural output, putting too much human effort into disease detection is a waste of time. Learning the diagnosis skills and standards would take a long time and hundreds of hours of practice. Thus, farmers require quick and efficient methods for detecting and identifying the real disease on leaves to save time [4].

2. Literature Review

Farmers are the most important person in our daily life because we depend directly or indirectly on them for food. Farmers are the agricultural system’s backbone. Farmers play an important role in the agriculture system since crops must be grown and harvested for them to function. Farmers help expand the agriculture industry, which feeds the local people and improves the economy by distributing the products. Most farmers use manual agriculture because they lack the technical expertise necessary to do so, and they are also unaware of the crops that do well in their area. These kinds of things will lead to different types of the disease occurring in leaves, which spoil the entire crop [4]. Crop disease can cause low productivity and economic losses for farmers and the agriculture industry [7]. Suppose farmers identify the disease in leaves using their observation. As a result, farmers face various challenges in controlling crop diseases and frequently experience significant production losses.

2.1 Guava fruit impact

Guava is a tropical fruit found in India, Indonesia, Pakistan, Bangladesh, and South America that belongs to the Myrtaceae family. Guava was first discovered in the early 17th century and was originally assigned to the American tropics [8]. The word “Guava” is thought to come from the Arawak word guayaba, which means “Guava Tree” in Spanish. Guava fruit is high in phosphorus, calcium, nicotinic acid, and other nutrients. In addition, it eases diabetes, reduces blood pressure, guards against dysentery, and stops diarrhea. Guava can tolerate intense and widespread global warming and thrive on a variety of soil types with a pH range of 4.4 to 4.9 [8]. The guava leaves are borne on small stalks (petioles) that are 4-10 mm long and are placed in opposite directions along the stems. Another study found that the flavonoids in guava leaf extract had antibacterial activities, whereas quercetin is responsible for the antidiarrheal characteristics of the extract. One of the most prevalent flavonoids identified in guava leaf is quercetin. It has the ability to calm the smooth muscle of the intestine and prevent bowel spasms [9].

2.2 Disease types on guava leaves

2.2.1 Alga leaf spot

Cephaleuros virescens is a pathogenic green alga that appears on the upper surfaces of guava leaves as orange yellow, approximately round specks to large patches. Patches can be small or large, packed or dispersed, and can cover any region of the leaf. Algal pathogen resides on the surfaces of guava leaves and cover the leaves photosynthetic area.

2.2.2 Rust

Another source of rust is the fungus that produces circular lesions on leaves, young shoots, deformed leaves, black borders, and yellow haloes with orange to red bumps. There is no growth on the leaf surface, the lesions cover the entire lamina, and sporulation takes place on the exterior of the disease on the leaf surface.

2.2.3 Whitefly

Whiteflies are flying insects with delicate bodies linked to aphids and ladybugs. Whiteflies, although their name, are not insects, despite having wings and the ability to fly. Whiteflies can be as little as a tenth of an inch in length, have a triangular form, and gather on the underside of the leaf.

2.3 Image processing techniques

2.3.1 Image enhancement technique

Image enhancement's major goal is to alter a given image so that the finished product is better suited to a particular application than the original image. For example, it emphasizes or sharpens picture components like borders, boundaries, or contrast to make a visual representation more effective for presentation and analysis. The Median Filter, Histogram Equalization, Fuzzy Histogram Equalization, Contrast Stretching, and Contract Limited Adaptive Histogram Equalization are some techniques used in image enhancement [6].

2.3.2 Image segmentation techniques

Image segmentation is the division or classification of an image into multiple segments. There are many different ways to segment images, from straightforward thresholding to intricate colour picture segmentation methods. The many properties of the image serve as the foundation for segmentation. This could be colour information, image borders, or a specific area of an image. There are several segmentation approaches that can be used to construct the system including Colour Region Segmentation, Grab Cut Segmentation, RGB Threshold Segmentation and K-Means Cluster [4].

2.3.3 Feature extraction technique

Feature extraction technique is important in identification of an image in more clear vision. Feature extraction is applied in many image processing applications. Colour, texture, morphology, edges and other characteristics can be utilised to diagnose plant disease. Colour, texture, and shape as disease detecting features. It discovered the morphological outcome outperforms the other characteristics. There are some techniques involved in the Feature Extraction method which are Shape Detection, Gray Level Co-occurrence Matrix (GLCM), Grey Level Histogram and Colour Co-occurrence Matrix (CCM).

3. Methodology

3.1 Project work flow

Figure 1 shows the work flow of this project.

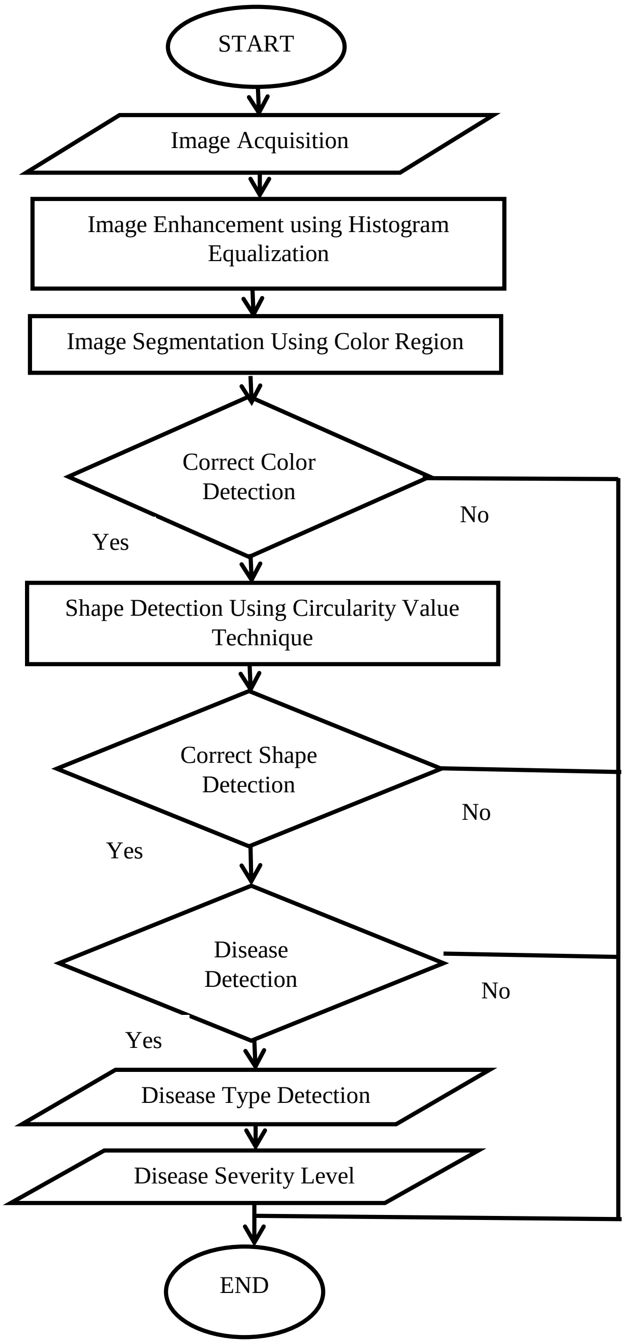

Figure 1: Flow Chart for Disease Detection

3.1.1 Image acquisition

In this project, the guava leaves images are obtained from Shutterstock and BU_Guava_Leaf (BUGL2018) websites [10]. Figure 2 shows sample of guava leaves. RGB (Red, Green, and Blue) conversion was used to present the image. A device-independent colour space transformation is performed on the colour transformation structure after generating one for the RGB leaf image. The classifier's better result in the last stage of the disease detection is due to the image database.

Figure 2: Sample of Guava Leaves; (a) Alga Leaf Spot, (b) Rust, (c) Whitefly

3.1.2 Image enhancement technique

In this project, Image Enhancement is very important as most of the original image has a watermark and low quality. Background Removal and Histogram Equalization have been applied to increase the image quality in this project. Background Removal is essential since it aids in the elimination of all unwanted things from an image. As a result, removing the image background can aid in the creation of consistent visuals and also can focus on detecting the leaf. In this application, the background of the leaf image was removed based on its leaf shape. The purpose of using Histogram Equalization under the Enhancement Technique is to improve contrast from the original image. The method has the advantage of being a simple technique adaptable to the input image and using an invertible operator. As a result, Histogram Equalization is necessary to increase the image's visual quality or make it easier to analyse.

3.1.3 Image segmentation using colour region

Segmentation is an important phase of the image because it extracts the items of interest for data pre-processing, such as detection or identification. The colour space is the most extensively used colour space, in which a colour point in the space is defined by the three colour elements of the pixel intensities: Red (R), Green (G), and Blue (B). The classification of image pixels is accomplished using colour image segmentation. In this project, colour segmentation was applied to detect the disease area on the leaf based on its disease-type colour.

3.1.4 Shape detection using circularity value technique

Shape detection plays an important role in image processing techniques. In its most basic form, shape-based image retrieval involves comparing the similarity of shapes represented by their attributes. Shapes can be described using certain simple geometric properties. In this project, circularity value technique was applied based on the shape of the disease area on the leaf.

3.1.5 Disease type detection

The disease was detected based on its disease colour and shape on guava leaf. When the disease was detected based on its colour and shape, it was classified into three types which are Alga Leaf Spot, Rust, or Whitefly.

3.1.5 Disease severity level

The severity level of the infected area is classified according to the Disease Severity Level developed by Chaudhary CP, as shown in Table 1. The disease severity level will be classified based on the guava leaf image measured by the disease-affected area on the leaves. Eq. (1) is used to calculate the disease area.

$$\text{Disease Area (\%)} = ((\text{Disease Leaf Area}) \div (\text{Entire Leaf Area})) * 100 \quad \text{(Eq.1)}$$

Table 1: Disease Severity Level Developed by Caudhary CP

Severity Level	Disease Area (%)
Level 1	0 - 20
Level 2	21 – 40
Level 3	41 – 60
Level 4	61 – 80
Level 5	81 - 100

4. Result and Discussion

4.1 Background removal

Background removal was used to remove any traces of dust, grime, blemishes, or other unnecessary flaws from the background. This Photo Scissor application tool has used to removed unwanted backgrounds and undesired things from the site images. Overall, 30 sample images have been chosen for this project which are 10 samples from Alga Leaf Spot, 10 samples from Rust, and another 10 samples from Whitefly. Figure 3 shows the comparison result of original image with Background Removal image of guava leaf.

(a) (b)

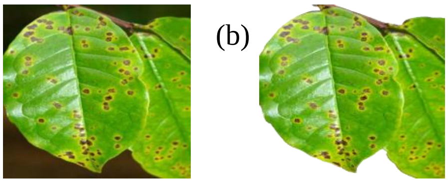

Figure 3: Background Removal; (a) Original Image, (b) Background Removal Image

4.2 Image enhancement using histogram equalisation

After the background removal technique, the next technique is image enhancement, which can be done by histogram equalization. After applying the histogram equalization technique, the output result of the enhanced image will become more contrasted than the background removal image. Apart from that, the histogram graph after the enhanced image would be slightly different from the background removal graph which is shown in Figure 4.

(a) (b)

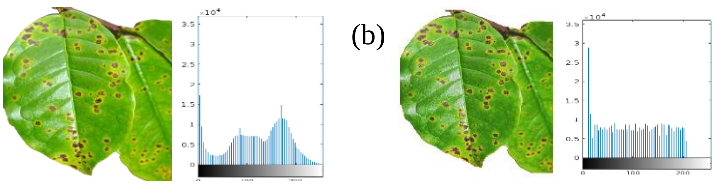

Figure 4: Histogram equalization; (a) Background removal, (b) Enhanced image

4.3 Colour region segmentation

Colour Region Segmentation is the third technique applied in this project. This technique is mainly focused on disease detection based on disease colour. Since there are several colour pixels in the image, this technique will help identify the pixel in the image matching the specified colour. Once the disease colour was detected on the leaf, the result was displayed in three forms of region: Region 1 was represented as White colour, Region 2 was represented as Red colour, and Region 3 was represented as Black or Brown colour. The outcome of the colour region segmentation is shown in Figure 5.

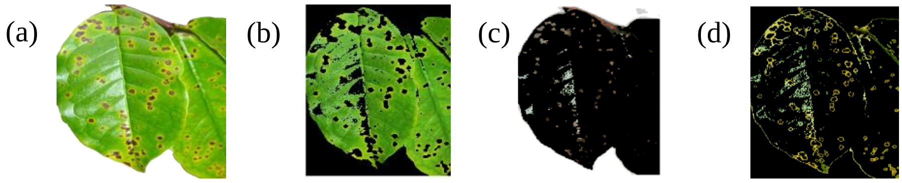

Figure 5: Colour segment detection; (a) Enhanced Image, (b) No Brown Colour Detection, (c) No Brown Colour Detection, (d) Brown Colour Detection

Table 2 shows the analysis result based on Colour Detection that has been detected on the sample images using the proposed technique. There are overall, 30 sample leaf images have been tested for colour detection. Therefore, by referring the Table 2, the proposed technique has successfully found 30 out of 30 sample images which is 100% detected its disease colour on guava leaf.

Table 2: Analysis result of Disease Colour Detection

Colour	Correct detection	Incorrect detection
Number of Images	30	0
Percentage	100%	0%

4.4 Shape detection using circularity value technique

The shape will be detected based on the circularity of the disease shape on the leaf region. In this project, the circularity of the disease shape will be calculated based on its perimeter and the shape's area. Eq. (2) shows the formula for calculating the circularity of the disease shape.

$$\text{Circularity of the disease shape} = (\text{Perimeter}^2) / (4*\text{PI}*\text{Area}) \qquad \text{(Eq.2)}$$

In this project, if the circularity value of the disease shape is less than 1.19, the shape will be detected as a diamond. When the circularity value is between 1.19 and 1.53, the shape will be detected as spread all over the leaf. The shape will be detected as round when the circularity value of the disease shape is greater than 1.53. Figure 6 shows the output of the detection.

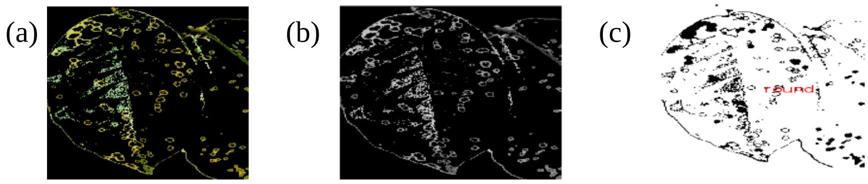

Figure 6: Shape detection technique; (a) Brown Colour Segmented Image, (b) Circularity Detection, (c) Shape Detected is round

Table 3 shows the analysis result of the Shape Detection based on its disease shape for all 30 sample leaf images. As a result, it can be stated that there are only 16 sample images (53.33%) detected its correct shape and the balance of 14 sample images (46.67%) did not detected its correct shape. From the overall analysis, it can be stated that, most of the shapes detected on sample leaf images are round shape and spread all over the leaf. This is because all the shapes were calculated based on the circularity region of the disease shape by using equation (2).

Table 3: Analysis result of Shape Detection

Shape	Correct detection	Incorrect detection
Number of Images	16	14
Percentage	53.33%	46.67%

4.5 Disease detection

The disease detection on the leaf image is classified according to its disease colour and shape as shown in Figure 7. When the disease was detected based on its colour and shape, it was classified into three types which are Alga Leaf Spot, Rust, or Whitefly. When the disease colour was detected as brown or black, and its shape was detected as round, the disease was classified as Alga Leaf Spot. When the disease colour was detected as black or red, and its shape was detected as spread all over the leaf, the disease was classified as Rust. The disease was classified as Whitefly when the white colour and diamond shape were detected on the guava leaf.

(a) (b) (c)

Figure 7: Disease detection; (a) Brown Colour, (b) Round Shape, (c) Disease Classify as Alga Leaf Spot

Table 4 shows the overall analysis of the disease detection based on disease colour and its shape for all 30 sample leaf images that have been successfully detected. From the overall analysis result, 16 sample images (53.33%) were detected and classify the correct disease. On the other hand, 14 sample images (46.67%) classified the wrong disease. As a result, it can be stated that the proposed technique is 53.33% accurate, and another 46.67% is inaccurate for the disease detection. Most of the disease were classified as Alga Leaf Spot and Rust.

Table 4: Overall analysis result based on Colour and Shape Detection

Result	Correct disease detection	Incorrect disease detection
Number of Images	16	14
Percentage	53.33%	46.67%

4.6 Analysis of disease severity on guava leaves image sample

The severity level of the infected area is classified based on the disease severity Level by using Eq. 1. When the disease-affected area is displayed between 0%-20%, the disease severity level is Level 1. For level 2, the disease-affected area will be displayed between 21% - 40%. For Level 3 and Level 4, the disease-affected area will be displayed between 41% - 60% and 61% - 80%. Finally, the disease-affected area will be displayed in 81% - 100% for level 5.

Table 5 shows the analysis result of the disease severity level. The disease severity level was classified based on disease affected area on the leaf image. 29 sample images were accurate its disease severity level, while only 1 sample image was inaccurate. Therefore, this proposed technique has 96.67% accuracy and 3.33% inaccurate in disease severity level.

Table 5: Analysis result of Disease Severity Level

Result	Accurate	Inaccurate
Number of Images	29	1
Percentage	96.67%	3.33%

5. Conclusion

At the end of this project, the three main objectives have been successfully achieved. The first objective is to detect the disease area on Guava Leaf using Colour Region Segmentation Technique. In this project, the proposed technique has 100% successfully detected its disease colour. Next, the second objective is to detect the disease shape on Guava Leaf using Circularity Value Technique. Based on the second objective, the proposed technique has 53.33% successfully detected its correct shape. Finally, the disease type will eventually be classified once its colour and shape have been determined. The third objective is to analyse the severity level of disease on Guava Leaf image sample. The disease severity level was classified based on the disease-affected area on the guava leaf image. This proposed technique has 96.67% accurate in disease severity level. To assist farmers in identifying diseases at an early or beginning stage and providing important information for their control, the detection technique has been developed employing cutting-edge computer such as Image Processing Technique.

For future projects, by utilizing this technique, additional plant varieties and various plant diseases may be added to the current dataset for disease detection. For the Shape Detection using Circularity Value Technique, the programming coding would be modified until 100% of the shape would be successfully detected, especially for the diamond shape. Next, the Background Removal image would be done manually in this project using Photo Scissor Tool. This proposed technique can be improvised by using a suitable technique to remove the object's background image directly. Doing this can reduce the workload and time. Apart from that, some of the sample images have a watermark, and removing the watermark from the online application tool is very difficult. Sometimes, the process would be confused about detecting the correct disease area on the sample leaf. To avoid this problem, future researchers will also focus on developing a mobile application to make the procedure much smoother for farmers, using drones to increase the dataset of sample images and increase the image quality without any watermark on the original sample images.

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References

[1] Md.Rasel Howlader, Umme Habiba, Rahat Hossain Faisal and Md. Mostafijur Rahman, "Automatic Regonition of Guava Leaf Disease using Deep Convolution Neural Network", 2nd International Conference on Electrical, Computer and Communication Engineering, ECE 2019, doi: 10.1109/ECACE.2019.8679421

[2] Santhosh Kumar.S, B.K.Raghavendra, "Disease Detection of Various Plant Leaf Using Image Processing Techniques: A Review", 2019 5th International Conference on Advanced Computing & Communication Systems (ICACCS), doi: 10.1109/ICACCS.2019.8728325

[3] D.Kucharshki, K.Kucharska/Shutterstock, "Whiteflies", almanac.com / pest /whiteflies

[4] Vijay Singh, Varsha, Prof. A K Misra, "Detection of Unhealthy Region of Plant Leaves using Image Processing and Genetic Algorithm", 2015 International Conference on Advances in Computer Engineering and Applications (ICACEA) IMS Engineering College, Ghaziabad, India, doi: 10.1109/ICACEA.2015.7164858

[5] Charturbhuj Meena, R.R.Meena, K.C.Meena, B.L.Meena and K.R.Meena, "Doubling The Farmer Income Through Guava (Psidium Guava) Cultivation", International Journal of Science, Environment and Technology, Vol.7, No 3, 2018, 905-909, ISSN 2278-3687 (O) 2277-663X (P)

[6] Mrs. Shruthi U, Dr Nagaveni V, Dr Raghavendra B K, "A Review on Machine Learning Classification Techniques for Plant Disease Detection", 2019 5th International Conference on Advanced Computing & Communication System (ICACCS)

[7] Md. Arifur Rahman, G M Shahir Mahdee, Md Mukitul Islam, Md Wasi UI Kabir, “Improved Segmentation Approach for Plant Disease Detection”, 1st International Conference on Advance in Science, Engineering and Robotics Technology 2019

[8] Almetwally M.Mostafa, Swarn Avinash Kumar, Talha Meraj, Hafiz Tayyab Rauf , Abeer Ali Alnuaim, Maram Abdullah Alkhayyal, “Guava Disease Detection Using Deep Convolutional Neural Networks: A Case Study of Guava Plants”, 2021 Applied Science

[9] Noer Laily, Retno Windya Kusumaningtyas, Lim Sukarta, Maria Rosari Devi Karthika Rini, “The Potency of Guava Psidium Guajava (L) Leaves as a Functional Immunostimulatory Ingredient”, 2nd Humbold Kolleg in Conjuction with International Conference on Natural Sciences, HK-ICONS 2014

[10] BU_Guava_Leaf. https://github.com/MHR12/BU_Guava_Leaf-BUGL2018/tree/master/test_set and https://www.shutterstock.com/search/disease+guava