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AUTOMATED FRUIT DISEASE DETECTION USING IMAGE PROCESSING TECHNIQUES

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Abstract: Mango production has been significantly affected by climatic variations and environmental factors, including excessive rainfall, high humidity, declining soil nutrient levels, and the increasing prevalence of diseases and physiological disorders. Conventional identification of mango plant diseases primarily relies on visual inspection, which is subjective, time-consuming, and often prone to inaccurate diagnosis. In particular, farmers with limited access to agricultural expertise may fail to recognize disease symptoms at an early stage, resulting in reduced crop productivity and economic losses. Image processing and digital image processing (DIP) techniques provide an efficient and reliable alternative for the automated detection and classification of fruit diseases. Various computational approaches have been investigated for disease identification, including clustering techniques, color-based segmentation (CBS), artificial neural networks (ANN), and other machine-learning-based classification methods. This paper presents a comprehensive survey of image processing techniques employed by different researchers for the detection and classification of fruit diseases, with particular emphasis on their methodologies, algorithms, and performance. The study aims to analyze and compare existing approaches and provide an overview of the current developments in automated fruit disease detection. The reviewed techniques can be implemented using Python and its associated image-processing and machine-learning libraries.

Keywords: DIP - Digital Image Processing, CBS – Color Based Segmentation, ANN- Artificial Neural Network.

I. INTRODUCTION

There are lots of techniques to identify diseases in fruits in their early stages. The old method of disease detection in fruit is naked eye observation and it’s not effective. Using digital methods, disease detection can be efficient, accurate, less time consuming, saves time, effort and labor. As agriculture is the backbone of the Ethiopian economy every citizen should participate in a successful implementation of programs in the sector. Today’s technology advancements have so many advantages for agricultural practices and implementations, the area of artificial intelligence is one of these technologies beside that image processing are emerging technologies that can benefit Ethiopian agriculture especially in crop disease detection.

The project work is to be carried out under the following major phases. Several related literatures will also be reviewed during the process of the project work in order to have a better understanding of the actual situations of the problem and the technology available to finally come up with a good solution. A number of image data is required for the model to be trained as well to be tested. The image data can be collected from Ethiopian Institute of Agricultural Research, Holetta Research Center in addition to images that are found on the Internet. These images will be acquired with a good quality digital camera or smartphone camera and be ready for the dataset preparation.

Classification is the major decision-making stage of image recognition and finding whether the fruit image is normal or abnormal. It uses the features extracted in the previous stage to identify the image segment according to preset rules. There are several techniques for classification, some of them are called, Linear Regression (LR), Logistic Regression (LogR), k-Nearest Neighbor (k-NN), Naïve Bayes (NB), Decision Trees (DT), Artificial Neural Networks (ANN), Linear Classifier (LC), Support Vector Machine (SVM), Random Forest (RF) and so forth.

II. PROCESSING

An image can be defined as a two-dimensional function, where x and y are spatial coordinates, and the amplitude of the function at any pair of coordinates (x, y) is called the intensity or gray level of the image at that point. When x, y, and the intensity values of f are all finite, discrete quantities, we call the image a digital image. The field of digital image processing refers to processing of images i.e., digital images by the help of a digital computer. Consider that a digital image is a collection of a finite number of elements, each of which has a particular location f(x, y) and value. These elements are called pixels or picture elements.

2.1 LOW-LEVEL PROCESSING

This low-level image processes can involve operations which are considered primitive such as image preprocessing to reduce noise, image sharpening, contrast enhancement, and image resizing.

2.2 MID-LEVEL PROCESSING

The mid-level processing includes partitioning image into regions(segmentation), description of objects to reduce them to a certain region so that a computer can process and recognition of objects become easy. Here inputs are images but outputs are features or attributes that are extracted from input image and can differentiate the region from other regions.

2.3 HIGH-LEVEL PROCESSING

In high-level processing, we make sense of a collection of recognized objects. The process of acquiring an image of a text, processing it, extracting (segmenting) individual characters, describing characters suitable for computer processing and recognizing those individual characters are in the scope of digital image processing. Making sense of the content of the page (text) is viewed as the domain of image analysis and computer vision.

create the chances of arbitrage and the investors have the chance to earn above the normal profit. But the assumption of the APT is that there should not be arbitrage in the market and the investors can earn only normal profit. Jarque bera test is used to test the normality of data.

III. STEPS IN IMAGE PROCESSING

3.1 IMAGE ACQUISITION

Image acquisition is the very first step in any image processing work, in which an original input image is acquired from the initial source (where an image can be found). Image acquisition can be implemented in different ways. Most of the time, this step is only considered as capturing an image from actual environmental scene but is it can also be browsing an already existed image file from any electronic source with any method of Image Pre-processing ROI Segmentation Feature Extraction Image Acquisition Classification Performance Evaluation Overall System Feature Selection acquisition. The image that is acquired is totally unprocessed, when we see it from the corner of the intended image processing application. The original image is the result of whatever hardware was used to generate it, which can be very important in some fields to have a consistent baseline from which to work, the actual hardware device can be anything from desktop scanner to a massive optical telescope.

Raw image or unprocessed image is acquired from different sources according to the application or type of process, for instance image can be acquired using digital camera, cell phone camera or web camera for an application mostly related with capturing environmental scene, like face recognition application, object or animal identification, plant disease detection and so many others. Possibly images can be found from medical imaging equipment like X-Ray machines, MRI machines for medical diagnosis applications, like tumor detection and cancer detection. Images can also be acquired from satellites for geographic information handling and related applications.

3.2 IMAGE PRE-PROCESSING

The other essential step, image preprocessing is the technique of enhancing image data prior to computational processing. The preprocessing of images might include shade correction, removing artifacts, formatting and filtering. Formatting deals with storage representation and setting the attributes of the image and the purpose of filtering is to remove low-frequency background noise, normalizing the intensity of the individual particle images, removing reflections, and masking portions of images in order to improve the stability of the image characteristics. Image processing usually refers to digital image processing, however optical and analog image processing is also possible. Some of the image pre-processing tasks are explained as follows.

For simplified computation, images can be resized to a lightweight version of the original image by minimizing the number of pixels, we call this image resizing task. But this is only recommended when the resizing action does not affect the resultant image meaning or appearance of the original image.

Image enhancement is another sub-step of image pre-processing in which different techniques are used to give an image more understandable meaning. Contrast arrangement is the mostly used technique in image enhancement. Image restoration sub-step concerned with how to improve the appearance of an image. Though, unlike image enhancement, which is subjective, image restoration is objective.

3.3 IMAGE PROCESSING TASKS

In the preprocessing task input image passes through different filtering techniques for the sake of getting a better image. The preprocessing task is the fundamental step in any image processing application which can help to get a more meaningful interpretation of an image. In addition, preprocessing tasks can affect the overall performance of a classifier since they can reveal hidden or unclear information in an image. This task has number of sub-tasks like image type conversion for ease of computation, image enhancement for visual easiness, noise removal for process consistency, image scaling and resizing or shrinking for complexity minimization quick computation, using filter functions and other important techniques that are necessary to improve the quality of the input leaf image. These sub-tasks can be used one or more times during the process of the implementation. Image resizing is applied for ease of computation in some cases image files with large size can slow down the overall performance of a model. This resizing task is applied in a way which cannot abuse the information that is found in the original image. Histogram equalization is another sub-task under the preprocessing task, that is applied for contrast enhancement which enables to get detailed information from input images. Input image has RGB/BGR color space originally, but for additional purposes this color image can be converted to different color spaces. Grayscale conversion helps to work fine with many image processing algorithms. Grayscale images are easier to process than RGB images. Because the number of possible pixel values in different color spaces varies, most algorithms treat input images differently.

3.4 IMAGE SEGMENTATION

Image segmentation or Region of Interest (ROI) Segmentation, is a reserved name in the digital image processing domain, which represents any process of either separating or grouping an image into different meaningful parts or regions. These regions normally correspond to part of the image that human perception can easily separate and view as individual objects. The segmentation process is based on various information found in the image. This might be color information, boundaries or segments of an image. The precision of the segmentation result directly influences the reliability of feature extraction and the accuracy of detection. Computers have no means of intelligently recognizing objects currently, there exist several different methods and techniques of performing image segmentation, ranging from the simple thresholding method to advanced color image segmentation methods. There are several existing techniques of image segmentation techniques in the area of image processing and computer vision having their own advantages and disadvantages according to the problem they are applied on, i.e., the image to be segmented. These all techniques can be found from two basic approaches of segmentation i.e., region based or edge-based approaches. Every technique can be applied on different images to perform required segmentation. These all techniques also can be classified into three categories. Some of the mostly used techniques are raised next,

- Structural Segmentation Techniques: The structural techniques are those techniques of image segmentation that relies upon the information of the structure of the required portion of the image i.e., the required region which is to be segmented.
- Stochastic Segmentation Techniques: The stochastic techniques are those techniques of image segmentation that work on the discrete pixel values of the image instead of the structural information of the region.

● Hybrid Techniques: The hybrid techniques are those techniques of the image segmentation that uses the concepts of both above techniques i.e., these uses discrete pixel and structural information together.

IV. FEATURE EXTRACTION

Feature extraction involves simplifying the amount of resources required to describe a large set of data accurately. When performing analysis of complex data one of the major problems, branches from the number of variables involved. Analysis with a large number of variables generally requires a large amount of memory and computation power or a classification algorithm which over-fits the training sample and generalizes poorly to new samples. Feature extraction is a general term for methods of constructing combinations of the variables to get around these problems while still describing the data with sufficient accuracy.
The segmentation techniques yield data in the form of pixels along a boundary or pixels in a region. After an image is segmented into regions; the resulting aggregate of segmented pixels is represented and described for further computer processing. In the process of image representation regions can be represented in terms of its external characteristics (boundary) or in terms of its internal characteristics (pixels comprising the region). If our primary focus is on shape characteristic, we can use external representation, on the other hand if our primary focus is on region properties like color and texture, we can use internal representations. Sometimes, we can also use both representation techniques. Thus, based on these region representation techniques, we make the data useful to computers.

V. EXTRACTING FEATURES

5.1 COLOR

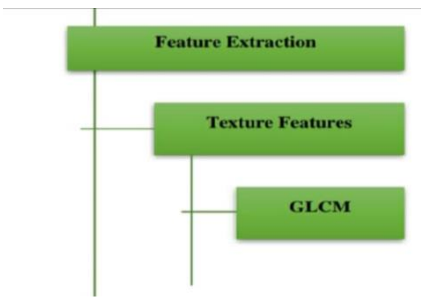
A color is mostly used to compare images and is one of the most widely used visual features. For the representation of color of an image, we use the HSI [2] (hue, saturation and intensity) color model. And for representation of the distribution of a color image, we use a color histogram.

5.2 MORPHOLOGY

For extracting image components, a morphology tool is used. Description and representation of region shape such as boundary extraction can be done using extracted image components. Here, we used erosion dilation operation of morphology for obtaining the boundaries of images. After applying these operations, we subtract the eroded image from the original image. Finally, we will extract shape vectors from healthy fruit, by using morphology.

5.3 GLCM FEATURES EXTRACTION

Features can simply seem as a numerical function of the image. That is, any method that gives a number from the image, can be called as a feature [3]. Ideally, these should be meaningful. Features are categorized into two types: global and local. Global features are a function of the whole image. While local features have a position and are a function of a local image region. Texture defines the consistency of patterns and colors in an image. Gray Level Co-occurrence matrix (GLCM) uses adjacency concept in images. The basic idea is that it looks for pairs of adjacent pixel values that occur in an image and keeps recording it over the entire image. The co-occurrence matrix can be constructed based on the orientation and distance between image pixels. Texture patterns are governed by periodic occurrence of certain gray levels. Consequently, the repetition of the same gray levels at predefined relative positions can indicate the presence of a specific texture. Several texture features such as entropy, energy, contrast and homogeneity, can be extracted from the co-occurrence matrix. A gray level co-occurrence matrix P(i, j) is defined based on a displacement vector dxy = (dx, dy) [4]. The pairs of pixels separated by dxy distance that have gray levels i and j are counted and the results are stored to P(i, j).



Steps in image detail extraction

VI. TYPES OF CLASSIFIERS

6.1 NAIVE BAYES CLASSIFIER

This is a classification technique based on Bayes' Theorem with an assumption of independence among predictors. In simple terms, a Naïve Bayes classifier assumes that the presence of a particular feature in a class is unrelated to the presence of any other feature. Even if these features depend on each other or upon the existence of the other features, all of these ML Algorithm Supervised Learning Algorithms Naïve Bayes K-NN SVM Classified Data Performance Evaluation RF properties independently contribute to the probability. [5]

6.2 K-NEAREST NEIGHBOR CLASSIFIER

K-Nearest Neighbor is considered to be a simple classifier in the supervised learning algorithms where the classification is achieved by identifying the nearest neighbors to an input and then 50 make use of those neighbors for determination of the class of the input. In K-NN the classification i.e., to which class the given point belongs is based on the calculation of the minimum distance between the given point and other points. It is not applicable in the case of a large number of training examples as it is not robust to noisy data.

6.3 SUPPORT VECTOR MACHINES CLASSIFIER

SVM constructs a hyperplane in multidimensional space to separate different classes. SVM generates optimal hyperplanes in an iterative manner, which is used to minimize an error. The main idea here is to find a maximum marginal hyperplane that best divides the dataset into classes. The classifier separates data points using a hyperplane with the largest amount of margin. The SVM algorithm [6] is implemented in practice using a kernel. A kernel transforms an input data space into the required form This helps to build a more accurate classifier. For this implementation linear kernel is applied, A linear kernel can be used as a normal dot product of any two given observations. The product between two vectors is the sum of the multiplication of each pair of input values.

6.4 RANDOM FOREST CLASSIFIER

Random forest is a type of supervised machine learning algorithm based on ensemble learning where different types of algorithms or same algorithm are joined multiple times to form a more powerful prediction model. The random forest algorithm combines multiple algorithm of the same type i.e., multiple decision trees, resulting in a forest of trees, hence the name "Random Forest"[7]. This algorithm can be applied in both regression and classification applications. The algorithm works in the following four steps

1.Select random samples from a given dataset.

2.Construct a decision tree for each sample and get a prediction result from each decision tree.

3.Perform a vote for each predicted result.

4.Select the prediction result with the most votes as the final prediction.

VII. IMPLEMENTATION

An image in grayscale is to read the image in grayscale mode directly, we can read an image in grayscale by using the cv2.imread(path, flag) method of the OpenCV library. We can also convert an image to grayscale using the standard RGB to grayscale conversion formula that is

$$imgGray = 0.2989 * R + 0.5870 * G + 0.1140 * B.$$

We can implement this method using the matplotlib library in Python, first we need to read the image using the mpimg.imread() method and then get the red, blue and green dimension matrices of the RGB image after getting the matrices we can apply the formula on them to get the grayscale image. We need to multiply the complete matrices with the values given in the formula to get the grayscale image

Thresholding is a technique in OpenCV, which is the assignment of pixel values in relation to the threshold value provided. In thresholding, each pixel value is compared with the threshold value. If the pixel value is smaller than the threshold, it is set to 0, otherwise, it is set to a maximum value (generally 255). Thresholding is a very popular segmentation technique, used for separating an object considered as a foreground from its background.

The basic Thresholding technique is Binary Thresholding. For every pixel, the same threshold value is applied. If the pixel value is smaller than the threshold, it is set to 0, otherwise, it is set to a maximum value.

When we join all the points on the boundary of an object, we get a contour. Typically, a specific contour refers to boundary pixels that have the same color and intensity. OpenCV makes it really easy to find and draw contours in images. It provides two simple functions:

findContours()

drawContours()

VIII. OBSERVATIONS AND OUTCOMES

STEP 1: READ THE IMAGE

The first step in this is to read the image. The image is captured by electronic device. Digital Camera or Webcam. The image captured is stored in JPEG format. Let's take a sample image of a fruit and start with detecting the disease place. We will then use the same image for Character Segmentation. [8]

STEP 2: GRAY SCALING

Gray scaling is the process of converting an image from other color spaces e.g. RGB, to shades of gray. It varies between complete black and complete white.

STEP 3: THRESHOLDING

The basic Thresholding technique is Binary Thresholding. For every pixel, the same threshold value is applied. If the pixel value is smaller than the threshold, it is set to 0, otherwise, it is set to a maximum value.

● cv2.THRESH_BINARY: If pixel intensity is greater than the set threshold, value set to 255, else set to 0 (black).

● cv2.THRESH_BINARY_INV: Inverted or Opposite case of cv2.THRESH_BINARY.

STEP 4: FIND AND DRAW CONTOURS

Contours are defined as the line joining all the points along the boundary of an image that are having the same intensity. Contours come handy in shape analysis, finding the size of the object of interest, and object detection. OpenCV has a findContour() function that helps in extracting the contours from the image. It works best on binary images, so we should first apply thresholding techniques. The contours are the boundaries of a shape with the same intensity. It stores the (x, y) coordinates of the boundary of a shape. But does it store all the coordinates, that is specified by this contour approximation method. If we pass cv2.

STEP 5: PRINT ("DISEASE" OR "NO DISEASE")

- We printed the quality of the fruit as 'Disease' or 'No Disease' using a non-zero counting method.
- We used the binary reverse image to calculate the non-zero value.
- Print 'Disease' when the non-zero value is high.
- Print 'No Disease' when the non -zero value is low.

IX. CONCLUSION

Accurate identification and classification of fruit diseases are essential for maintaining crop quality and improving agricultural productivity. Image processing techniques offer an effective approach for automatically identifying diseased or damaged regions of fruits. This study examines different methods for image segmentation, feature extraction, and classification to distinguish healthy fruits from infected or damaged ones. The analysis involves comparing images of fresh fruits with those exhibiting visible damage, allowing the affected regions to be identified through digital image processing techniques.

In addition to image-based analysis, the proposed approach incorporates a sensor-based disease monitoring system. An SHT11 sensor integrated with a Raspberry Pi 3 is employed to collect environmental parameters and transform the acquired sensor data into meaningful information for disease assessment. The system is designed as a wireless disease-detection sensor node that can support fruit-farm monitoring through an Android application. Farmers can use a smartphone-based application to initiate the detection process and monitor the condition of their crops. This integrated approach combines image processing, wireless sensing, and mobile technology to provide a practical and accessible solution for fruit disease detection and monitoring.

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