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EXAMINATION OF MANGO FRUIT DISEASES TO IMPROVE THE QUALITY OF MANGO FRUIT USING IMAGE PROCESSING

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Abstract

Mango fruit disease inspection is crucial for improving quality and productivity. This study explores the application of image processing techniques to automatically detect and diagnose diseases such as alternaria, anthracnose, black mold rot, and stem-end rot. The data used in this research consists of images of healthy mangoes and those infected with diseases. The methodology involves capturing mango images under various lighting conditions and backgrounds. These images undergo segmentation to isolate the infected areas, allowing for more precise analysis. Image features are extracted using min-max algorithms, enhancement, and convolution, with MATLAB 2018b assisting in the process. A classification model is developed to recognize patterns indicating the presence of diseases. The study's findings reveal that image processing techniques achieve high accuracy in disease detection, making them effective for sorting and quality control. This system improves disease detection efficiency compared to traditional manual observation methods. By implementing this technology, the quality of marketed mangoes can be enhanced, benefiting both producers and consumers. Additionally, this innovation strengthens the competitiveness of the mango industry in local and international markets. Farmers gain a valuable tool to optimize harvest yields, while consumers receive higher quality and more consistent products.

Keywords: Image Processing; Disease Detection; Mango Fruit; Image Segmentation

Abstrak

Pemeriksaan penyakit buah mangga sangat penting untuk meningkatkan kualitas dan produktivitas. Studi ini mengeksplorasi penerapan teknik pemrosesan gambar untuk mendeteksi dan mendiagnosis penyakit seperti alternaria, antraknosa, busuk jamur hitam, dan busuk ujung batang secara otomatis. Data yang digunakan dalam penelitian yaitu data gambar mangga sehat dan yang terinfeksi penyakit. Metodologi ini melibatkan pengambilan gambar mangga dalam berbagai kondisi pencahayaan dan latar belakang. Gambar-gambar ini mengalami segmentasi untuk mengisolasi area yang terinfeksi, sehingga memungkinkan analisis yang lebih tepat. Fitur gambar diekstraksi menggunakan algoritma min-max, enhancement, dan convolution, dengan MATLAB 2018b membantu prosesnya. Model klasifikasi dikembangkan untuk mengenali pola yang menunjukkan keberadaan penyakit. Temuan penelitian menunjukkan bahwa teknik pemrosesan gambar mencapai akurasi tinggi dalam deteksi penyakit, sehingga efektif untuk penyortiran dan pengendalian kualitas. Sistem ini meningkatkan efisiensi deteksi penyakit dibandingkan dengan metode observasi manual tradisional. Dengan menerapkan teknologi ini, kualitas mangga yang dipasarkan dapat ditingkatkan, yang menguntungkan produsen dan konsumen. Selain itu, inovasi ini memperkuat daya saing industri mangga di pasar lokal dan internasional. Petani memperoleh alat yang berharga untuk mengoptimalkan hasil panen, sementara konsumen menerima produk berkualitas lebih tinggi dan lebih konsisten.

Kata kunci: Pengolahan Citra; Deteksi Penyakit; Buah Mangga; Segmentasi Citra

INTRODUCTION

Mango fruit (Mangifera indica) is one of the leading horticultural commodities which has high economic value (Owino & Ambuko, 2021) and is in great demand both in local and international markets. Indonesia, as one of the largest mango producing countries in the world, faces big challenges in maintaining consistent quality and quantity of mango production. One of the main challenges is the attack of various diseases which can significantly reduce the quality of mango fruit

(Dofuor et al, 2023), (Islam et al, 2023). These diseases not only affect the aesthetic appearance of the fruit but can also reduce the nutritional value and shelf life of mangoes.

Diseases that often attack mangoes include anthtracnose caused by the fungus Colletotrichum gloeosporioides, (Peralta-Ruiz et al, 2023) powdery mildew caused by the fungus Oidium mangiferae, and black spots caused by the fungus Asperisporium caricae. (Adikaram & Yakandawala, 2020), (Aliyarukunju et al, 2021). This disease can cause various symptoms such as black spots, brown spots, and changes in the shape of the fruit surface. Early detection and effective control of these diseases is essential to minimize economic losses and maintain the quality of fruit produced.

Traditionally, disease detection in mangoes is done through visual inspection (Gining et al, 2021) by farmers or trained experts. However, this method has several significant limitations. Subjectivity in assessments, the need for experienced labor, and the time and costs required to conduct manual inspections on a large scale are some of them. Therefore, a more efficient and accurate solution is needed to detect diseases in mango fruit. (Safari et al. 2024)

Image processing is a technology that offers great potential in meeting these challenges. Image processing technology allows automatic image analysis to detect disease symptoms in mango fruit with high accuracy. With the development of artificial intelligence and machine learning technology, image processing systems are now able to learn and recognize disease patterns with increasing levels of accuracy. (Ibrahim & Abdulazeez, 2021). The application of this technology can not only increase efficiency in the disease detection process but also ensure consistency in assessment. This research aims to develop a disease detection system in mangoes based on image processing that can provide fast and accurate results. The research process includes taking images of mango fruit in various lighting conditions and backgrounds, image segmentation to separate infected areas from healthy areas, image feature extraction using certain algorithms, and building a classification model that is able to identify various types of disease. It is hoped that the resulting system can be integrated into the process of sorting and controlling the quality of mango fruit to improve the quality of products marketed.

By implementing this system, it is hoped that it will provide significant benefits for farmers and the mango processing industry. The use of image processing technology will not only improve the quality of marketed mangoes but also reduce economic losses due to fruit being attacked by disease. Additionally, this technology can support farmer welfare by providing an effective tool to ensure high-quality and disease-free harvests. The main reason why I chose the idea of detecting mango diseases is to support mango production in Indonesia which is decreasing due to various diseases.

This paper describes how various diseases affect mango fruit productivity. The main diseases that affect the productivity of mango fruit are alternaria, anthtracnose, black mold rot and stem end rot. This article also describes how to prevent and treat the main diseases in mango fruit..

This paper proposes a disease detection system using a MATLAB-based application. (Ijemaru et al, 2021). This system has proven its ability to detect diseases on leaves even though there are many main diseases that affect the productivity of mango plants. For example, Black Ribbon is mostly found on bark or stems and still affects productivity. Apart from that, there are also several diseases that occur on the fruit itself. Accuracy is also a major obstacle that needs to be improved.

The first step in digital image processing is Image Preprocessing which is one of the main steps to maintain the originality of an image (Maharana & Nemade, 2022) may be degraded due to some noise or due to other reasons. This article is a review of several Image Preprocessing techniques that can be used.

Image segmentation is important for selecting the right areas of interest in an image. This is important to reduce the processing time that may be required to process the entire image. This paper shows a segmentation technique called a convolutional algorithm or filter. The advantage of this algorithm is that it automatically selects and sharpens the details of the disease being observed, or also uses a min-max algorithm which aims to simultaneously find the minimum and maximum values of an image. .

This paper presents a review of the features that will be extracted. Features that can be extracted from images can be of various types, such as global or local. Within it there are subcategories like texture or color based features, etc.

In feature extraction, for successful disease detection, it is important to select the right features that best describe a particular disease. This paper illustrates algorithms ranging from resize, min-max, enhancement and convolution.

Feature selection and feature assessment methods such as convolution are expected to be good methods used in this research. (Arshad, H., et al, 2020)

RESEARCH METHODS

In this research, the image taking technique was obtained from a dataset on Kaggle, the images taken were images of healthy mangoes and those infected with disease. After the system receives an image of the infected part of the mango plant, the image will be entered into the Matlab system. After that, technical processes will be applied to the image such as image pre-processing which includes steps such as resizing the image, cropping the image, enhancing the image. etc. After that, image segmentation is carried out which divides the image into small parts for better results. For image segmentation, you can also use edge detection, which is a segmentation method that aims to find and highlight object boundaries. This segmentation works by identifying pixels in the image that have significant changes in intensity values in the image. (Lu, X et al, 2022)

Classify disease types based on characteristics obtained from the Kaggle dataset by direct or manual observation so that in the process the type of disease identified can be determined. In the proposed methodology, several steps are carried out such as image acquisition, image pre-processing, image segmentation, feature extraction and image classification. (Dhiman et al, 2023) In this paper there are several frames, namely images captured with the help of a camera.

Each image is pre-processed to enhance and remove noise from it. Segmentation techniques are applied to detect the affected areas. Next, Features and Classification are carried out to extract defective image parts from disease-infected mangoes. In this image processing, the Matlab 2018b application is used.

Digital Image Processing

Digital Image Processing is a science that studies image processing techniques. Digital image processing aims to manipulate and analyze images with the help of computers. (Kheradmandi & Mehranfar, 2022) In general, digital image processing extends to two-dimensional (2D) image processing using computers. In a broader context, digital image processing refers to the processing of two-dimensional data. A digital image is an array containing real and complex values presented with a certain bit sequence. In this research, the image processing process is carried out in several ways tahap, antara lain pra-pemrosesan hingga klasifikasi.

Classification

Classification is the process of grouping objects that have the same characteristics into several classes. In image processing, classification involves identifying and grouping pixels or areas in an image based on certain characteristics such as color, texture, or shape. (Chen et al, 2021) This process generally begins with feature extraction, where the important features of an image are identified and represented in the form of a feature vector. Once these features are extracted, the images can be grouped into different classes according to their similar characteristics.

Classification of images in large files is a challenge due to their complexity and high computational requirements. The larger the file size, the more data that must be processed and identified, (Orsburn, B. C, 2021) so it can slow down the system and require greater computing resources. In this situation, optimization and use of dimensionality reduction techniques become important to reduce the computational burden. Additionally, advances in hardware technology and the use of parallel processing and cloud computing can help overcome these challenges, enabling more efficient and faster processing of big data.

Preprocessing

Preprocessing is used to remove noise, highlight features, detect patterns, normalize. (Torres-García et al. 2022) The data pre-processing stage generally consists of several things, including filling in empty data, eliminating duplicate data, and checking data for inconsistencies. Usually empty data is caused by equipment errors when collecting data or the presence of new data for which there is no information yet.

Resize

The imresize filter in MATLAB refers to various methods to enlarge or soften an image. Bilinear Interpolation, This method uses two-way linear interpolation (horizontal and vertical) to enlarge the image. Bilinear interpolation provides smoother results than nearest interpolation but can still produce blurry edges. (Ding et al, 2021)

Bicubic Interpolation This method uses cubic interpolation in both directions and usually produces smoother results than bilinear interpolation. Bicubic interpolation is a good

choice when visual quality is critical. (Zhu, Y et al, 2022)

Nearest Neighbor Interpolation This method selects the closest pixel values and usually produces grainier images. This is the simplest and fastest interpolation method, but the results may be less than satisfactory for images that require fine detail. Fourier Transform: This method can be used to enlarge images in the frequency domain. The Fourier transform converts the image into the frequency domain, allows more complex resizing operations, and in some cases can provide better results. In MATLAB, the imresize function is often used to enlarge images. This function supports several interpolation methods such as 'nearest', 'bilinear', and 'bicubic'. With a size that cannot be changed.

where:
- I_{new} is the image resize
- $I_{original}$ is the original image
- (x^o,y^0) is the pixel coordinate in the resized image
- s_x dan s_y is the scale factor on the x and y axes
- round is a rounding function

Min-Max

The Min-Max filter in image processing functions to normalize pixel values, namely changing the pixel intensity range in an image to a certain range such as 0 to 1 or 0 to 255. This is very useful for accelerating the convergence of machine learning algorithms and ensuring consistency of image feature scales. Additionally, Min-Max normalization can improve image contrast, make previously invisible details more prominent, and prepare the image for further analysis by ensuring that the input meets the requirements of certain value ranges required by many image processing and machine learning algorithms. (Huang & Wan, 2022).

The Min-Max normalization process involves changing the image data type to twofold for more precise calculations, then calculating the minimum and maximum values of the original image. Each pixel is then normalized using a certain formula so that all pixel values are within the desired range. With this step, the visual quality of the image can be improved, and the image is ready for use in advanced applications that require pixel values within a certain range. This makes the Min-Max filter an important tool in the pre-processing stage of image processing.

$$I_{normalized(x,y)} = \frac{I(x,y) - I_{min}}{I_{max} - I_{min}} x(N_{max} - N_{min}) + N_{min} \quad (1)$$

where:
- $I(x,y)$ is the pixel value at coordinates (x,y) in the original image
- $I_{\min}$ and $I_{\max}$ are the minimum and maximum pixel values in the original image
- $N_{\min}$ and $N_{\max}$ is the desired range of values for normalization, for example 0 to 1 or 255
- $I_{\text{normalized}}(x,y)$ is the coordinate pixel value (x,y) in the normalized image.

Enhancement

Enhancement filters in image processing are used to improve the visual quality or certain features of an image so that it is easier to analyze or interpret. Enhancement techniques include contrast enhancement, sharpening, and noise reduction. With increased contrast, details in the image that were previously invisible can become clearer, helping in the identification and analysis of important features. Image sharpening enhances edges and contours, making boundaries between objects clearer and making edge detection or object recognition easier. (Sun, 2022)

Enhancement techniques also include methods for reducing noise that often obscures important details in an image. Filters such as Gaussian blur are used to smooth images and reduce noise without losing important details. Histogram equalization is a very effective technique for evenly distributing pixel intensity, thereby increasing the overall image contrast. With these various enhancement techniques, images can be better prepared for further analysis or applications that require high visual quality. The calculations used in the enhancement process are shown in the following calculations:

$$s_k = \left[(L-1) \sum_{j=0}^{k} \frac{n_j}{N} \right] \quad (2)$$

where:
- s_k = is the new intensity value
- L = the total number of possible intensities
- n_j = number of pixels with intensity j
- N = the total number of pixels in the image

This formula is used to increase image contrast by involving pixel intensity transformation using the cumulative distribution of the image histogram.

Convolution

Convolution is a basic technique in image processing that is used to change the original

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image by applying filters or kernels. The convolution process involves mathematical calculations between the kernel (a small matrix) and each pixel in the image, resulting in an image that is modified in a certain way. Convolution techniques can be used for various purposes such as image smoothing to reduce noise, sharpening to highlight important details, edge detection to identify sharp changes in intensity, or noise reduction to improve the visual quality of an image. (Li, Z et al, 2022)

Applications of convolution are often performed using various pre-designed filters, such as Gaussian filters for smoothing or Sobel kernels for edge detection. In MATLAB, users can easily apply convolution operations using the imfilter function, which allows effective manipulation of images according to the needs of specific analysis or image processing applications. (Su, Y et al, 2023) Thus, convolution not only allows better visual modification of images, but also improves analysis and interpretation capabilities in the context of image processing. The calculations used in the convolution process are shown in the following calculations:

$$(I * K)(x, y) = \sum_{i=-\infty}^{\infty} \sum_{j=-\infty}^{\infty} I(i, j) \, . \, K(x - i, y - j) \quad (3)$$

The calculation above is a convolution between an image ***I*** and a kernel ***K*** can be represented in the form of mathematical symbols, here, *(I * K) (χ , γ)* shows the new pixel value in position *(χ , γ)* in the image resulting from convolution between images *I* and kernels *K*. This operation involves redirecting the kernel *K* along each pixel *I (i,j)* in the image, multiplying it by the corresponding pixel value of the image, and then adding the results to produce a new pixel value in the convolved image. The kernel K can be a small matrix, such as: *= [0 0 9; 0 0 0; -0 -0 -9];*

Matlab 2018b

MATLAB 2018b offers a wide range of features and significant updates in image processing and numerical computing. This version features improved computing performance and speed, as well as better integration with modern development environments and hardware. Users can take advantage of new features such as deep learning support with Network Analyzer, which makes it easier to develop and analyze neural network models. Apart from that, there are improvements to image processing tools such as Image Segmenter which makes it easier to segment objects in images using various techniques such as active contours and graph-based segmentation. (Rackauckas, n.d.)

In addition to these new features, MATLAB 2018b also offers a variety of new tools for data analysis and visualization, such as Live Editor which allows users to run interactive MATLAB code and immediately see the results. With better integration with the graphical user interface (GUI), MATLAB 2018b makes it easier for users to run simulations, data analysis, and algorithm development more efficiently. Overall, MATLAB 2018b is a powerful update that expands capabilities and improves the user experience in a variety of scientific and engineering applications. (Kumar, 2022).

Method

This research was conducted to classify types of mango fruit diseases using image processing techniques for mango fruit images (*image processor*). Several stages of image processing must be carried out. However, before entering the image processing stage, the dataset must first be collected. The collected data will then be divided into training data, test data, and validation data so that it can be processed up to the classification stage. Figure 1 presents the stages carried out.

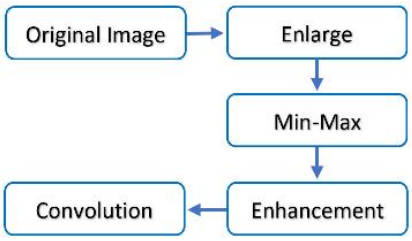

Figure 1. Processing stages

Research data

In this research, the image dataset was obtained from the Kaggle website. Images are selected randomly based on disease infections detected from the observed images. The images used were 40 images which were divided into four classes with each class namely, 10 images of alternaria, 10 images of anthtracnose, 10 images of black mold rot, and 10 images of stem end rot.

RESULTS AND DISCUSSION

To test for diseases in the observed mango fruit, initial images were taken of the condition of the mango fruit which was truly healthy and had characteristics free from the mango diseases discussed in this paper. Figure 2 presents Healthy mango fruit.

Figure 2. Healthy mango fruit

In the next process, the stage of image processing of mangoes infected with disease is carried out. Image processing starts from enlarging the image, detecting edges in the image, reducing and eliminating noise, increasing image contrast and smoothing the image so that it is easy to observe later. Figure 3 presents the results of image processing process the image processing process fruit.

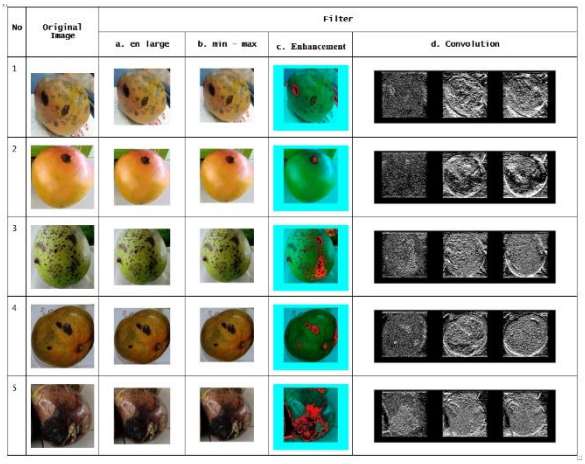

Figure 3. The results of the image processing process

From the results of the image processing carried out, the disease detection process is very easy to observe. This can be seen from pictures 1 to 5. These pictures show the automatic detection of diseases found in mangoes using Matlab. In the enhancement algorithm section, it is clear that disease-infected mango fruit can be displayed by eliminating noise and using color contrast so that disease infection is detected. In the next image, using the convolution algorithm technique, you can get a much more complex image by including embossed elements to give a three-dimensional effect, as if the image is embossed or has a relief, thus creating the illusion of depth and texture in the resulting convolution image which consists of three picture.

CONCLUSIONS

The research carried out really allows us to quickly and accurately detect and recognize diseases that attack mangoes and can provide input to mango sorters so that truly healthy quality mangoes are selected. This image processing process is also very fast so it can reduce the time for manually sorting mangoes.

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