Algorithm of Weed Detection in Crops by Using Matlab

Abstract:

This research has been based on the use of precision agriculture tools for the management of weeds in crops. It has focused on the creation of an image-processing algorithm to detect the existence of weeds in a specific site of crops. The main objective has been to obtain a formula so that a weed detection system can be developed through binary classifications. The initial step of image processing is the detection of green plants in order to eliminate all the soil in the image, reducing information that is not necessary. Then, it has focused on the vegetation by segmentation and eliminating unwanted information through medium and morphological filters. Finally, a labeling of objects has been made in the image so that weed detection can be done using a threshold based on the area of detection. This algorithm establishes an accurate monitoring of weeds and can be implemented in automated systems for the eradication of weeds in crops, either through the use of automated sprayers for specific site or a weedcutting mechanism. In addition, it increases the performance of operational processes in crop management, reducing the time spent searching for weeds throughout a plot of land and focusing weed removal tasks on specific sites for effective control.

Keywords: Image processing, weed detection, crop monitoring, morphological filters, precision agriculture

CHAPTER 1

INTRODUCTION

At present, many smart agriculture tasks, such as plant disease detection, crop yield prediction, species identification, weed detection, and water and soil conservation, are realized through computer vision technology. Weed control is an important means to improve crop productivity. Considerable literature has proposed precise variable spraying methods to prevent waste and herbicide residual problems caused by the traditional full-coverage spraying. To achieve precise variable spraying, a key issue that should be solved is how to realize real-time precise detection and identification of crops and weeds

According to, a study carried out by professors of the Faculty of Agronomy of the University of Buenos Aires (FAUBA), has estimated that at least some 1,300 million dollars are destined every year for the control of weeds. Most people who practice agricultural activity for export, are people who use conventional methods for land treatment, irrigation and crop management, maintaining the quality of the product at an outstanding level. Despite the high quality of the national product, the outstanding quality standards developed countries have not yet achieved. The disparity lies in the use of new technologies to improve and optimize the processes of soil study and crop management. information that allows decision-making during the campaign, provide data to build the record of the sites on which long-term actions can be designed term, detect the entry of invasive species, not yet present in the lot and provide bases for precision agriculture and specific site management of inputs

Methods for realizing field weed detection by using computer vision technology mainly include traditional image processing and deep learning, They have either provided a comprehensive overview of the methods applied in the entire agricultural field or conducted the latest research on a certain type of technology for a specific task Weeds can cause significant economic losses for farmers by competing with crops for nutrients, water, and sunlight. Manual weed management can be time-consuming and labor-intensive, which is why automated weed detection and management systems are becoming increasingly popular. This algorithm leverages the power of computational vision to identify and distinguish between crops and weeds in digital images. By analyzing features

such as color, texture, and shape, the algorithm can accurately detect and locate weeds in the image. The algorithm is designed to work with a variety of crops and weeds, making it a versatile tool for farmers and agronomists. It can be used to monitor weed growth over time, assess the effectiveness of weed management strategies, and provide early warning of weed infestations

The idea of making an algorithm that by means of image processing detects the weeds that are located in a specific area of plantation then arises. This methodology is advantageous because it offers a technological tool for farmers throughout the process of sowing, growing and harvesting crops. In addition, it increases the performance of operational processes in crop management, reducing the time spent searching for weeds throughout a plot of land and focusing weed removal tasks on specific sites for effective control

Introduction to Image Processing:

Image processing in MATLAB is a powerful tool for manipulating digital images. MATLAB provides a variety of built-in functions and tools for performing operations such as image enhancement, image filtering, image segmentation, and image analysis. These operations can be used for a wide range of applications, from medical imaging to surveillance systems. MATLAB also allows for the development of custom image processing algorithms using its programming language, which enables researchers and developers to create highly specialized tools for their specific needs. Additionally, MATLAB has a user-friendly interface that allows for easy experimentation with different image processing techniques, making it an excellent tool for both beginners and experts in the field

There are two types of methods used for image processing namely, analogue and digital image processing. Analogue image processing can be used for the hard copies like printouts and photographs. Image analysts use various fundamentals of interpretation while using these visual techniques. Digital image processing techniques help in manipulation of the digital images by using computers. The three general phases that all types of data have to undergo while using digital technique are pre-processing, enhancement, and display, information extraction.

MATLAB is a data analysis and visualisation tool designed to make matrix manipulation as simple as possible. In addition, it has powerful graphics capabilities and its own programming language.

The basic MATLAB distribution can be expanded by adding a range of toolboxes, the one relevant to this course is the image-processing toolbox (IPT). The basic distribution and all of the currently available toolboxes are available in the labs. The basic distribution plus any installed toolboxes will provide a large selection of functions, invoked via a command line interface

Precision Agriculture (PA):

Precision Agriculture (PA) is a modern farming approach that uses technology to improve agricultural practices by optimizing inputs, reducing waste, and increasing yields. The history of PA can be traced back to the 1980s when researchers and farmers began using new technologies to improve agricultural productivity. In the early days of PA, farmers began using GPS and other mapping technologies to create precise field maps.

These maps allowed farmers to identify variations in soil type, moisture content, and other environmental factors that affect crop growth. By using this information, farmers could tailor their crop management strategies to specific areas of their fields, rather than treating the entire field uniformly. As technology continued to advance, new tools became available to help farmers optimize their use of inputs such as fertilizer, water, and pesticides. For example, variable rate technology (VRT) allows farmers to apply inputs at variable rates depending on the specific needs of each area of the field. This technology can save farmers money on inputs while also reducing the environmental impact of agriculture. Another key development in the history of PA has been the use of sensors and other monitoring tools to collect data on crop growth and environmental conditions.

This data can be used to create predictive models that help farmers make informed decisions about when to plant, irrigate, and harvest their crops. Today, PA continues to evolve as new technologies become available. For example, the use of drones and other unmanned aerial vehicles (UAVs) is becoming increasingly common in agriculture, providing farmers with a new way to collect data and monitor their crops. Overall, the history of PA demonstrates how technology can be used to improve agricultural productivity and sustainability, while also reducing the environmental impact of agriculture. As technology continues to advance, it is likely that PA will become an even more important part of modern farming practices.

CHAPTER 2

LITERATURE SURVEY

[1] **M. A. Molina-Villa y L. E Solaque Guzmán:** "Machine vision system for weed detection using image filtering in vegetables crops", Facultad de Ingeniería Universidad de Antioquia, vol. 80, pp. 124-130, 2016

This work presents a machine vision system for weed detection in vegetable crops using outdoor images, avoiding lighting and sharpness problems during acquisition step. This development will be a module for a weed removal mobile robot with camera obscura (Latin for "dark room") for lighting controlled conditions. The purpose of this paper is to develop a useful algorithm to discriminate weed, using image filtering to extract color and area features, then, a process to label each object in the scene is implemented, finally, a classification based on area is proposed, including sensitivity, specificity, positive and negative predicted values in order to evaluate algorithm performance

Summary: A machine vision system using image filtering for weed detection in vegetable crops

[2] **K. R. Thorp and L. F. Tian:** "A review on remote sensing of weeds in agriculture", Precision Agriculture, p. 477–508, 2004.

Remote sensing refers to the use of sensors and other technologies to collect data from a distance, such as from satellites, drones, or ground-based instruments. In the context of agriculture, remote sensing can be used to monitor and manage crops, including identifying and mapping weeds. remote sensing has the potential to improve weed management in agriculture by enabling more precise and targeted interventions, such as targeted herbicide application or mechanical weed removal. However, there are also challenges associated with implementing these technologies in real-world agricultural settings, such as the cost of equipment and the need for accurate and timely data analysis

Summary: Remote sensing is a valuable tool for detecting and mapping weeds in agriculture, allowing for more efficient and targeted weed management practices.

[3] **B. I. Justusson :** "Median filtering : Statistical properties" , in Two-Dimensional Digital Signal Processing II Berlin, Springer, 1981, pp. 161- 196.

Median filtering is a nonlinear signal processing technique useful for noise suppression. It was suggested as a tool in time series analysis by Tukey in 1971 and has later on come into use also in picture processing. Median filtering is performed by letting a window move over the points of a picture (sequence) and replacing the value at the window center with the median of the original values within the window. This yields an output picture (sequence) which usually is smoother than the original one. The classical smoothing procedure is to use a linear low-pass filter and in many cases this is the most appropriate procedure. However, in certain situations median filtering is better and two of its main advantages are: I) Median filtering preserves sharp edges, whereas linear low-pass filtering blurs such edges. II) Median filters are very efficient for smoothing of spiky noise. We illustrate these properties

Summary: Median filtering is a robust statistical technique that reduces the impact of outliers on the processed signal/image.

[4] **R. Kumar, K. Rama reddy and B. Rao**: "A simple region descriptor based on object area per scan line," International Journal of Computer Applications, vol. 3, no. 7, pp. 24-27, 2010.

In the field of image processing, identifying object is based on appropriately chosen descriptors. The proper choice of descriptors in pattern recognition is the most sensitive criteria as small misjudgments may lead to wrong identification. There have been several algorithms proposed and worked in this field. Here, the idea is to identify the objects in an uncomplicated method while being computationally efficient. This paper is based on identifying the patterns of objects / polygons based on the recording area of the objects per line scan. The descriptors here are invariant to translation and become invariant to scaling after normalization. Here the objects considered are regular polygons in various background conditions. In order to reduce the noise, after segmentation by thresholding along with labeling and area filtering is done. Along with polygon identification, descriptors for all the numbers are also shown. In order to identify the objects, the average magnitude difference function (AMDF) is applied to each characteristic curve. This paper also shows that though AMDF is a dissimilarity measure, it works better here than auto correlation function (ACF), which is a similarity measure.

Summary: Region descriptor based on object area per scan line explained simply.

[5] **J. L. Tang, X. Q. Chen, R. H. Miao and D. Wang:** "Weed detection using image processing under different illumination for site-specific areas spraying," Computers and Electronics in Agriculture, vol. 122, pp. 103- 111, 2016..

Traditional methods have the problems of high light and sample quality etc requirements. Therefore, accurately identifying weeds and precisely spraying are important strategies for promoting agricultural sustainable development. To avoid the influence of different illumination on images, this paper adopts the color model and then proposes component to gray images; the vertical projection method and the linear scanning method are combined to quickly identify the center line of the crop rows; the classic Weeds Infestation Rate is modified to decrease the computational complexity and the improved horizontal scanning method is taken to calculate within cells; finally, Modified Weeds Infestation Rate is used to realize real-time decision through the minimum error ratio of Bayesian decision under normal distribution. The experimental results show that the accuracy of this algorithm is 92.5%, which exceeds the BP algorithm and SVM algorithm.

Summary: Detecting weed with images for targeted spraying in varying light conditions.

[6] **A. Paikekari, V. Ghule, R. Meshram and V. B. Raskar:** "Weed detection using image processing", International Research Journal of Engineering and Technology (IRJET), vol. 3, no. 3, pp. 1220-1222, 2016.

Agriculture is one of the origins of human sustenance in this world. Nowadays due to growing population we need the greater productive capability of the agriculture to meet the demands. In olden days, people used natural methods to increase the productivity, such as using the cow dung as a fertilizer in the fields we have implemented some methods to reduce the usage of herbicides by spraying them only in the areas where weed is present. In this paper, we have implemented image processing using MATLAB to detect the weed areas in an image we took from the fields. In recent years, as the world population growth, existing land and natural resources decreased, the precision agriculture is increasingly capturing more attention of the researchers. Image processing approaches could be applied to solve this problem

Summary: weed detection using image processing in Matlab is a promising approach for improving crop management and reducing the environmental impact of agriculture

CHAPTER 3

EXISTING METHOD

The control of weeds is of vital importance in agriculture, these are unwanted by the farmer since they are causing several problems in the crop. Among its negative effects is the contamination of production, shelter of insects and diseases, facilitates the growth of other pests and increases irrigation costs. The monitoring of these weeds allows us to detect the presence and/or abundance of weeds, gather information that allows decision-making during the campaign, provide data to build the record of the sites on which long-term actions can be designed term, detect the entry of invasive species, not yet present in the lot and provide bases for precision agriculture and specific site management of inputs

1. **Image Acquisition:** The first step in the algorithm is to acquire images of the crops and weeds. The images can be captured using cameras mounted on drones or ground vehicles.
2. **Pre-processing:** The acquired images may contain noise and artifacts, which can affect the accuracy of the weed detection algorithm. Therefore, pre-processing steps such as noise reduction, image enhancement, and normalization are applied to ensure that the images are of high quality**.**
3. **Segmentation:** The next step is to segment the image into regions that contain crops and weeds. This can be done using thresholding, edge detection, or region-based segmentation methods.
4. **Feature Extraction:** Once the regions are segmented, features such as color, texture, and shape are extracted from the regions. These features are used to classify the regions as either containing crops or weeds.
5. **Classification:** The extracted features are used to train a classifier, which can distinguish between crops and weeds. Various machine learning algorithms can be used for classification, including support vector machines, decision trees, and neural networks.
6. **Post-processing**: Finally, post-processing steps such as morphological operations, filtering, and clustering are applied to refine the classification results and remove false positives

it is important to include detailed descriptions of each step, including the specific methods and parameters used. Additionally, the performance of the algorithm should be evaluated using metrics such as accuracy, precision, recall, and F1 score

Image acquisition is the first step in the algorithm for weed detection in crops using computational vision, and it involves acquiring images of the crops and weeds. There are several methods for acquiring images, but some of the most common ones include using cameras mounted on drones or ground vehicles. Using drones to capture images of crops and weeds has become increasingly popular due to their ability to cover large areas quickly and capture images from various angles. Drones can be equipped with cameras that capture high-resolution images, which can be used to detect weeds with high accuracy. Ground-based vehicles can also be used to capture images of crops and weeds. These vehicles can be equipped with cameras that are mounted on a boom or a pole, which allows them to capture images from different heights and angles. However, ground-based vehicles are typically slower than drones and can cover less area in a given amount of time. When acquiring images, it is important to consider factors such as lighting conditions, weather conditions, and the height and angle of the camera. The images should be captured in such a way that the crops and weeds are clearly visible and can be accurately segmented and classified using computational vision algorithms. Previous studies have based their criteria for selection on an index that stands out green component of source image as the NDVI (Normalized Difference Vegetation Index) and SAVI (Soil Adjusted Vegetation Index)

What is Normalized Difference Vegetation Index?

Normalized Difference Vegetation Index (NDVI) is a commonly used remote sensing index that measures the difference between near-infrared (NIR) and visible red (RED) reflectance of vegetation. NDVI is often used to quantify vegetation growth and health, as it correlates well with the amount and condition of vegetation. Diabetic retinopathy typically affects both eyes and can occur in anyone with diabetes, whether it is type 1 or type 2. The risk of developing diabetic retinopathy increases the longer a person has diabetes, and it is more common in people who have poorly controlled blood sugar levels, high blood pressure, and high cholesterol.

To calculate NDVI in Matlab, you can use the following equation:

$$\mathbf{NDVI = (NIR - RED) / (NIR + RED)}$$

where NIR and RED are the reflectance values for near-infrared and red bands, respectively. Refraction test

What is Soil Adjusted Vegetation Index?

Soil Adjusted Vegetation Index (SAVI) is a vegetation index used to assess the density of vegetation cover in a given area. It is an improved version of the Normalized Difference Vegetation Index (NDVI) which was developed to compensate for the influences of soil background reflectance in remote sensing data. The SAVI formula incorporates a soil adjustment factor to reduce the influence of soil reflectance on the NDVI values, which may be high in arid and semi-arid regions where the soil is often exposed. This helps to produce more accurate estimates of vegetation cover density in these regions.

The formula for SAVI is as follows:

SAVI = ((NIR - Red) / (NIR + Red + L)) x (1 + L)

where: NIR = Near-Infrared band reflectance

Red = Red band reflectance

L = Soil adjustment factor (0 to 1)

The soil adjustment factor, L, is determined based on the vegetation cover and soil conditions in the study area. A low value of L is used in areas with low vegetation cover, whereas a high value is used in areas with dense vegetation cover. SAVI has many applications in environmental monitoring, agricultural management, and land use planning. It can be used to estimate vegetation growth, monitor crop health, and detect changes in land use patterns.

Disadvantages in Existing Method:

- Limited accuracy.
- High computational requirements
- Difficulty in detecting small weeds
- Limited scalability
- lack of robustness

CHAPTER 4

PROPOSED METHOD

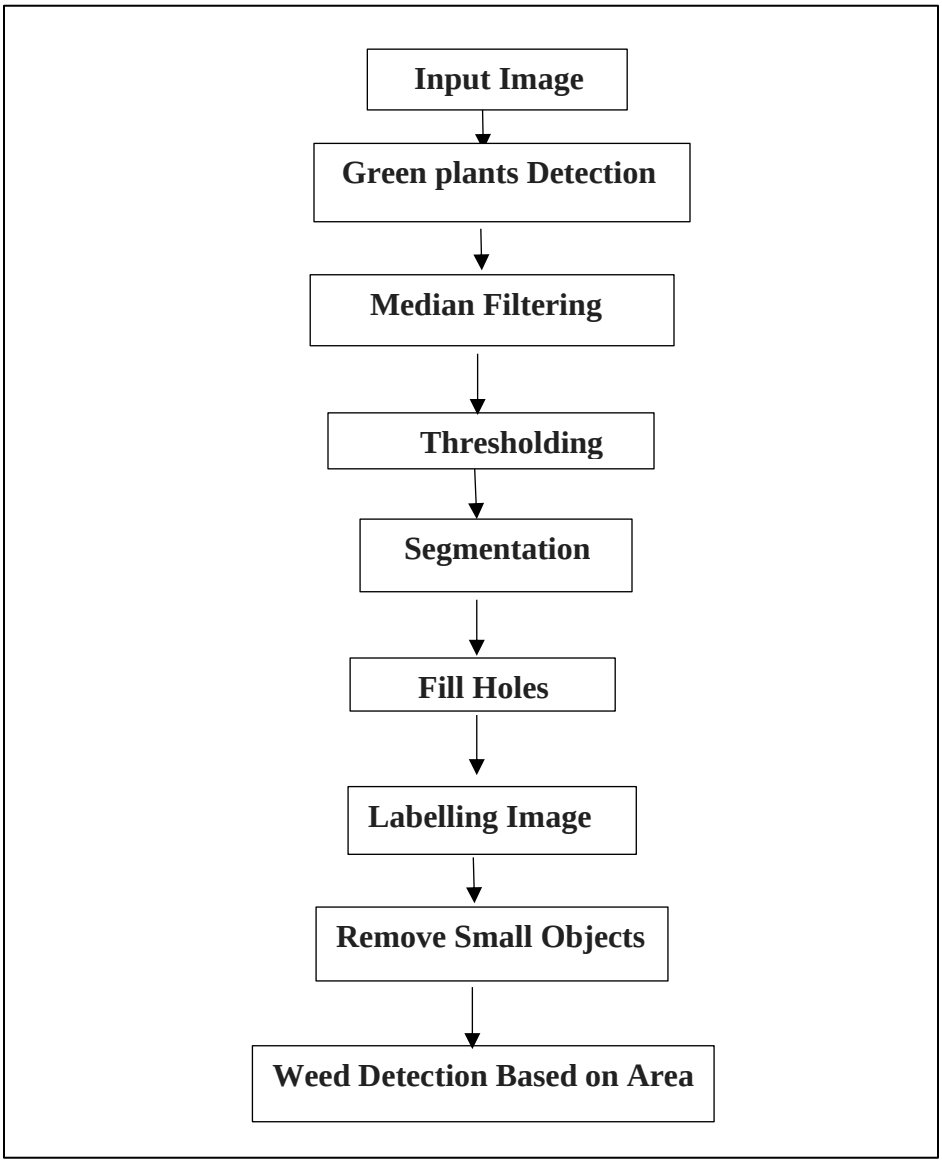

Fig: Block Diagram

Acquisition of the Image:

The ability to acquire own images and use them for the tests of the algorithm is advantageous, because in this way, the algorithm will adapt to the characteristics of the images obtained. It has been proposed to use a semi-professional camera of 24.2 megapixels with the ability to take photographs at 1080 pixels resolution, enough to capture good quality images. The images were

acquired at a height of 1.20 meters from the surface of the ground, this height was set to obtain a good resolution of the crop and the weeds on the surface. Each acquired image has a resolution of 4512x3000 pixels, which results in it covering an area of 180x120 cm above the crop. The position of the camera was positioned vertically to avoid shadows and ensure uniform illumination. The proposed algorithm considers the processing of images that contain uniform illumination; images with better illumination are processed with greater precision

Image preprocessing:

Preprocessing of an image refers to a series of operations that are applied to an image before performing a specific task, such as object detection, recognition, or segmentation. The main purpose of preprocessing is to enhance the quality of an image, reduce noise, and extract relevant features for further analysis.

Preprocessing techniques include operations such as resizing, cropping, color correction, filtering, segmentation, thresholding, and normalization. These operations may be applied individually or in combination, depending on the specific requirements of the task at hand.

For example, resizing an image may be necessary to reduce the computational cost of a task, while color correction may be needed to ensure consistency across images. Filtering can be used to remove noise from an image, while segmentation can be used to separate different objects in an image.

Overall, preprocessing plays a critical role in image analysis by improving the quality and relevance of the data used for further analysis.

RGB To Gray Converter:

RGB2GRAY is a commonly used image processing technique that converts a color image represented in the Red-Green-Blue (RGB) color space into a grayscale image. In the RGB color space, each pixel of an image is represented by three values, indicating the intensity of the red, green, and blue components of the color. To convert an RGB image to grayscale, the intensity values of the three color channels are weighted and combined to produce a single grayscale value for each pixel. The most common method of doing this is the luminosity method, where the red, green, and blue components are weighted according to their perceived brightness by the human eye.

Green Channel Extraction:

Green channel extraction is a common technique used in image processing to extract the green color component from an RGB (red, green, blue) color image. In RGB images, each pixel is represented as a combination of red, green, and blue intensities, and the green channel refers to the intensities of the green color component. The green channel is often extracted because it can contain the most important information in an image, especially in natural scenes where there is a lot of greenery. For example, in a landscape photo, the green channel may contain the most important details about the foliage and the grass. Green channel extraction can be useful for a variety of image processing tasks, such as color correction, image segmentation, and feature extraction. However, it's important to note that the green channel may not always contain the most important information in an image, depending on the content of the image.

Substraction of Image:

the source image is converted to grayscale intensity whereby the hue and saturation information is eliminated while retaining the luminance, this operation can be performed through the function rgb2gray of Matlab 2020a. Taking advantage of the RGB components of the image, all the components in the XY space that correspond to the green value in the image, are subtracted from the grayscale image to separate the vegetation from the other components

The operation that makes this stage possible is shown in equation

$$\mathbf{I\ Plant(X,Y)= I\ Green(X,Y,G)– I\ Gray(X,Y)}$$

Medium Filter and Threshold Segmentation:

The median filter is used regularly to reduce noise in images with subtraction of components like the one that has been used in this process. This filter works by replacing the central pixel of a region called neighborhood, in this case a neighborhood of 3x3 pixels, creating a mask over the image. The value of the center of the mask is replaced with the calculation of the median of the values of the neighborhood pixels This operation can be executed through the function medfilt2 of Matlab 2020a.

Once the medium filter is applied, the image must be segmented. For the segmentation it is recommended to use the Otsu method described in , one of the most famous methods and used for this type of applications.

Thresholding Image:

Thresholding is a commonly used image processing technique in Matlab to segment images based on pixel intensity values. It involves setting a threshold value, and all pixels with intensity values above or below the threshold are classified as foreground or background

The selection of an appropriate threshold is carried out with image histogram, taking the valium t calculated by the operation gray thresh of Matlab2020a, the value of t is based on the average intensity value of the light and dark areas of the image

In MATLAB, thresholding has been a part of the Image Processing Toolbox since its inception. The toolbox provides a range of thresholding functions, including global thresholding, adaptive thresholding, and multi thresholding. The earliest version of MATLAB with the Image Processing Toolbox was released in 1993, and it included a basic thresholding function called "Imthreshold." This function could be used to apply a global threshold to an image, setting all pixel values below the threshold to 0 and all pixel values above the threshold to 1. Over the years, MATLAB's thresholding capabilities have been expanded and improved. In 1998, MATLAB introduced the "gray thresh" function, which calculates a global threshold using Otsu's method, a widely used algorithm for automatically determining the optimal threshold value for an image. In 2006, MATLAB added the "adapt thresh" function, which performs adaptive thresholding on an image by calculating a local threshold for each pixel based on the intensity values of neighboring pixels. This approach is particularly useful for images with uneven lighting or variations in contrast. In 2013, MATLAB added the "multi thresh" function, which can be used to segment images with multiple thresholds. This function is particularly useful for segmenting images with multiple regions or objects of interest. Today, thresholding remains an essential tool in MATLAB's Image Processing Toolbox, with a range of thresholding functions available for various applications.

Segmentation:

Segmentation is an important image processing technique used in MATLAB to separate the foreground objects from the background in an image. The purpose of segmentation is to simplify

and/or change the representation of an image into something that is more meaningful and easier to analyze. The main purpose of segmentation in MATLAB is to identify regions of interest in an image, which can then be analyzed further. Some common applications of image segmentation include object recognition, image compression, image enhancement, and image analysis. For example, in medical imaging, segmentation can be used to isolate specific tissues or organs for further analysis or to identify tumors. In surveillance systems, segmentation can be used to detect and track moving objects in a video stream. In MATLAB, there are various segmentation techniques available such as thresholding, clustering, region growing, edge-based segmentation, and morphological operations. Each technique has its own advantages and limitations and the choice of technique depends on the specific application and the properties of the image being segmented.

Segmentation is a key process in image processing, which involves partitioning an image into several regions or segments based on their pixel intensity, color, texture, or other features. MATLAB, a popular software tool for image processing, provides various segmentation techniques that are widely used in research and industry.

1. Convert Image to Binary Image Based on threshold:

The binary function in MATLAB is used to convert a grayscale or RGB image to a binary image. The function takes an input image and a threshold value as arguments and returns a new binary image, where pixel values below the threshold are set to 0 and pixel values equal to or above the threshold are set to 1.

The binary function can also be used with RGB images, in which case it converts the image to grayscale first before applying the threshold. The im2bw function is useful in image processing tasks where it is necessary to extract objects or features from an image based on their intensity values. For example, in medical imaging, it can be used to segment areas of an image that correspond to different tissue types, such as bone and soft tissue This operation can be done using Convert Image to Binary Image, im2bw of Matlab 2020a

Morphological filters:

Morphological filters are a type of image processing technique that operate on the geometric structure of an image. They are used to perform operations such as erosion, dilation, opening, and

closing on binary or grayscale images. The purpose of morphological filters is to modify the shape and size of objects in an image, to remove noise and unwanted features, and to enhance the structural characteristics of an image. Morphological filters are commonly used in a variety of applications, including image segmentation, object recognition, and pattern analysis

morphological filters are used to enhance the quality of images, to remove noise and unwanted features, and to improve the accuracy of image processing applications

1. Morphological filters using Filling image region holes:

Morphological filters are a type of image processing technique used to modify or enhance the geometric structure of an image. The purpose of morphological filters is to extract important features of an image such as edges, boundaries, and shapes, by analyzing the shape, size, and spatial relationship of the image pixels. The main purpose of morphological filters is to remove unwanted noise or smooth out an image by removing small and irrelevant details, while preserving important structural features. They are also used to segment images into different regions based on their shapes, sizes, or connectivity. Morphological filters operate on binary or grayscale images and are based on mathematical operations such as erosion, dilation, opening, and closing. Erosion is used to shrink the size of an object in an image, while dilation is used to enlarge the size of an object. Opening is a combination of erosion and dilation, which is used to remove small details from an image, while closing is a combination of dilation and erosion, which is used to fill in small gaps in an image. Morphological filters are commonly used in various applications such as medical image processing, computer vision, robotics, and pattern recognition

The classification of the labels is based on the area of each object, it is convenient to fill the holes in the objects of the image. Therefore, a filter based on morphological reconstruction should be applied in order to fill the holes and obtain a more effective area

The methodology iterates until all holes of the objects in the image are filled. This operation can be done using the morphological operators imfill of Matlab2020a

2. Morphological Operations on binary Images:

Morphological operations on binary images are a type of image processing technique that modifies or enhances the geometric structure of an image composed of only two colors, typically black and

white. These operations are based on set theory and mathematical morphology, and are used to analyze the shape, size, and spatial relationship of the image pixels. The two main morphological operations on binary images are erosion and dilation. Erosion is a process that removes small structures in an image, by shrinking the boundaries of the foreground object, while dilation expands the boundaries of the foreground object, making it larger. In erosion, a structuring element (also known as a kernel) is used to slide over the image and if all the pixels under the kernel are white, the center pixel is set to white. If there is even a single black pixel under the kernel, the center pixel is set to black.

This process is repeated for every pixel in the image, resulting in the foreground object becoming smaller and the holes within the object getting larger. In dilation, the same process is applied, but in the opposite direction. If at least one pixel under the kernel is white, the center pixel is set to white. If all the pixels are black, the center pixel is set to black. This process is repeated for every pixel in the image, resulting in the foreground object becoming larger and the holes within the object getting smaller. Other morphological operations on binary images include opening, closing, and boundary extraction. Opening is a combination of erosion followed by dilation, which is used to remove small objects and thin out the remaining objects in the image. Closing is the opposite, where dilation is followed by erosion, and is used to fill in small gaps and connect broken parts of an object. Boundary extraction is used to extract the boundary of an object in the image. Morphological operations on binary images are widely used in applications such as edge detection, object recognition, and image segmentation.

The methodology iterates Operations on binary Images. This operation can be done using the morphological operators bwmorph of Matlab2020a

Labeling and classification labels:

The function takes a binary image as an input and returns a new image, where each connected component is labeled with a unique integer value. The labeled output image can be used to perform various operations on the connected components of the binary image, such as measuring their properties, counting their number, or separating them from each other

The implementation of bwlabel in MATLAB uses a depth-first search algorithm to identify and label connected groups of pixels. The algorithm starts at a pixel with a value of 1 and explores all

its neighboring pixels that also have a value of 1. If a group of connected pixels is found, the algorithm assigns a unique label to that group and continues searching for additional groups until all pixels in the binary image have been labeled. In later versions of MATLAB, additional functions such as bwlabel in were introduced to handle labeling of connected components in higher dimensions and with more complex connectivity requirements. Overall, the introduction of bwlabel in MATLAB has greatly simplified the task of labeling connected components in binary images and has enabled more efficient and accurate image analysis and processing.

To identify the objects in the image as plants it is necessary to label them, the labels are rectangles that border the areas of all the identified objects, this is a crucial step since those labeled areas can be extracted characteristics. The region labeling stage evaluates each pixel with a 4 neighbor-connectivity, using a heuristic stated on pixel values according to predecessor labels at north and west position. The computational tool to perform this step is the bwlabel operator of Matlab2020a

Remove Small Objects:

removing small objects from an image is a common image processing task. The purpose of removing small objects is to eliminate small features or noise in the image that may interfere with subsequent analysis. Removing small objects in MATLAB can be done using the remove small object function. This function removes all connected components (objects) that have fewer pixels than a specified threshold value. The function takes two input arguments: the binary image and the minimum area size (in pixels) that you want to keep. The output is a binary image with the small objects removed

Measure The Properties of Image Regions:

The image region function in MATLAB is used to extract measurements and statistics of connected regions (objects) in a binary or grayscale image. It calculates properties such as area, perimeter, centroid, bounding box, eccentricity, orientation, and many more for each connected region in the image once objects on the scene are labeled, the next step is to extract area features from each element to discriminate weed and crop. The algorithm defines an area counting the number of pixels in the object region; then, the value is stored for all items. The extraction of characteristics of areas in images is done through of the region props function of Matlab2020a

It is used to extract a specific field from a structure array and return its values as a cell array or numeric array. the only way to extract a field from a structure array was to use a loop or other repetitive code to iterate over each element in the array and extract the field value. This could be time-consuming and inefficient, especially for large arrays. The algorithm performs two stages of discarding to identify weeds, the first consists in eliminating those areas that are too small to be considered considerable weeds.

rectangle bounding box is often used to define the extent of an object or region of interest within an image. The purpose of the bounding box is to enclose the object or region of interest within a rectangle that is aligned with the image axes. This allows for easy visualization and manipulation of the object or region of interest. The rectangle bounding box can be defined using the coordinates of the upper-left corner of the box and its width and height. This information can be used in various image processing operations such as object detection, object tracking, and image segmentation. For example, in object detection, the bounding box can be used to isolate the object of interest from the background, and to determine its location and size.

In image segmentation, the bounding box can be used to define the region of interest that is to be segmented. Overall, the rectangle bounding box is a useful tool in MATLAB for a wide range of image processing tasks.

After the first discard stage, a threshold based on the classification of weeds is defined by the difference between the average values of the largest areas corresponding to crop plants. The average value of the crop is calculated, this value is taken as the threshold for crop and weed classification. The value of the threshold is compared with the size of all the objects in the image. If the area of the analyzed object is smaller than the threshold value extract field has become a widely used function in MATLAB and has been included in subsequent versions of the software. It is a useful tool for data analysis and processing tasks, especially when working with large datasets that contain complex structures. The summary of the procedure to develop the algorithm for weed detection is presented

One of the earliest approaches to weed detection through computational vision was the use of traditional image processing techniques such as thresholding, edge detection, and segmentation. These techniques were used to identify and isolate weed patches from crop images. However, the accuracy of these techniques was limited due to variability in lighting and crop growth conditions.

In recent years, researchers have turned to machine learning algorithms, particularly deep learning, to improve the accuracy of weed detection in crops. Deep learning algorithms such as convolutional neural networks (CNNs) have been used to classify images of crops and weeds, enabling more accurate and reliable weed detection. Today, several companies and research institutions are developing and testing algorithms for weed detection in crops through computational vision. These algorithms have the potential to reduce the need for herbicides and other chemical treatments in agriculture, leading to more sustainable and environmentally friendly farming practices.

Analysis:

By displaying the detected weeds on top of the original image, users can easily see where the weeds are located and verify their accuracy. This can help farmers or researchers to make informed decisions about weed control and management strategies. Additionally, MATLAB provides powerful tools for image processing and visualization, making it a popular choice for implementing computational vision algorithms for weed detection and other applications.

the algorithm are defined by the average of its specificity and sensitivity To check both indexes it is necessary to tabulate the following variables

1.True Positive:

true positive is a term used in the context of binary classification, which involves classifying data into one of two possible categories. A "true positive" occurs when a data point is correctly classified as belonging to the positive category by a machine learning model. The concept of true positives has its roots in the field of statistics and has been used in various forms for decades. However, its use in the context of machine learning and computer science has become more prevalent in recent years as the use of machine learning algorithms has grown.

The true positive (TP) is the number of positive cases that are correctly identified by the model. It can be calculated using the following formula:

TP = sum ((predicted label == 1) & (actual label == 1))

where predicted label is a vector containing the predicted class labels for each observation, actual label is a vector containing the true class labels, and "==" denotes element-wise equality. The "&"

operator represents element-wise logical AND operation, and the "sum" function computes the total number of elements that are true

2. True Negative:

true negative is a term used in the context of binary classification problems. It refers to the situation where a model correctly predicts that a sample does not belong to a certain class. The concept of true negatives can be traced back to the development of the confusion matrix, also known as the error matrix or contingency table. This matrix is a tool used to evaluate the performance of binary classification models by comparing the predicted and actual class labels of a set of samples.

TP = sum ((predicted label == 0) & (actual label == 0))

where "predicted" is the vector of predicted labels (0 for negative, 1 for positive), and "actual" is the vector of actual labels. The "&" symbol performs element-wise logical AND operation

3. False Positive:

false positive occurs when a test or algorithm incorrectly indicates the presence of something that is actually absent. In the context of MATLAB, false positives can occur in a variety of situations, such as statistical hypothesis testing, signal processing, and image processing

FP = sum ((predicted labels == 1) & (true labels == 0))

Here, "predicted labels" is a vector of predicted class labels generated by the classifier, and "true labels" is a vector of true class labels. The "&" operator performs an element-wise logical AND operation, and the "sum" function adds up the number of True values in the resulting vector.

4.False Negative:

The concept of False Negative (FN) is commonly used in machine learning and statistics to evaluate the performance of classification models In, the False Negative formula is often expressed in terms of the confusion matrix. The confusion matrix is a table that summarizes the performance of a classification model by comparing the actual class labels with the predicted class labels. It is a 2 x 2 matrix that shows the number of true positives (TP), false positives (FP), false negatives (FN), and true negatives (TN)

FP = sum ((predicted labels == 0) & (true labels == 1))

Here, "predicted labels" is a vector of predicted class labels generated by the classifier, and "true labels" is a vector of true class labels. The "&" operator performs an element-wise logical AND operation, and the "sum" function adds up the number of True values in the resulting vector.

Specificity:

In MATLAB, specificity refers to the ability to specify certain elements or parts of an array or matrix based on certain criteria or conditions. The concept of specificity in MATLAB can be traced back to its early versions, as MATLAB has always been designed to provide powerful and flexible indexing and slicing capabilities for manipulating matrices and arrays. One of the earliest features for specifying specific elements of a matrix was the use of linear indexing, where elements of a matrix could be accessed using a single index number that corresponds to the linear index of the element in the matrix.

This feature was introduced in the early versions of MATLAB and is still widely used today. In later versions of MATLAB, more advanced indexing techniques were introduced, including logical indexing and conditional indexing. Logical indexing allows users to select specific elements of a matrix based on a logical condition, while conditional indexing allows users to select elements based on a conditional expression. MATLAB also provides a number of built-in functions that allow users to specify specific elements of a matrix based on certain criteria, such as find(), which returns the indices of nonzero elements in a matrix, or sort(), which sorts the elements of a matrix in ascending or descending order. Overall, the concept of specificity has been a core feature of MATLAB since its inception, and its indexing and slicing capabilities have only become more powerful and flexible over time

Specificity = TN / (TN + FP)

Sensitivity:

Sensitivity analysis is a widely used technique in engineering and scientific fields to study how the output of a system or process changes in response to variations in its input parameters. In MATLAB, sensitivity analysis has been a fundamental feature since its early versions. The first version of MATLAB was released in 1984, but sensitivity analysis capabilities were not included until the release of the Control System Toolbox in 1990.

The toolbox introduced a range of functions for analyzing and designing control systems, including sensitivity analysis tools. Over the years, MATLAB has continued to develop and enhance its sensitivity analysis capabilities. In the late 1990s, the Optimization Toolbox was introduced, which provided additional optimization and sensitivity analysis tools. In 2000, the Global Optimization Toolbox was added, which allowed for the efficient optimization of systems with multiple inputs and outputs.

In more recent versions of MATLAB, sensitivity analysis has been further improved with the introduction of advanced tools such as the Sensitivity Analysis Tool (SAT) and the Simulink Design Optimization (SDO) tool. SAT provides a graphical interface for visualizing sensitivity analysis results, while SDO allows for the optimization of Simulink models with sensitivity analysis. Today, MATLAB is widely used in academic and industrial settings for sensitivity analysis and other types of optimization and analysis tasks. Its advanced features and powerful tools make it a popular choice for engineers and scientists who need to perform complex analyses of systems and processes.

Specificity = TN / (TN + FP)

Positive Predictive Value:

Positive Predictive Value (PPV) is a statistical metric used to measure the performance of a binary classification model. It represents the proportion of true positive predictions out of all positive predictions made by the model. PPV is also known as precision in machine learning. MATLAB is a numerical computing environment and programming language widely used in various fields, including data science and machine learning. It provides several built-in functions and tools for calculating PPV and evaluating the performance of classification models. The history of PPV in MATLAB can be traced back to the early versions of the software, which were released in the 1980s. However, the specific implementation of PPV in may have evolved over time, as new algorithms and techniques for classification and performance evaluation were developed. One of the most commonly used functions in for calculating PPV is the confusion mat function, which computes the confusion matrix of a classification model given its predicted labels and true labels. The PPV can be obtained from the confusion matrix using the formula:

PPV = true positives / (true positives + false positives)

In addition to the confusion mat function, MATLAB also provides other functions for calculating PPV, such as precision and perf curve. These functions can be used to plot precision-recall curves and evaluate the performance of binary classification models. Overall, the history of PPV in MATLAB reflects the evolution of the field of machine learning and the development of new algorithms and tools for performance evaluation. Today, MATLAB remains a popular choice for data scientists and machine learning practitioners who want to implement and evaluate classification models

Negative Predictive Value:

Negative Predictive Value (NPV) is a statistical measure used to evaluate the performance of a diagnostic test. It is the proportion of people who test negative and are truly negative out of all the people who tested negative.

PPV = true negatives / (true negatives + false negative)

It provides a range of functions and tools for statistical analysis and modeling, including calculating NPV. The history of NPV as a statistical measure can be traced back to the early days of medical research, where it was used to evaluate the accuracy of diagnostic tests. The concept of NPV was first introduced in the medical literature in the 1970s. In, the NPV can be calculated using the function "negative predictive value." This function takes two input arguments: the number of true negatives and the number of false negatives. The output is the NPV value

Subsequently, the analysis and results of a sample image are shown. The calculations of indexes and variable counts were executed. To validate the image processing algorithm, the algorithm was tested on 36 crop images of multiple vegetables, this in order to be able to average the appropriate specificity and sensitivity of the algorithm. Table 2 shows the results of the corresponding sample

the sensitivity result of the algorithm is 97%, which indicates a good performance of the algorithm proposed to detect weeds correctly. On the other hand, the specificity value of 79% represents the ability of the system to correctly detect the vegetables. Comparing the specificity and sensitivity indexes, the specificity is of lower index because several of the acquired images were from sections of crops that the crop plants were the same size as the weed. As a result, the algorithm detects the vegetable as a weed and increases the FP variable.

For this reason, the high value of FP affects the effectiveness of the algorithm's specificity. The index of positive predictive value is 99% which indicates that in almost all cases, the weed was correctly identified. In contrast, the negative predictive value is 47% which indicates that the vegetables detected were not always vegetables, this is due to cases where the weeds were almost the same size as the crop plants.

CHAPTER 5

ADVANTAGES AND APPLICATIONS

Advantages:

- Increased efficiency
- detect weeds in real-time
- Flexibility.
- Sustainability.

Applications:

Applications of Proposed method are:

- Precision agriculture
- Crop monitoring
- Research
- yield optimization

CHAPTER 6

RESULTS

Fig1: Original Image

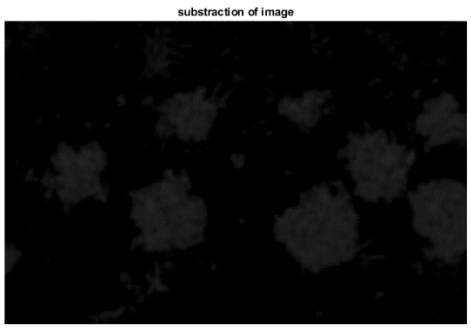

Fig2:Substraction of Image

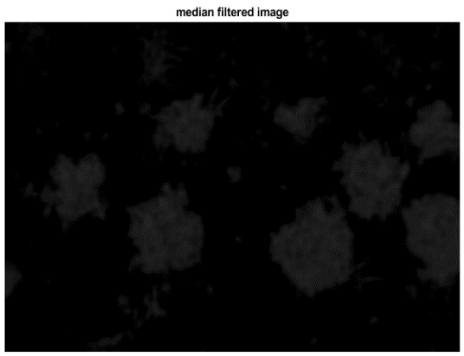

Fig3: Median Filtered Image

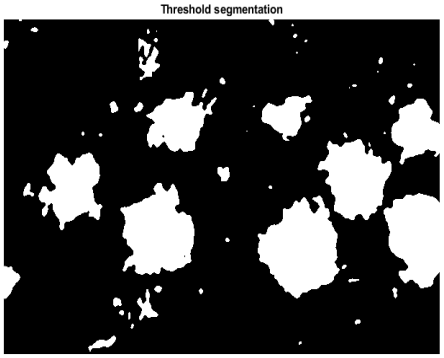

Fig4:Threshold Segmentation Image

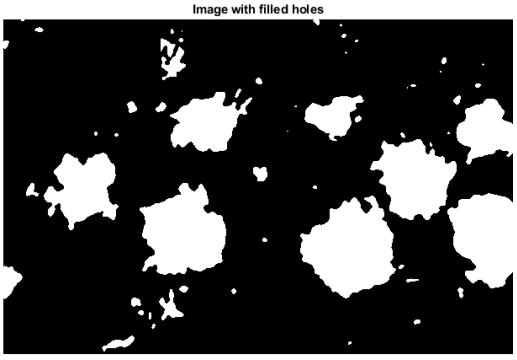

Fig5: Filled holes Image

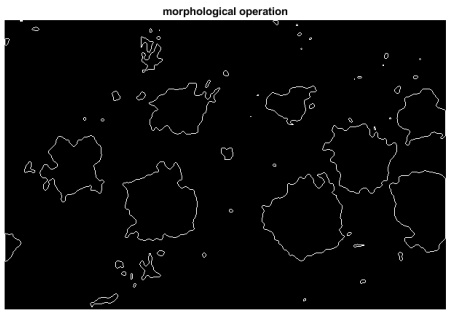

Fig6: Morphological Operation

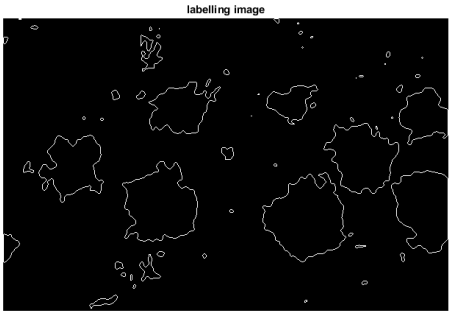

Fig7: Labelling Image

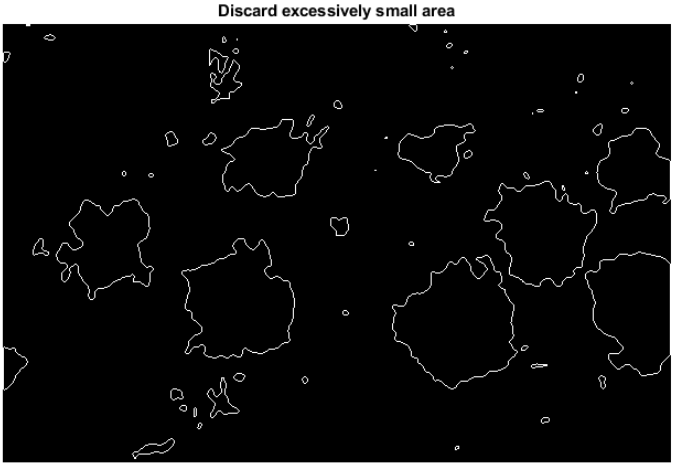

Fig8: Discard excessively small areas

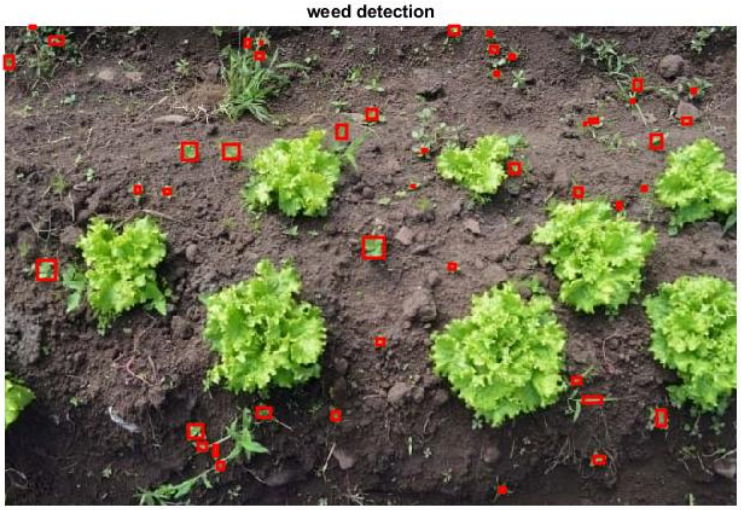

Fig9: Weed Detection Image

CHAPTER 7

CONCLUSION

This research has proposed a practical way to detect weeds by image processing based on the characteristic of the area of each object in an image. Although research has been limited in that the size of the weed is smaller than that of the crop, high indices of sensitivity, specificity and positive predictive value have been achieved, contrary to the negative predictive value, which is lower than 50%. The proposed algorithm has the advantage of detecting weeds present between the plants in the crop lines. It also detects effectively as crop plants even those that are outside the crop lines, which is an objective difficult to achieve with other methods using computational vision. However, the algorithm loses effectiveness when the sizes of the weeds are similar to the sizes of the plants of the crop, since the characteristic that is taken as variable of classification is the size of the plants. This problem can be solved by adding another characteristic as a classification method. The use of low level characteristics such as the color of the plants and the area is an advantage given that the specific characteristics of the weeds as texture or shape are not relevant, providing versatility for the application of the algorithm in different crops of vegetables. This advantage is important, due to the great variety and types of weeds that exist in crops. A specific database of weeds is not necessary to be able to train the algorithm and identify weeds, as an automatic learning algorithm would do. It was concluded that the proposed algorithm using low level characteristics and a threshold based on the area, have an improvement field in the specificity indexes and NPV, but the results are good enough to use the algorithm in practical applications of precision agriculture.

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Introduction To Matlab

What Is MATLAB?

The name MATLAB stands for Matrix Laboratory. The software is built up around vectors and matrices. This makes the software particularly useful for linear algebra but MATLAB is also a great tool for solving algebraic and differential equations and for numerical integration. MATLAB has powerful graphic tools and can produce nice pictures in both 2D and 3D. It is also a programming language, and is one of the easiest programming languages for writing mathematical programs. These factors make MATLAB an excellent tool for teaching and research.

MATLAB was written originally to provide easy access to matrix software developed by the LINPACK (linear system package) and EISPACK (Eigen system package) projects. It integrates computation, visualization, and programming environment. Furthermore, MATLAB is a modern programming language environment: it has sophisticated data structures, contains built-in editing and debugging tools, and supports object-oriented programming. MATLAB has many advantages compared to conventional computer languages (e.g., C, FORTRAN) for solving technical problems.

MATLAB abilities a family of add-on software program utility software application software program software utility software-unique solutions called toolboxes. Very essential to maximum customers of MATLAB, toolboxes assist you to studies and observe specialized technology. Toolboxes are entire collections of MATLAB abilities (M-files) that increase the MATLAB surroundings to remedy precise schooling of problems. Areas in which toolboxes are to be had embody signal processing, manipulate systems, neural networks, fuzzy correct judgment, wavelets, simulation, and hundreds of others.

It has powerful built-in routines that enable a very wide variety of computations. It also has easy to use graphics commands that make the visualization of results immediately available. Specific applications are collected in packages referred to as toolbox. There are toolboxes for

signal processing, symbolic computation, control theory, simulation, optimization, and several other fields of applied science and engineering. MATLAB is an interactive system whose basic data element is an array that does not require dimensioning. The software package has been commercially available since 1984 and is now considered as a standard tool at most universities and industries worldwide.

Brief History of MATLAB:

Cleve Moler, the chairman of the computer science department at the University of New Mexico, started developing MATLAB in the late 1970s. The first MATLAB® was not a programming language; it was a simple interactive matrix calculator. There were no programs, no toolboxes, no graphics and no ODEs or FFTs. He designed it to give his student's access to LINPACK and EISPACK without them having to learn FORTRAN. It soon spread to other universities and found a strong audience within the applied mathematics community. The mathematical basis for the first version of MATLAB was a series of research papers by J. H. Wilkinson and 18 of his colleagues, published between 1965 and 1970 and later collected in Handbook for Automatic Computation, Volume II, Linear Algebra, edited by Wilkinson and C. Reinsch. These papers present algorithms, implemented in Algol 60, for solving matrix linear equation and Eigen value problems.

In the 1970s and early 1980s, I was teaching Linear Algebra and Numerical Analysis at the University of New Mexico and wanted my students to have easy access to LINPACK and EISPACK without writing FORTRAN programs. By "easy access," I meant not going through the remote batch processing and the repeated edit-compile-link-load-execute process that was ordinarily required on the campus central mainframe computer. Jack little, an engineer, was exposed to it during a visit Moler made to Stanford University in 1983. Recognizing its commercial potential, he joined with Moler and Steve Bangert. They rewrote MATLAB in C and founded Math Works in 1984 to continue its development. These rewritten libraries were known as JACKPAC. In 2000, MATLAB was rewritten to use a newer set of libraries for matrix manipulation, LAPACK. MATLAB was first adopted by researchers and practitioners in control engineering, Little's specialty, but quickly spread to many other

domains. It is now also used in education, in particular the teaching of linear algebra and numerical analysis, and is popular amongst scientists involved in video processing**.**

EISPACK and LINPACK:

In 1970, a group of researchers at Argonne National Laboratory proposed to the U.S. National Science Foundation (NSF) to "explore the methodology, costs, and resources required to produce, test, and disseminate high-quality mathematical software and to test, certify, disseminate, and support packages of mathematical software in certain problem areas." The group developed EISPACK (Matrix Eigen system Package) by translating the Algol procedures for Eigen value problems in the handbook into FORTRAN and working extensively on testing and portability. The first version of EISPACK was released in 1971 and the second in 1976.

In 1975, four of us Jack Dongarra, Pete Stewart, Jim Bunch, and myself proposed to the NSF another research project that would investigate methods for the development of mathematical software. A byproduct would be the software itself, dubbed LINPACK, for Linear Equation Package. This project was also centered at Argonne. LINPACK originated in FORTRAN; it did not involve translation from Algol. The package contained 44 subroutines in each of four numeric precisions. In a sense, the LINPACK and EISPACK projects were failures. We had proposed research projects to the NSF to "explore the methodology, costs, and resources required to produce, test, and disseminate high-quality mathematical software." We never wrote a report or paper addressing those objectives. We only produced software.

So, I studied Niklaus Wirth's book Algorithms + Data Structures = Programs and learned how to parse programming languages. I wrote the first MATLAB an acronym for Matrix Laboratory in FORTRAN, with matrix as the only data type. The project was a kind of hobby, a new aspect of programming for me to learn and something for my students to use. There was never any formal outside support, and certainly no business plan. This first MATLAB was just an interactive matrix calculator. This snapshot of the start-up screen shows all the reserved words and functions. There are only 71. To add another function, you had to get the source code from

me, write a FORTRAN subroutine, add your function name to the parse table, and recompile MATLAB.

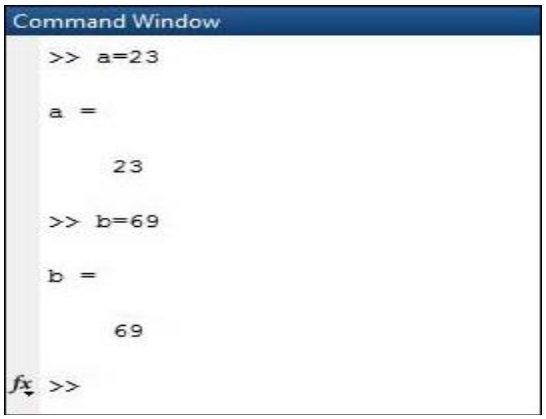
Starting MATLAB:

After logging into your account, you can enter MATLAB by double-clicking on the MATLAB shortcut icon (MATLAB 7.0.4) on your Windows desktop. When you start MATLAB, a special window called the MATLAB desktop appears. The desktop is a window that contains other windows. The major tools within or accessible from the desktop are:

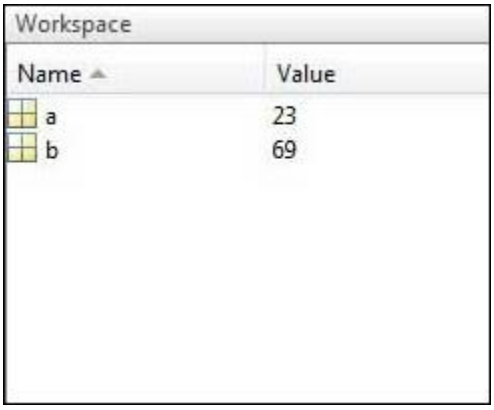
- The Command Window
- The Command History
- The Workspace
- The Current Directory
- The Help Browser

Current Folder: This panel allows you to access the project folders and files.

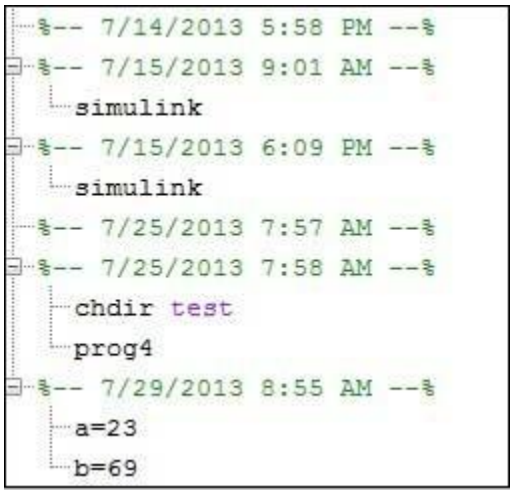
Command Window: This is the main area where commands can be entered at the command line. It is indicated by the command prompt (>>).



Workspace: The workspace shows all the variables created and/or imported from files.



Command History: This panel shows or return commands that are entered at the command line.



Help Browser:

The critical way to get assist online is to use the MATLAB help browser, opened as a separate window every through clicking at the question mark photograph (?) on the computing tool toolbar, or through manner of typing assist browser on the spark off in the command window. The assist Browser is an internet browser blanketed into the MATLAB computing tool that shows a Hypertext Markup Language (HTML) files. The Help Browser consists of panes, the help navigator pane, used to find out information, and the show pane, used to view the information. Self-explanatory tabs apart from navigator pane are used to performs are searching out.

MATLAB language:

This is a high-level matrix/array language with control flow statements, functions, data structures, input/output, and object-oriented programming features. It allows both "programming in the small" to rapidly create quick and dirty throw-away programs, and "programming in the large" to create complete large and complex application programs.

MATLAB working environment:

This is the set of tools and facilities that you work with as the MATLAB user or programmer. It includes facilities for managing the variables in your workspace and importing and exporting data. It also includes tools for developing, managing, debugging, and profiling M-files, MATLAB's applications.

MATLAB mathematical function library:

This is a vast collection of computational algorithms ranging from elementary functions like sum, sine, cosine, and complex arithmetic, to more sophisticated functions like matrix inverse, matrix eigenvalues, Bessel functions, and fast Fourier transforms.

MATLAB Application Program Interface (API):

This is a library that allows you to write C and FORTRAN programs that interact with MATLAB. It includes facilities for calling routines from MATLAB (dynamic linking), calling MATLAB as a computational engine, and for reading and writing MAT-files.

MATLAB DESKTOP:

MATLAB Desktop is the precept MATLAB utility window. The computing tool includes five sub home windows, the command window, the workspace browser, the modern-day-day list window, the command records window, and one or greater decide domestic windows, which is probably confirmed high-quality on the identical time due to the truth the client suggests a photo. The command window is in which the character types MATLAB instructions and expressions at the spark off (>>) and in which the output of these commands is displayed. MATLAB defines the workspace because the set of variables that the client creates in a bit consultation. The workspace browser suggests those variables and some facts about them. Double clicking on a variable within the workspace browser launches the Array Editor, which may be used to gain statistics and profits instances edit exceptional homes of the variable.

The modern-day-day-day Directory tab above the workspace tab suggests the contents of the cutting-edge list, whose path is shown inside the modern-day list window. For example, in the home windows on foot machine the path is probably as follows: C: MATLAB Work, indicating that listing “artwork” is a subdirectory of the number one list “MATLAB”; WHICH IS INSTALLED IN DRIVE C. Clicking on the arrow within the modern list window suggests a listing of these days used paths. Clicking at the button to the right of the window permits the individual to trade the present day listing. MATLAB uses a seeking out path to find out M-documents and one-of-a-type MATLAB associated documents, which can be put together in directories within the computer document tool. Any report run in MATLAB need to be dwelling in the modern-day-day listing or in a list that is on is looking for course. By default, the documents supplied with MATLAB and math works toolboxes are included inside the searching out direction. The first-rate manner to look which directories are on the searching out route. The satisfactory manner to appearance which directories are speedy the quest route, or to characteristic or regulate a searching for course, is to pick out outset path from the File menu the computing device, and then use the set course talk discipline. It is proper exercise to feature any generally used directories to the hunt route to avoid again and again having the exchange the cutting-edge-day listing.

The Command History Window contains a file of the instructions a person has entered in the command window, together with every contemporary-day and former MATLAB periods. Previously entered MATLAB instructions can be determined on and re-completed from the command statistics window thru proper clicking on a command or series of commands. This movement launches a menu from which to select numerous options similarly to executing the commands. This is useful to select out abilities options in addition to executing the instructions. This is a beneficial feature at the equal time as experimenting with numerous commands in a piece session.

Using the MATLAB Editor to create M-Files:

The MATLAB editorial manager is a literary substance proofreader particular for growing M-facts and a graphical MATLAB debugger. The supervisor can seem in a window through command facts technique for itself, or it is probably a right-clicking inside the PC. M-information this gadget signified through the use of the expansion .M, as in pixel up.M. The MATLAB editorial supervisor window has a few draws down menus for obligations collectively with sparing, seeing, and troubleshooting facts. Since it plays more than one easy test and furthermore affects utilization of shade to separate among exclusive variables of code, this article editorial supervisor is often supported due to reality the system of a need for composing and altering M-talents. To open the manager, type at enact opens the M-document filename. M in a supervisor window, sorted out for enhancing. As stated earlier than, the file should be inside the cutting-edge posting, or in a posting in the seeking out direction.

Features of MATLAB:

Following are the basic features of MATLAB.

- It is a high-level language for numerical computation, visualization and application development.
- It also provides an interactive environment for iterative exploration, design and problem solving.
- It provides vast library of mathematical functions for linear algebra, statistics, Fourier analysis, filtering, optimization, numerical integration and solving ordinary differential equations.

- It provides built-in graphics for visualizing data and tools for creating custom plots.
- MATLAB's programming interface gives development tools for improving code quality maintainability and maximizing performance.
- It provides tools for building applications with custom graphical interfaces.
- It provides functions for integrating MATLAB based algorithms with external applications and languages such as C, Java, .NET and Microsoft Excel.

Uses of MATLAB:

MATLAB is widely used as a computational tool in science and engineering encompassing the fields of physics, chemistry, math and all engineering streams. It is used in a range of applications including

- Signal Processing and Communications
- Video and Video Processing
- Control Systems
- Test and Measurement
- Computational Finance
- Computational Biology
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Applications of MATLAB:

MATLAB can be used as a tool for simulating various electrical networks but the recent developments in MATLAB make it a very competitive tool for Artificial Intelligence, Robotics, Video processing, Wireless communication, Machine learning, Data analytics and whatnot. Though it’s mostly used by circuit branches and mechanical in the engineering domain to solve a basic set of problems its application is vast. It is a tool that enables computation, programming and graphically visualizing the results. The basic data element of MATLAB as the name suggests is the Matrix or an array. MATLAB toolboxes are professionally built and enable you to turn your imaginations into reality. MATLAB programming is quite similar to C programming and just requires a little brush up of your basic programming skills to start working with.

Below are a few applications of MATLAB –

- **Statistics and machine learning (ML)**

This toolbox in MATLAB can be very handy for the programmers. Statistical methods such as descriptive or inferential can be easily implemented. So is the case with machine learning. Various models can be employed to solve modern-day problems. The algorithms used can also be used for big data applications.

- **Curve fitting**

The curve fitting toolbox helps to analyze the pattern of occurrence of data. After a particular trend which can be a curve or surface is obtained, its future trends can be predicted. Further plotting, calculating integrals, derivatives, interpolation, etc. can be done.

- **Control systems**

Systems nature can be obtained. Factors such as closed-loop, open-loop, its controllability and observability, Bode plot, NY Quist plot, etc. can be obtained. Various controlling techniques such as PD, PI and PID can be visualized. Analysis can be done in the time domain or frequency domain.

- **Signal Processing**

Signals and systems and digital signal processing are taught in various engineering streams. But MATLAB provides the opportunity for proper visualization of this. Various transforms such as Laplace, Z, etc. can be done on any given signal. Theorems can be validated. Analysis can be done in the time domain or frequency domain. There are multiple built-in functions that can be used.

- **Mapping**

Mapping has multiple applications in various domains. For example, in Big Data, the Map Reduce tool is quite important which has multiple applications in the real world. Theft analysis or financial fraud detection, regression models, contingency analysis, predicting techniques in social media, data monitoring, etc. can be done by data mapping.

- **Deep learning**

It's a subclass of machine learning which can be used for speech recognition, financial fraud detection, and medical video analysis. Tools such as time-series, Artificial neural network (ANN), Fuzzy logic or combination of such tools can be employed.

- **Financial analysis**

An entrepreneur before starting any endeavor needs to do a proper survey and the financial analysis in order to plan the course of action. The tools needed for this are all available in MATLAB. Elements such as profitability, solvency, liquidity, and stability can be identified. Business valuation, capital budgeting, cost of capital, etc. can be evaluated.

- **Video processing**

The most common application that we observe almost every day are bar code scanners, selfie (face beauty, blurring the background, face detection), video enhancement, etc. The digital video processing also plays quite an important role in transmitting data from far off satellites and receiving and decoding it in the same way. Algorithms to support all such applications are available.

- **Text analysis**

Based on the text, sentiment analysis can be done. Google gives millions of search results for any text entered within a few milliseconds. All this is possible because of text analysis. Handwriting comparison in forensics can be done. No limit to the application and just one software which can do this all.

- **Electric vehicles designing**

Used for modeling electric vehicles and analyze their performance with a change in system inputs. Speed torque comparison, designing and simulating of a vehicle, whatnot.

- **Aerospace**

This toolbox in MATLAB is used for analyzing the navigation and to visualize flight simulator.

- **Audio toolbox**

Provides tools for audio processing, speech analysis, and acoustic measurement. It also provides algorithms for audio and speech feature extraction and audio signal transformation.

DIGITAL IMAGE/VIDEO PROCESSING

Digital image processing:

Digital Image Processing means processing digital image by means of a digital computer. We can also say that it is a use of computer algorithms, in order to get enhanced image either to extract some useful information.

Image:

An image is defined as a two-dimensional function, F(x, y), where x and y are spatial coordinates, and the amplitude of F at any pair of coordinates (x, y) is called the intensity of that image at that point. When x, y, and amplitude values of F are finite, we call it a digital image. In other words, an image can be defined by a two-dimensional array specifically arranged in rows and columns. Image is composed of a finite number of elements, each of which elements have a particular value at a particular location. These elements are referred to as picture elements, image elements, and pixels.

A Pixel is most widely used to denote the elements of an Image. To be processed digitally, it has to be **sampled** and transformed into a matrix of numbers. Since a computer represents the numbers using finite precision, these numbers have to be **quantized** to be represented digitally. Digital image processing consists of the manipulation of those finite precision numbers. The processing of digital images can be divided into several classes: **image enhancement, image restoration, image analysis,** and image compression.

How a digital image is formed?

Since capturing an image from a camera is a physical process. The sunlight is used as a source of energy. A sensor array is used for the acquisition of the image. So when the sunlight falls upon the object, then the amount of light reflected by that object is sensed by the sensors, and a continuous voltage signal is generated by the amount of sensed data. In order to create a digital image, we need to convert this data into a digital form. This involves sampling and

quantization. (They are discussed later on). The result of sampling and quantization results in a two-dimensional array or matrix of numbers which are nothing but a digital image.

Image processing mainly include the following steps:

- Importing the image via image acquisition tools.
- Analyzing and manipulating the image.
- Output in which result can be altered image or a report which is based on analyzing that image.

An image can be portrayed as a - dimensional trademark f(x, y), in which x and y are spatial directions, and the sufficiency of any combine of instructions (x, y) is known as the pressure or darkish degree of the image at that inconvenience. Whenever x, y and the abundance estimations of f are on the entire confined discrete quantities, we call the picture a virtual photo. The district of DIP alludes to getting ready computerized photo through strategies for to method for MATLAB. Manner of the use of advanced pc. Computerized image incorporates of a confined form of things, every one in every of which has a chosen location and fee. The components are alluded to as pixels.

Vision is the maximum innovative of our sensor, so it isn't sudden that photograph play the unmarried greatest important component in human conviction. Nonetheless, in appraisal to humans, who are controlled to the visible band of the EM variety imaging machines cover nearly the complete EM range, starting from gamma to radio waves. They can highlight also on previews created with the valuable useful manual of benefits that people aren't conscious of accomplice with airship picture. There isn't commonly any present settlement among creators concerning in which photo managing stops and specific associated districts nearby aspect photo evaluation& workstation imaginative and prescient start.

In a few instances a difference is made through the use of characterizing picture handling as an area wherein each the information and yield at a way are snap shots. This is constraining and predominantly manufactured restriction. The district of image investigation (photograph getting to know) is in amongst photograph getting ready and PC imaginative and insightful. There aren't any easy restrictions in the continuum from picture preparing at one prevent to complete ingenious and sensible on the inverse. In any case, one precious worldview is to revel

in as a primary challenge three types of automatic procedures in this continuum: low-, mid-, and radical affirmation methodologies. Low-certificate way includes crude obligations which incorporates image preparing to reduce clamor, appraisal improvement and photo cleansing. A low-certificates approach is described through the way that very it inputs and yields are previews.

Mid-degree method on photographs incorporates of commitments which exemplify division, depiction of that question decreases them to a form becoming for pc getting ready and category of man or woman devices. A mid-degree method is portrayed thru technique for the reality that its resources of info broadly speaking are images anyway its yields are residences extricated from the one's photographs. At lengthy remaining better-degree making ready carries "Making history" of a meeting of analyzed gadgets, as in photo assessment and at a broadened path give up of the continuum performing the psychological abilities often connected with human imaginative and prescient. Computerized image making ready, as formally depicted is utilized accurately in a huge kind of locales of astonishing social and financial price.

PHASES OF IMAGE PROCESSING:

- **Acquisition:**

It could be as simple as being given an image which is in digital form. The main work involves: a) Scaling b) Color conversion (RGB to Gray or vice-versa).

- **Image enhancement:**

It is amongst the simplest and most appealing in areas of Image Processing it is also used to extract some hidden details from an image and is subjective.

- **Image restoration:**

It also deals with appealing of an image but it is objective (Restoration is based on mathematical or probabilistic model or image degradation).

- **Color image processing:**

It deals with pseudo color and full color image processing color models are applicable to digital image processing.

- **Wavelets and Multi-resolution processing:**

  It is foundation of representing images in various degrees.

- **Image compression:**

  It involves in developing some functions to perform this operation. It mainly deals with image size or resolution.

- **Morphological processing:**

  It deals with tools for extracting image components that are useful in the representation & description of shape.

- **Segmentation:**

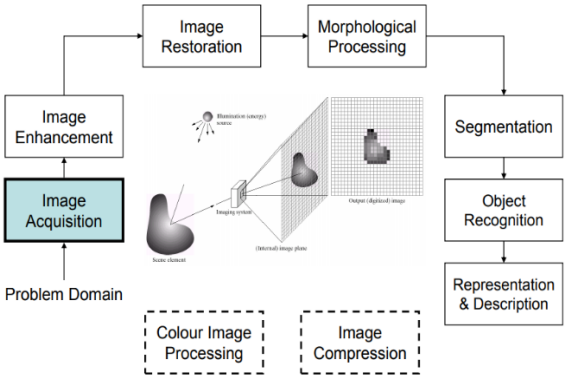
  It includes partitioning an image into its constituent parts or objects. Autonomous segmentation is the most difficult task in Image Processing.

- **Representation and description:**

  It follows output of segmentation stage, choosing a representation is only the part of solution for transforming raw data into processed data.

- **Object detection and recognition:**

  It is a process that assigns a label to an object based on its descriptor.



Color image:

It may be spoken to with the aid of techniques for manner of three capacities, R (xylem) for purple, G (xylem) for inexperienced and B (xylem)for blue. An image may be nonstop with

renowned to the x and y arranges and moreover in sufficiency. Changing over this type of picture to digital form requires that the guidelines in addition to the adequacy to be digitized. Digitizing the set up's qualities is called analyzing. Digitizing the abundancy esteems is known as quantization.

Grayscale image: *f*

The image has 8 bits and 256 tons of grey; 1 = black and 255 = white. *f* Requires 8 times more saving space than a line-art image. Suitable for presenting black and white photographs, for instance. Can be used in printing office.

Image Types:

The tool compartment underpins 4 types of images:

1. Intensity of pixels;

2. Twofold images;

3. Filed images;

4. R G B images.

Most monochrome image making ready sports are finished utilizing parallel or force pix, so our underlying highlight is on this image composes. Filed and RGB shading images.

Intensity Images:

A profundity picture is a measurement lattice whose traits were scaled to talk to goals. At the point while the components of a profundity photo are of class unit8, or elegance unit sixteen, they have complete quantity traits in the collection [0,255] and [0, 65535], for my part. On the off danger that the picture is of class twofold, the qualities are skimming phase numbers. Estimations of scaled, twofold pressure images are within the assortment [0, 1] by means of methods for subculture.

Binary Images:

Double depictions have a completely unique because of this in MATLAB.A parallel photograph is a sensible cluster 0s and1s.Thus, a variety of 1s whose features are of

measurements excellence, say unit8, and isn't always concept approximately as a twofold image in MATLAB .A numeric show off is modified to paired the utilization of spotlight coherent. In this manner, if A can be a numeric showcase along problem 1s, we make a cluster B using the announcement.

B=logical (A)

In the event that A contains of elements separated from 0s and 1s. Use of the intelligent capability changes over all nonzero segments to sensible 1s and all sections with rate 0 to coherent 0s. Utilizing social and valid administrators further makes clever well-known shows. To take a look at if a cluster is coherent, we make use of the I practical trademark: is logical(c). In the occasion that c is a coherent show off, this trademark restores a 1. Otherwise returns a zero. Consistent cluster is probably modified over to numeric reveals the utilization of the statistics style transformation presents.

Indexed Images:

Framework define a m*3 kind of magnificence twofold containing skimming trouble esteems within the assortment [0, 1]. The duration m of the guide is identical to the huge sort of shades it characterizes. Each line of manual suggests the blood pink, green and blue brought materials of a solitary shading. Recorded pix make utilization of "coordinate mapping" of pixel electricity esteems shading map esteems. The tinge of every pixel is resolved through way of using the relating rate the whole range grid x as a pointer in to delineate. On the off danger that x is of modernity twofold, at that factor the majority of its segments with values masses substantially less than or indistinguishable to no less than one difficulty to the crucial column in delineate, brought materials with fee 2 thing to the second line et cetera. In the event that x is of complexity devices or unit 16, at that factor all delivered substances fee zero thing to the important line in outline, introduced materials with charge 1 aspect to the second et cetera.

RGB Image:

A RGB shading photograph is a M*N*three exhibit of tinge pixels wherein each coloration pixel is triplet much like the purple, inexperienced and blue brought materials of a RGB image, at a particular spatial area. A RGB image is probably considered as "stack" of three dim scale pics that after advocated in to the darkish pink, green and blue contributions of a tinge display

screen. Deliver a shading picture at the show. Tradition the three previews shaping a RGB color image are alluded to as the red, unpracticed and blue brought substances pictures. The information fashion of the brought materials images comes to a decision their form of qualities. On the off hazard that a RGB image is of modernity twofold the type of traits is [0, 1]. Correspondingly the sort of characteristics is [0,255] or [0, 65535]. For RGB pics of modernity gadgets or unit sixteen individually. The form of bits uses to speaks to the pixel estimations of the aspect pictures makes a decision the bit profundity of a RGB photo. For instance, if every aspect image is a 8bit picture, the evaluating RGB photo is expressed to be 24 bits profound. For the most part, the collection of bits in all inconvenience snap shots is the indistinguishable. For this case the type of feasible shading in a RGB photograph is (2^b) ^three, in which in b is numerous bits in the entirety about. For the 8bit case the amount is 16,777,216 colorations.

Advantages of digital image:

- The processing of images is faster and more cost-effective. One needs less time for processing, as well as less film and other photographing equipment. *f*
- It is more ecological to process images. No processing or fixing chemicals are needed to take and process digital images. However, printing inks are essential when printing digital images.
- When shooting a digital image, one can immediately see if the image is good or not. *f* copying a digital image is easy, and the quality of the image stays good unless it is compressed.
- For instance, saving an image as jpg format compresses the image. By resaving the image as jpg format, the compressed image will be recompressed, and the quality of the image will get worse with every saving.
- Fixing and retouching of images has become easier. In new Photoshop 7, it is possible to smooth face wrinkles with a new Healing Brush Tool in a couple of seconds.
- The expensive reproduction (compared with restoring the image with a repro camera) is faster and cheaper.
- By changing the image format and resolution, the image can be used in a number of media.

Applications of Digital Image Processing:

Some of the major fields in which digital image processing is widely used are mentioned below.

- Image sharpening and restoration
- Medical field
- Remote sensing
- Transmission and encoding
- Machine/Robot vision
- Color processing
- Pattern recognition
- Video processing
- Microscopic Imaging