Machine Vision Based Identification and Dimensional Measurement of Electronic Components

A Thesis
submitted towards the partial fulfillment of
requirements for the award of the degree of
Master of Engineering
(Electronics Instrumentation & Control)
Submitted by
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Under the Guidance of

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Declaration

I hereby certify that the work which is being presented in the thesis entitled, "**Machine Vision Based Identification and Dimensional Measurement of Electronic Components"** in partial fulfillment of the requirements for the award of degree of Master of Engineering in Electronics Instrumentation and Control at Electrical and Instrumentation Engineering Department of Thapar Institute of Engineering and Technology (Deemed University), Patiala, is an authentic record of my own work carried out under the supervision of Mandeep Singh (Assistant Professor) and M.D Singh (Lecturer).

The matter presented in the thesis has not been submitted by me for the award of any other degree of this or any other university.

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It is certified that the above statement made by the student is correct to the best of our knowledge and belief.

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Jainy Sachdeva

Table of Contents

Contents **Page No.**

List of Figures

Figure **Page No.**

List of Tables

Table **Page No.**

Abstract

Machine Vision is an emerging area related to real-time capturing, processing, and analyzing the images for various kinds of scientific and industrial applications. It is

robust computing tool, which provides the electronic processing of real time images underpinning for a global society in electronic business and research. It provides services in number of applications in the fields where the identification and measurements of manufactured goods such as that of semiconductor chips, automobile parts etc., is required. Manual measurement of large number of objects in any of these applications can be a tedious and time consuming process, prone to human errors. This can be automated using Machine Vision concepts.

In my thesis, I propose a technique of “Machine Vision Based Identification and Dimensional Measurement of Electronic Components” which is based on color pattern matching approach, that enables identification of an electronic component present in a group and gauging gives the dimensional measurement of the electronic component. In Machine Vision it is important to determine which course of action suits the best for processing of images in shortest amount of time, using the resources most efficiently and minimizing the cost. Image processing can be done by developing softwares using C-compiler, Matlab etc. but these methods are quite cumbersome and require great deal of programming skills. We have made use of National Instrument’s Machine Vision tool **Vision Assistant 7.1** to make the programming easy, fast and accurate. The electronic components are matched with the previously saved templates, in which their own characteristics are saved.

Organization of Thesis

The first chapter briefly introduces vision basic concepts which provide the anatomy of Machine Vision. The second chapter provides an overview of application software: Machine Vision Assistant 7.1, on which my research work is focused. Chapter third discusses the color pattern matching technique and its extension for identification of electronic components. In this chapter a robust, scalable, flexible and evolvable framework is discussed that has been demonstrated by the use of machine vision assistant 7.1, a production-quality high throughput computing system. The fourth chapter concerns the use of machine vision algorithm for dimensional measurement, finally, concluding thesis in fifth chapter with future scope.

Chapter 1: Introduction to Machine Vision Basics

1.1 Introduction

Machine Vision is an emerging area in automation and control wherein images are captured by camera in real time, which are further, processed and analyzed to get important information out of them. Sometimes processing and analysis is done on the images that are already stored in record. Machine Vision (MV) is the application of computer vision to industry and manufacturing. Whereas computer vision is mainly focused on machine-based image processing, machine vision often requires digital input/output devices and computer networks to control other manufacturing equipment such as robotic arms. Machine Vision is a subfield of engineering that encompasses computer science, optics, mechanical engineering, and industrial automation.

Computing devices in machine vision 'see' by examining individual pixels of images, process them and attempt to develop conclusions with the assistance of knowledge bases and by feature extraction. Numbers of unique processing methods have been developed to process images and identify relevant image features in an effective and consistent manner. Machine vision systems are capable of processing images consistently [1].

1.2 Image

An image is defined as the representation of the real scene, either in black and white or in color, and either in print form or in digital form. Printed images are reproduced either by multiple colors and, gray scales or by a single ink source. Most print application, only one color of ink is available (such as black ink on white paper in a newspaper or copier). In such cases changing the ratio of black versus white areas produces all gray levels. Printed images, television and digital images are divided into small sections called Picture Cells, or Pixels (in three-dimensional images these are called voxels or volume cells), where the size of each pixel is same, but the intensity of light in each pixel is varied to create the gray images. There are two types of images:

1.) Two-Dimensional Images
2.) Three-Dimensional Images

Two-Dimensional Images Two-Dimensional images are those images in which depth measurement of the scene is not required. For example: Vision system required to inspect an integrated circuit board in which there is no need for the measurement of the depth, as all the objects are mounted on the flat circuit board.

Three-Dimensional Images Three-Dimensional images are those images in which depth measurement is required, as these operations require motion detection, remote sensing, relative positioning, navigation etc. For example, in Computed Tomography (CT) scan, three-dimensional images are required. The images of the one of the slice of an object are take n at different profiles (at different angles ranging from 0 degree to 360 degrees) and are combined to form a three-dimensional image of the internal characteristic of the object.

1.3 Digital Image Basics

Digital Image Processing is done to process any image to get useful information from it. For Image processing, we must know about the image basics. These basics are given below:

1.3.1 Digital Image

An image is a 2D array of values representing light intensity. For the purposes of image processing, the term image refers to a digital image. An image is a function of the light intensity f (x, y) where f is the brightness of the point (x, y), and x and y represents the spatial coordinates of a picture element, or pixel. By convention, the spatial reference of the pixel with the coordinates (0, 0) is located at the top, left corner of the image. Notice in Figure 1.6 that the value of x increases moving from left to right, and the value of y increases from top to bottom.

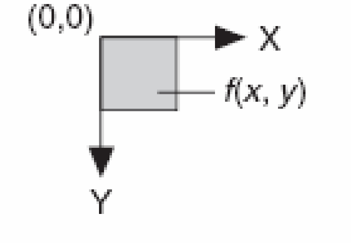


Figure1.1 Spatial reference of the (0, 0) pixel

In digital image processing, an imaging sensor converts an image into a discrete number of pixels. The imaging sensor assigns to each pixel a numeric location and a gray level or color value that specifies the brightness or color of the pixel.

1.3.2 Properties of a digitized image

A digitized image has three basic properties: resolution, definition, and number of planes. These three properties are described below:

1.) Image resolution: It is spatial resolution of an image, which is determined by its number of rows and columns of pixels. An image composed of m columns and n rows has a resolution of m × n. This image has m pixels along its horizontal axis and n pixels along its vertical axis.

2.) Image definition: It indicates the number of shades that we can see in the image. The bit depth of an image is the number of bits used to encode the value of a pixel. For a given bit depth of n, the image has an image definition of 2n, meaning a pixel can have 2n different values. For example, if n equals 8 bits, a pixel can have 256 different values ranging from 0 to 255. If n equals 16 bits, a pixel can have 65,536 different values ranging from 0 to 65,535 or from –32,768 to 32,767. The manner in which we encode our image depends on the nature of the image acquisition device, the type of image processing need to use, and the type of analysis we need to perform. For example, 8-bit encoding is sufficient if we need to obtain the shape information of objects in an image. However, if we need to precisely measure the light intensity of an image or region in an image, we must use 16-bit or floating-point encoding. Software does not directly support other types of image encoding, particularly images encoded as 1-bit, 2-bit, or 4-bit images. In these cases, Software automatically transforms the image into an 8-bit image the minimum bit depth for Software when opening the image file.

3.) Number of planes: The number of planes in an image corresponds to the number of arrays of pixels that compose the image. A grayscale or pseudo-color image is composed of one plane; while a true-color image is composed of three planes one each for the red component, blue component, and green component. In true-color images, the color component intensities of a pixel are coded into three different values. A color image is the combination of three arrays of pixels corresponding to the red, green, and blue components in a Red Green Blue (RGB) image. Hue Saturation Luminescence (HSL) images are defined by their hue, saturation, and luminance values.

1.3.3 Image Types

There are three types of images: grayscale, color, and complex images. For an identical spatial resolution, a color image occupies four times the memory space of an 8-bit grayscale image, and a complex image occupies eight times the memory of an 8-bit grayscale image.

Grayscale images are composed of a single plane of pixels. Each pixel is encoded using one of the following single numbers:

- An 8-bit unsigned integer representing grayscale values between 0 and 255
- A 16-bit signed integer representing grayscale values between –32,768 and +32,767
- A single-precision floating-point number, encoded using four bytes, represents grayscale values ranging from –∞ to ∞.

Color images are encoded in memory as a red, green, and blue (RGB) image. Color image pixels are a composite of four values. RGB images store color information using 8 bits each for the red, green, and blue planes. RGB 64 bit images store color information using 16 bits each for the red, green, and blue planes. In the RGB and HSL color models, an additional 8-bit value goes unused. This representation is known as 4-× 8-bit or 32-bit encoding. In the RGB 64 bit color model, an additional 16-bit value goes unused. This representation is known as 4-× 16-bit or 64-bit encoding.

Complex images contain the frequency information of a grayscale image. We can create a complex image by applying a Fast Fourier transform (FFT) to a grayscale image. After we transform a grayscale image into a complex image, we can perform frequency domain operations on the image. Each pixel in a complex image is encoded as two single-precision floating-point values, which represent the real and imaginary components of the complex pixel. We can extract the following four components from a complex image: the real part, imaginary part, magnitude, and phase. Table 1.1 shows arrangement of number of Bytes per Pixel.

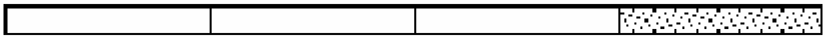
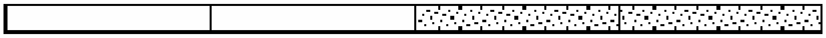
Image Type	Number of bytes per Pixel data
8-bit (Unsigned) Integer Grayscale) (1 byte or 8- bit)	 8bit for the grayscale intensity
16-bit (Signed) Integer Grayscale (2 bytes or 16-bit)	 16 bit for grayscale intensity
32 Bit Floating Point Grayscale (4 bytes or 32 bits)	 32 bit for grayscale intensity
RGB Color (4 bytes or 32 bits)	 8 bit for alpha value not used 8bit for red intensity 8bit for green intensity 8 bit for blue intensity

Table 1.1 Bytes per pixel

1.3.4 Image Files

An image file is composed of a header follow by pixel values. Depending on the file format, the header contains image information about the horizontal and vertical resolution, pixel definition, and the original palette. Image files may also store information about calibration, pattern matching templates, and overlays. The following are common image file formats:

- Bitmap (BMP)
- Tagged image file format (TIFF)
- Portable network graphics (PNG) offers the capability of storing image information about spatial calibration, pattern matching templates, and overlays
- Joint Photographic Experts Group format (JPEG)
- National Instruments internal image file format (AIPD) Used for saving floating-point, complex, and HSL images.

Standard formats for 8-bit grayscale and RGB color images are BMP, TIFF, PNG, JPEG, and AIPD. Standard formats for 16-bit grayscale, 64-bit RGB, and complex images are PNG and AIPD

1.3.5 Region of Interest

A region of interest (ROI) is an area of an image in which we want to perform our image analysis. We use ROIs to focus our processing and analysis on part of an image. We can define an ROI using standard contours, such as an oval or rectangle, or freehand contours also can perform any of the following options:

- Construct an ROI in an image display environment
- Associate an ROI with an image display environment
- Extract an ROI associated with an image display environment
- Erase the current ROI from an image display environment
- Transform an ROI into an image mask
- Transform an image mask into an ROI

1.4 Components of Machine Vision

Machine vision is related to artificial intelligence. We take the images in real time and process them for extracting useful information from them. The system making use of machine vision has basically three components: Camera (Analog camera or digital camera), Image Processor, Display Unit (PC monitor).

1.4.1 Camera: It is used for taking pictures of desired field, spot, point or any moving object. Camera must have high grabbing or sampling rate (frames are taken in one second). Frames are to be taken at fast rate such that we do not loose information about the object. These frames are to be taken in real time that's why frames are blurred and this needs image processing. Cameras used are mainly Analog Camera(Vidicon Camera) type or digital cameras. Resolution of camera must be strictly decided according to the object's area and size [2].

Analog Camera

Principle A vidicon camera is an analog camera that transforms an image into an analog electrical signal. The signal, a variable voltage (or current) versus time, can be stored, digitized, broadcast, or reconstructed into an image. With the use of a lens, the scene is projected onto a screen made up of two layers:

1.) A Transparent Metallic Film

2.) Photoconductive Mosaic

Working Photoconductive Mosaic is sensitive to light. The mosaic reacts to the varying intensity of light by varying its resistance. As a result, as the image is projected onto it, the magnitude of the resistance at each location varies with the intensity of the light. An electron gun generates and sends a continuous cathode beam (a stream of electrons with a negative charge) through two pairs of capacitors (deflectors) that are perpendicular to each other. Depending on the charge on each pair of capacitors, the electron beam is deflected up or down, and left or right, and is projected onto the photoconductive mosaic. At each instant, as the beam of electrons hits the mosaic, the charge is conducted to the metallic film, which can be measured at the output port.

The voltage measured at the output is $V = IR$,

I is the current (of the beam of electrons).

R is the resistance of the mosaic at the point of interest.

The charges in the two capacitors are changed and thus deflect the beam both sideways. and up and down so as to cause it to scan the mosaic. This process is called Raster Scan. As the beam scans the image, at each instant the output is proportional to the resistance of the mosaic or proportional to the intensity of the light on the mosaic. By reading the output voltage continuously, an analog representation of the image can be obtained.

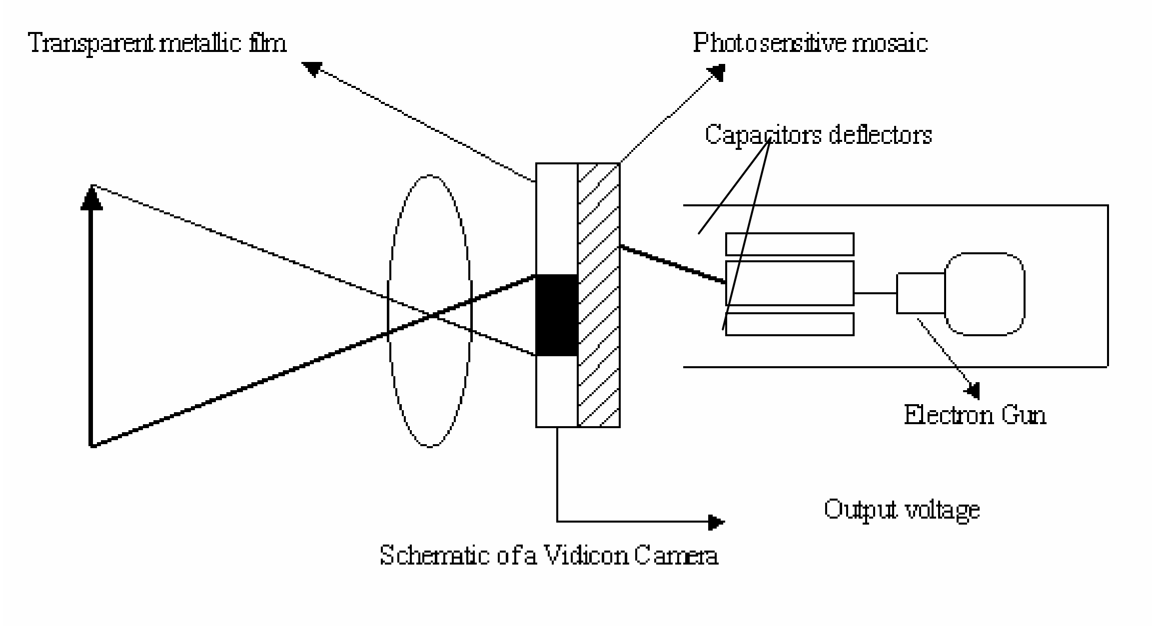
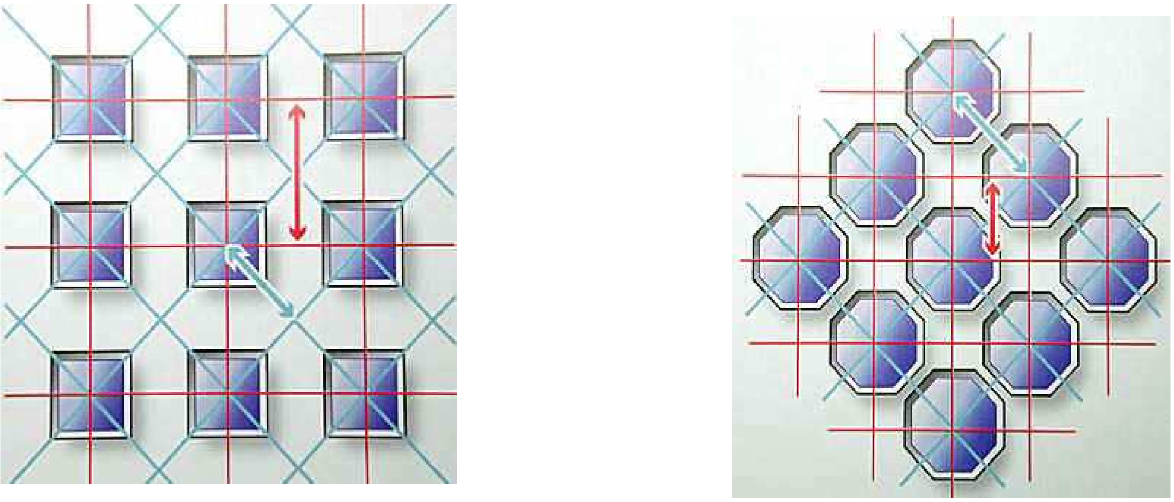


Figure 1.2 Analog Camera

Digital Camera

Principle A digital camera is based on solid-state technology. The camera uses a solid-state device called a CCD image sensor. These fingernail-sized silicon chips contain millions of photosensitive diodes called photosites. In the brief flickering instant as the shutter opens, each photosite records the intensity or brightness of the light that falls on it by accumulating a charge; the more light, the higher the charge. The brightness recorded by each photosite is then stored as a set of numbers that can then be used to set the color and brightness of dots on the screen or ink on the printed page to reconstruct the image. Digital photographs are made up of hundreds of thousands or millions of tiny squares called picture elements, or just pixels. Each of these pixels is captured by a single photosite on the image sensor when photo is taken.. On an image sensor, each photosite captures the brightness of a single pixel. The layout of the photosites can take the form of a grid or honeycomb.



An image sensor having photosites pixels arranged in rows and columns.

An image sensor having octagonal arranged in a honeycomb pattern.

Figure1.3 Image sensor patterns

Image Sensors contain a grid of photosites that convert light shining on them to electrical charges. These charges can then be measured and converted into digital numbers that indicate how much light hit each site.

Capturing of an image by Image Sensor: When an image is focused through the camera (or scanner) lens, it falls on the image sensor. Varying amounts of light hit each photosite and knock loose electrons that are then captured and stored. The number of electrons knocked loose from any photosite is directly proportional to the amount of light hitting it. When the exposure is completed, the sensor is like a checkerboard, with different numbers of checkers (electrons) piled on each square (photosite). When the image is read off the sensor, the stored electrons are converted to a series of analog charges that are then converted to digital values by an Analog-to-Digital (A to D) converter.

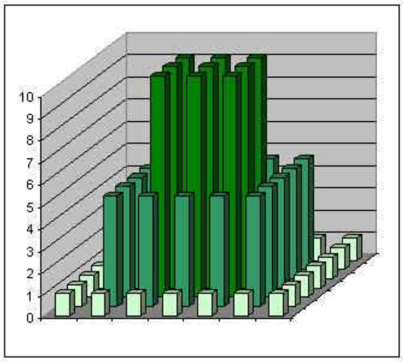


Figure 1.4 Check Board view of an image sensor

Working Charge-coupled devices (CCD's) capture light on the small photosites on their surface and get their name from the way that charge is read after an exposure. To begin, the charges on the first row are transferred to a read out register. From there, the signals are then fed to an amplifier and then on to an analog-to-digital converter. Once the row has been read, its charges on the read-out register row are deleted; the next row enters the read-out register, and all of the rows above march down one row. The charges on each row are "coupled" to those on the row above so when one moves down, the next moves down to fill its old space. In this way, each row can be read—one row at a time[3]

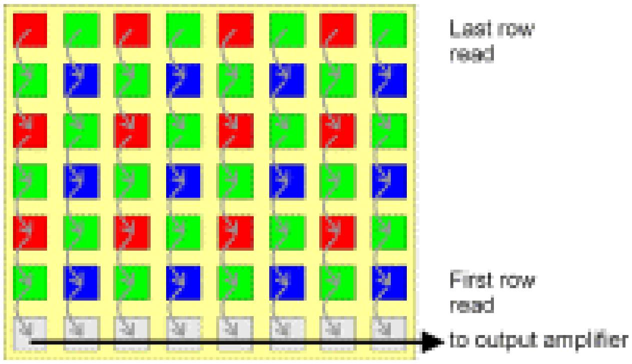


Figure 1.5 Photosites on charge-coupled device

1.4.2 Image Processor is used to get the best out of grabbed or captured images we make use of image processor. Image processor is usually a computer, laptop or a digital signal processor. Image can also be processed using tools available in LABVIEW. Image is divided into small sections on screen called picture cells, or pixels, where the size of all pixels is the same, while intensity of light in each pixel is varied to create the images. Image processor processes the blurred image pixel by pixel or sometimes reference points are processed which represent the whole image and make the picture more clear to the operator for further analysis. The more the pixels present, the better the resolution of camera. We have used Machine Vision Assistant 7.1 simulator software to perform image-processing tasks. Basically VA 7.1 helps us to make LABVIEW program[4].

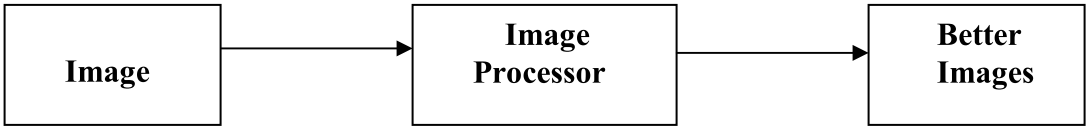


Figure 1.6 Effect of image processor

1.4.3 Display unit is mainly a screen having pixels to display the grabbed images. A personal computer or laptop is used for this purpose. Sometimes storage of grabbed images is also done with computer for offline analysis. We have used simple PC monitor to get images from camera. Camera is connected to monitor through CVS-1450 using LAN, which directly displays the acquired image on monitor.

1.5 Advantages and Limitations

1. Machine vision can be implemented to various industrial locations where cameras can replace two or three workmen.
2. It can also be employed in hazardous conditions where it is very difficult for operator to watch the process disturbances continuously.
3. The decisions are taken by processor in real time therefore it is very useful in real time process control.
4. The grabbing rate of some specialized cameras can be too high as compared to human perception therefore it can detect very fast and minute changes in case moving object.

5. System performance is affected due to vibration and noise because camera produces blurred image in these conditions.
6. Natural light affect the camera performance due to changing of brightness of natural light from day to night.
7. Sometimes the images that are heavily distorted may loose useful information during various processing functions.
8. The accuracy of decision made by processor is simply dependent upon the resolution of camera. The more the resolution the finer will be the image.

Chapter 2: Application Software Development

2.1 Introduction to Vision Assistant 7.1

Vision Assistant is a tool for prototyping and testing image processing applications. To prototype an image processing application, build custom algorithms with the Vision Assistant scripting feature. The scripting feature records every step of the processing algorithm. After completing the algorithm, we can test it on other images to make sure it works. The algorithm is recorded in a Builder file, which is an ASCII text file that lists the processing functions and relevant parameters for an algorithm that we prototype in Vision Assistant. We must have LabVIEW 6.1 or later and IMAQ Vision 7.1 for LabVIEW or later installed to use the LabVIEW VI Creation Wizard.

2.2 System Requirements and Installation

To run Vision Assistant, system must meet the following minimum requirements

- Personal computer using a 233 MHz Pentium-class processor. Using a Pentium III or Celeron 600 MHz or equivalent is recommended.
- Microsoft Windows 2000/NT/XP. If we are using Windows NT 4.0, we must have Service Pack 6 or later installed to run Vision Assistant.
- 1024 , 768 resolution or higher video adapter; 65,536 colors, 16-bit or higher
- Minimum of 128 MB RAM; 256 MB recommended
- Minimum of 200 MB of free hard disk space
- If we are acquiring images, the system must have National Instruments image acquisition (IMAQ) hardware and NI-IMAQ 3.0 or later or NI-IMAQ for IEEE 1394 Cameras 1.5 or later installed.

2.2.1 Installing Vision Assistant

- To install Vision Assistant on a Windows 2000/NT/XP system, we must be logged in with Administrator privileges.
- Insert the Vision Assistant CD into the CD-ROM drive.

- If we do not have auto run enabled, double-click `autorun.exe`. If we have auto run enabled, `autorun.exe` runs automatically.

2.2.2 Features

Vision Assistant offers the following features:

Script window: It Records a series of image processing steps and the settings we use for each of those steps. We can run scripts on single images or in a batch to analyze a collection of images. We also can modify and save scripts.

- **Image Browser**: It contains all of the images currently loaded in Vision Assistant. We can select an image to process by double-clicking it in the Image Browser.
- **Processing window**: It updates the image as we change parameters. Because this view immediately reflects the changes we have made in the Parameter window, we can continue modifying parameters until we get the result we want.
- **Functions window/Parameter window**: It displays a list of image processing functions we can use to develop an algorithm, or displays parameters that we can set for an image processing function. Each function available through the Functions window has a Parameter window in which we set the parameters for that function.
- **Reference window/Embedded Help window**: The Image tab of the Reference window displays the image source as we manipulate it in the Processing window. The other tabs in the Embedded Help window contain context help for the function we are using.
- **Solution Wizard:** It displays a list of industries and corresponding quality-assurance tasks that those industries perform. The wizard loads an IMAQ Vision-based solution for the task we select.
- **Performance Meter**: It estimates how long a script will take to complete on a given image.
- **LabVIEW VI Creation**: It creates a LabVIEW VI corresponding to the algorithm we prototype in Vision Assistant. Based on the options we select,

the LabVIEW VI Creation Wizard creates a new VI that implements the image processing steps of the current script or of a saved script file.

- **C Code Creation**: It creates a C file corresponding to the algorithm we prototype in Vision Assistant. Based on the options we select, the C Code Creation Wizard creates a C function that implements the image processing steps of the current script.
- **Builder File**: ASCII text file that lists the C and Microsoft Visual Basic functions and parameters for the algorithm we prototyped in Vision Assistant.

Chapter 3: Problem Statement and Solution

3.1 Problem Statement

Identification and dimensional measurement of electronic components are important issues to be considered. A lot of research is going on to increase the liberty in identifying and dimensional measurements of the electronic components.

In this thesis a new method is being proposed by the use of machine vision assistant 7.1. It is an efficient method which works on real time as well as previously acquired images. Electronic components such as IC chips, resistors, capacitors, LEDs etc. are identified by color pattern matching and gauging is used for dimensional measurement of the components. In identifying components, one script is embedded in other. This method increases the capacity and robustness of the system for fast calculations. In electronic component identification whatever might be the position of the component in the new image i.e. whether it is in horizontal, vertical, or in inclined position, it is matched with the previously saved template and the results of the component position with respect to x, y planes and the angle at which it is placed in the new image is displayed where as gauging steps such as caliper1, caliper2 and caliper3 displays the length, mid point and the angle measurements.

3.2 Justification of Problem Statement

Machine Vision is used because the images which are blurred and noisy can be processed to obtain better images. The color pattern matching technique can easily extract color planes. Gauging technique works very efficiently for dimensional measurement. Although same programming can be done with other methods such as C compiler, Mat lab etc. but these methods are time consuming and requires lots of programming skills which is quiet laborious and difficult for a designer where as with machine vision, this can be achieved in few steps. So the problem we are trying to solve is not previously attempted by this method.

3.3 Why it is Worthwhile to solve this Problem?

Machine Vision is not a fully mature technology; lot of research is going on in this field. It is capable of processing images consistently i.e. machine vision based systems are typically designed to perform single, repetitive tasks. This technique especially increases accuracy, robustness and efficiency of the image in the system. For detecting damaged part and flaws of the components which causes inefficient working of the whole system and also for checking the labels and color of the electronic components, vision assistant 7.1 provides the most advanced platform. Dimensional measurement is required in number of fields where the measurements of manufactured goods such as that of semiconductor chips, automobile parts etc. are to be noted thus it helps in finding the surface defects. Manufacturers favor machine vision systems for visual inspections that require high-speed, high-magnification, 24-hour operation, and repeatability of measurements, frequently as manual measurement of large number of manufactured goods in any of these applications can be a tedious and time consuming process, prone to human errors.

Just as human inspectors working on assembly lines visually inspect parts to judge the quality of workmanship, so machine vision systems use scanners or digital cameras and image processing software to perform similar inspections.

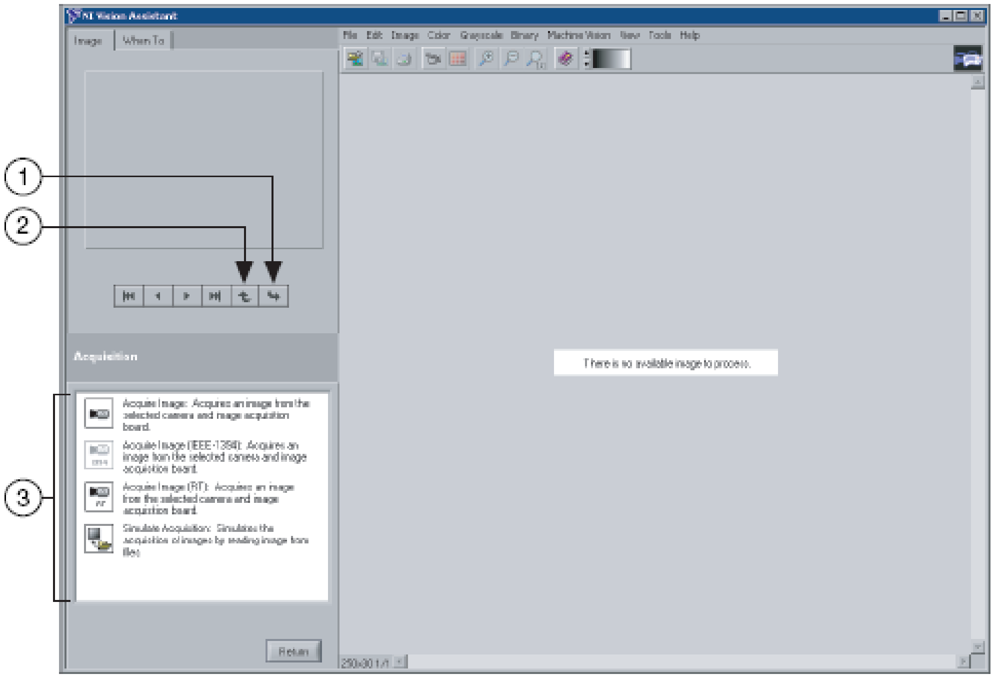
3.4 Problem Solution

3.4.1 IC chip identification from the group of electronic components.

In this section, from the group of electronic components an IC chip is selected for color pattern matching and this technique is further applied on other electronic components in the following sections.

3.4.1.1 Welcome screen

Image Browser contains all of the images currently loaded in Vision Assistant. We can select an image to process by double-clicking it in the Image Browser and processing window updates the image as we change parameters. Because this view immediately reflects the changes we have made in the parameter window, we can continue modifying parameters until we get the result we want.



Acquire Image: Acquires an image from the selected camera and image acquisition board.

Acquire Image (IEEE-1394): Acquires an image from the selected camera and image acquisition board.

Acquire Image (RT): Acquires an image from the selected camera and image acquisition board.

Simulate Acquisition: Simulates the acquisition of images by reading image from files.

There is no available image to process.

1. Make Image Active

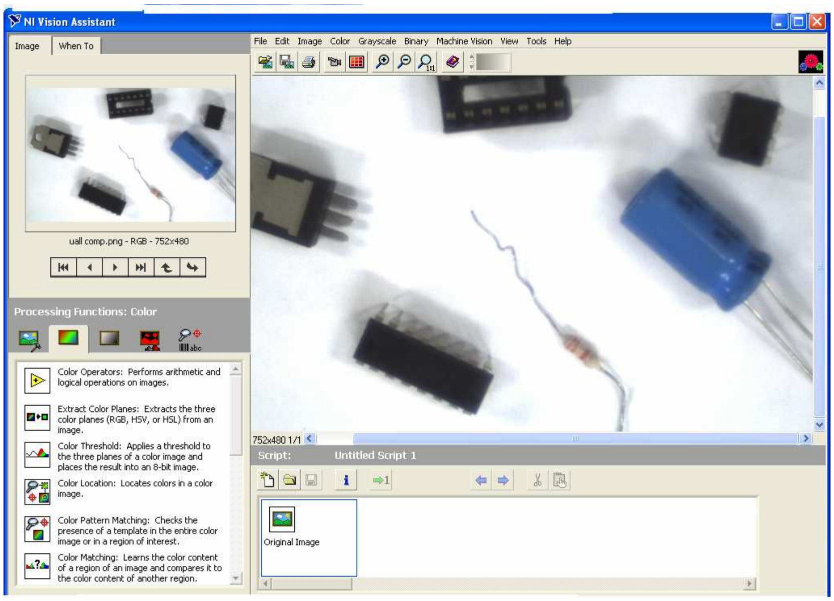
2. Store Acquired Image in Browser Button

3. Acquisition Functions

Figure 3.1 Acquiring images in vision assistant

3.4.1.2 Image Acquisition

It is acquiring the image in the welcome screen. The image is opened from the previously stored images.



Color Operators: Performs arithmetic and logical operations on images.

Extract Color Planes: Extracts the three color planes (RGB, HSV, or HSL) from an image.

Color Threshold: Applies a threshold to the three planes of a color image and places the result into an 8-bit image.

Color Location: Locates colors in a color image.

Color Pattern Matching: Checks the presence of a template in the entire color image or in a region of interest.

Color Matching: Learns the color content of a region of an image and compares it to the color content of another region.

Figure 3.2 Opening original image in the welcome screen

3.4.1.3 Setting Brightness

Television and digital images are divided into small sections called picture cells, or pixels (in three-dimensional images these are called voxels or volume Cells). The size of each pixel is same, but the intensity of light in each pixel is varied to make image bright.

Brightness: The sensation of an area exhibiting more or less light. It is a constant added to the red, green, and blue components of a color pixel during the color pattern matching process. It is the perception by which white objects are distinguished from gray and light objects from dark objects. Its range varies from 0 to 255.

Contrast: A constant multiplication factor applied to a color pixel in the color pattern matching process. Contrast is measured as the difference between the average pixel values in a rectangular region in the background and a rectangular region in a segment. Its range varies from 1 to 89.

Gamma: The nonlinear change in the difference between the video signal's brightness level and the voltage level needed to produce the required amount of brightness.

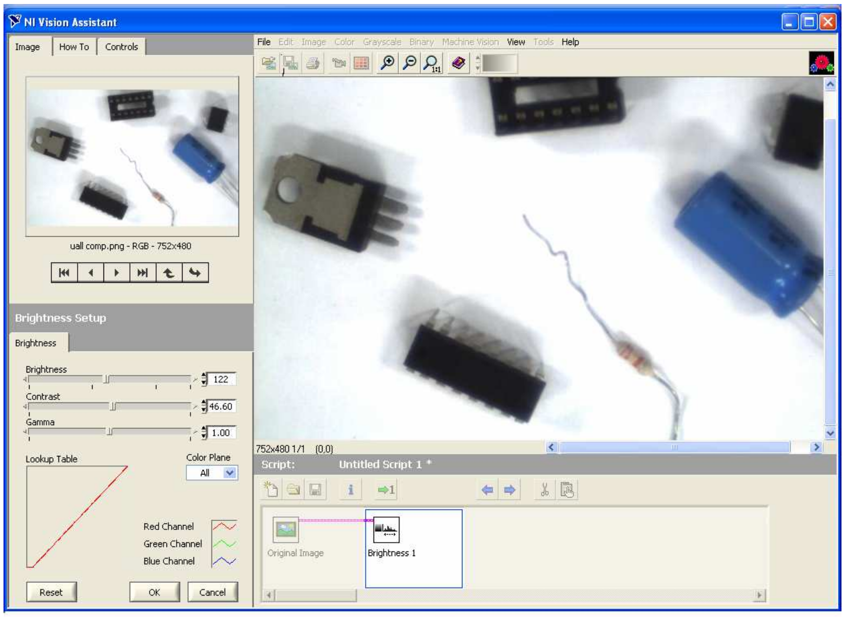
Its range varies from 0.10 to 10.

Brightness Parameters being set for the image in the Image Browser:

1.) Brightness-122

2.) Contrast-46.60

3.) Gamma-1



uall comp.png - RGB - 752x480

Brightness 122

Contrast 46.60

Gamma 1.00

Color Plane All

752x480 1/1 (0,0)

Script: Untitled Script 1 *

Figure 3.3 Setting brightness of an image

3.4.1.4 Color Pattern Matching

Color pattern matching uses color matching to locate the objects, and then pattern matching to refine the locations, providing more accurate results. If the components are identified by their color, color pattern matching provides a fast way to locate the components. It uses a combination of color location and grayscale pattern matching to search for the template. When color pattern matching is used to search for a template, the software uses the color information in the template to look for occurrences of the template in the image. The software then applies grayscale pattern matching in a region around each of these occurrences to find the exact position of the template in the image.

Color pattern matching is used when the object under inspection has the following qualities:

1.) The object contains color information that is very different from the background, and it is required to find the location of the object in the image very precisely. For these applications, finding the locations of the matches with pixel accuracy is easy with color pattern matching

2.) The object has grayscale properties that are difficult to characterize or that are very similar to other objects in the search image. In such cases, grayscale pattern matching may not give accurate results. If the object has some color information that differentiates it from the other objects in the scene, color provides the machine vision software with the

additional information to locate the object.

The color pattern matching tools in IMAQ Vision measure the similarity between an idealized representations of a feature, called a model, and the feature that may be present in an image. A feature is defined as a specific pattern of color pixels in an image. Color pattern matching is the key to many applications. It provides an application with information about the number of instances and location of the template within an image. Color pattern matching is used in the three general applications: gauging, inspection, and alignment. Inspection detects simple flaws, such as missing parts or unreadable printing. A common application is inspecting the labels on consumer product bottles for printing defects. Because most of the labels are in color, color pattern matching is used to locate the labels in the image before detailed inspection of the label is performed.

In automated machine vision applications, the visual appearance of materials or components under inspection can change due to factors such as orientation of the part, scale changes, and lighting changes. The color pattern matching tool maintains its ability to locate the reference patterns and gives accurate results despite these changes [5].

A color pattern-matching tool locates the reference pattern in an image even when the pattern in the image is rotated and slightly scaled. When a pattern is rotated or scaled in the image, the color pattern-matching tool detects the following features of an image:

1.) The pattern in the image

2.) The position of the pattern in the image

3.) The orientation of the pattern

4.) Multiple instances of the pattern in the image, if applicable.

Under the following conditions also color pattern matching can be efficiently done.

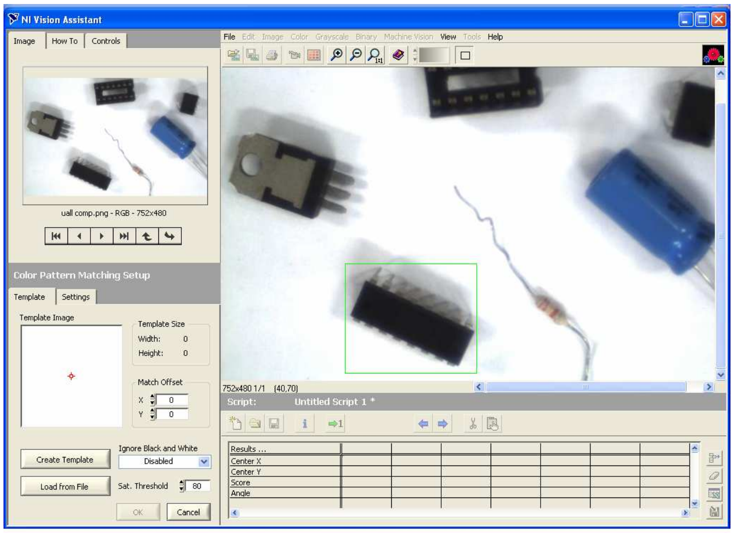
1.) Ambient Lighting Conditions

The color pattern-matching tool finds the reference pattern in an image under conditions of uniform changes in the lighting across the image. Because color analysis is more robust when dealing with variations in lighting, color pattern matching performs better under conditions of non-uniform light changes, such as in the presence of shadows.

2.) Blur and Noise Conditions

Color pattern matching finds patterns that have undergone some transformation because of blurring or noise. Blurring usually occurs because of incorrect focus or depth of field changes. Color pattern matching is a unique approach that combines color and spatial information to quickly find color patterns in an image. It uses the technologies behind color matching and grayscale pattern matching in a synergistic way to locate color patterns in color images.

Rectangular Tool is selected from the tool menu to draw region of interest around the desired component. It is differentiated by a green rectangular boundary around the object. This is shown in Figure 3.4, 3.5 in which an IC Chip is being selected by making a green rectangular box.



uall comp.png - RGB - 752x480

Width: 0

Height: 0

X 0

Y 0

Ignore Black and White: Disabled

Sat. Threshold 80

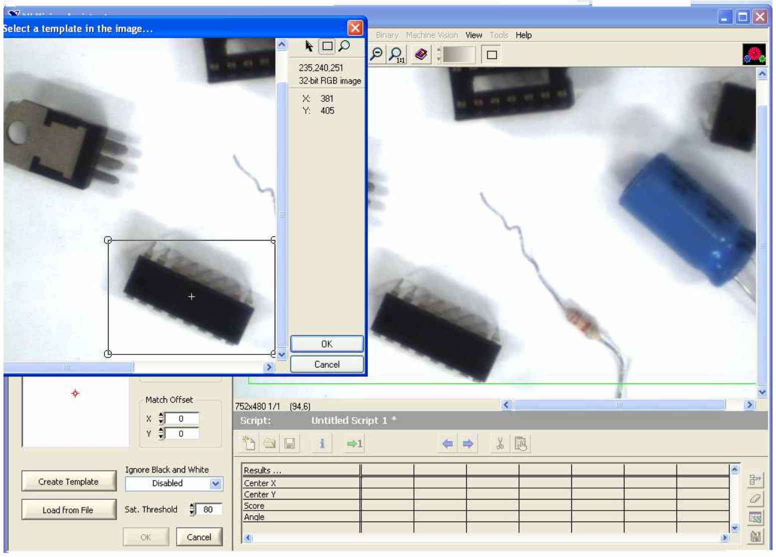
752x480 1/1 (40,70)

Script: Untitled Script 1 *

Figure 3.4 Creating template for matching

3.4.1.5 Template Matching

The technique used for object recognition is creating its model, which is known as template matching. If a suitable line drawing of a scene is found, the topological or structural elements, such as the total number of lines (sides), vertices, and interconnections can be matched to a model. Coordinate transformations (e.g., rotation, translation, and scaling) can be performed to eliminate the differences between the model and the object resulting from differences in position, orientation, or depth between them. This technique is limited by the fact that a prior knowledge of the models is needed for matching. Thus, if the object is different from the models, it will not match, and the object, will not be recognized. The ROI becomes the desired pattern.Template Matching reduces the risk of finding a mismatch. It speeds up the matching process.



235,240,251
32-bit RGB image
X: 381
Y: 405

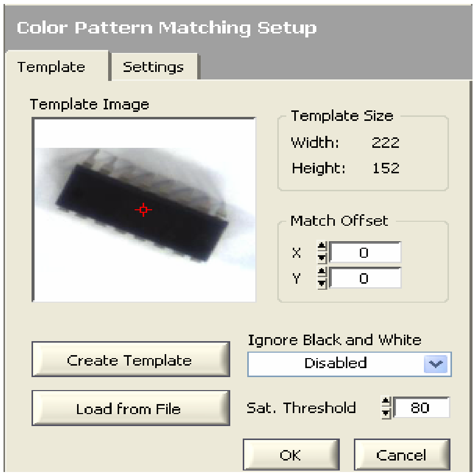
Match Offset
X 0
Y 0

Ignore Black and White: Disabled
Sat. Threshold 80

752x480 1/1 (94,6)

Script: Untitled Script 1 *

Figure 3.5 Learning of template match in the image



Template Size

Width: 222

Height: 152

Match Offset

X 0

Y 0

Ignore Black and White: Disabled

Sat. Threshold 80

Figure 3.6 Template Saving

3.4.1.6 Parameter Setting

Setting of Parameters

Number of Matches to be found-1

Minimum Score-600

Color Score Weight-500

Color Sensitivity-Low Sensitivity

Search Strategy-Conservative

Search for Rotated Patterns-yes

Angle Range +/- = 90

Mirror angle-yes

Sub-pixel accuracy-yes

Number of matches: It indicates the number of matched templates to be found. These can be more than one.

Score: It relates how closely the template resembles the located matches. A number ranging from 0 to 1,000 indicates how closely an acquired image matches the template image. A match score of 1,000 indicates a perfect match where as match score of 0 indicates no match. The score describes whether the template is accepted or rejected .If the minimum score is less than 600 than the template is rejected otherwise accepted.

Color Score Weight: The score returned by the color pattern-matching tool is used to decide whether a label is acceptable or not .It ranges from 0 to 1,000. A match score of 1,000 indicates a perfect match where as match score of 0 indicates no match.

Color Sensitivity: The color sensitivity parameter determines the number of sectors the hue space is divided into. Hue represents the dominant color of a pixel. The hue function is a continuous function that covers all the possible colors generated using the R, G, and B primaries. RGB is a color encoding scheme using red, green, and blue (RGB) color information where each pixel in the color image is encoded using 32 bits: 8 bits for red, 8 bits for green, 8 bits for blue, and 8 bits for the alpha value (unused). A color spectrum with a larger number of bins, or elements, represents the color information in an image with more detail, such as a higher color resolution, than a spectrum with fewer bins. In IMAQ Vision, three color sensitivity settings i.e. low, medium, and high can be chosen.

Low divides the hue color space into seven sectors, giving a total of 2 × 7 + 2 = 16 bins. Medium divides the hue color space into 14 sectors, giving a total of 2 × 14 + 2 = 30 bins. High divides the hue color space into 28 sectors, giving a total of 2 × 28 + 2 = 58 bins. The value of each element in the color spectrum indicates the percentage of image pixels in each color bin. When the number of bins is set according to the color sensitivity parameter, the machine vision software scans the image, counts the number of pixels that fall into each bin, and stores the ratio of the count and total number of pixels in the image in the appropriate element within the color spectrum array.

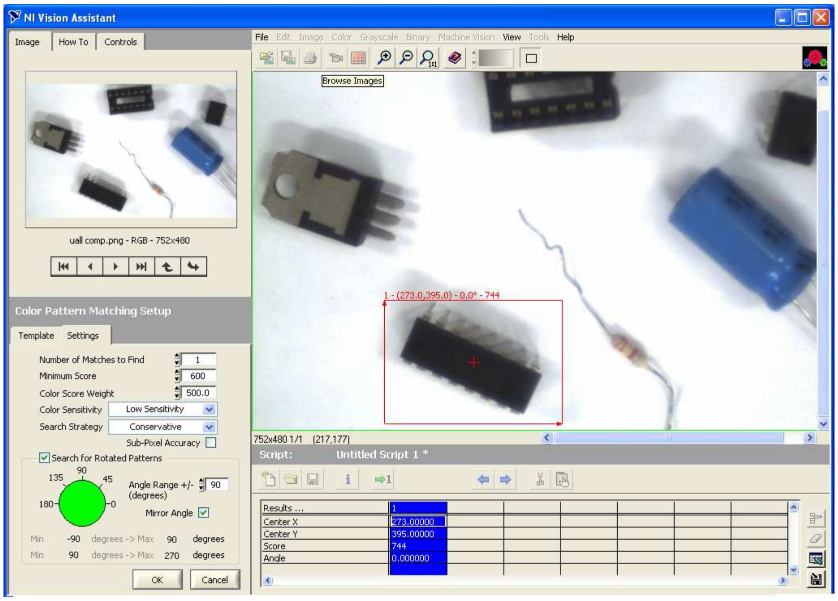
Search Strategy: It finds the rough locations of the matches in the image. The possible modes are Aggressive and Conservative.

In **Conservative** mode extensive criteria is used to determine if an object matches a trained character In **Aggressive** mode, the intensive criteria is used to determine if an object matches a trained character.

Search for Rotated Patterns: With this parameter, if the patterns in the image are rotated or scaled in the image; the rotated patterns are detected.

Mirror Angle: In reference to viewer and observed surface, the angle equal and opposite to the viewing angle is called the mirror angle.

Sub pixel accuracy: When the resolution of the image is high enough, most measurement applications make accurate measurements using pixel accuracy only. However, it is sometimes difficult to obtain the minimum image resolution needed by a machine vision application because of the limits on the size of the sensors available or the price. In these cases, edge positions with sub pixel accuracy are to be found. Sub pixel analysis is a software method that estimates the pixel values that a higher resolution imaging system would have provided. The interpolating function provides the edge detection algorithm with pixel intensity values between the original pixel values. The software then uses the intensity information to find the location of the edge with sub pixel accuracy.



uall comp.png - RGB - 752x480

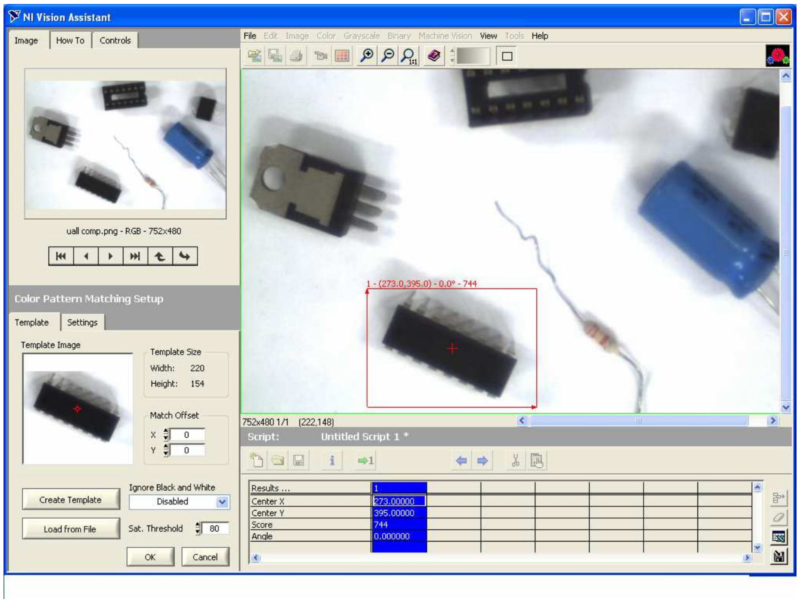
Number of Matches to Find: 1
Minimum Score: 600
Color Score Weight: 500.0
Color Sensitivity: Low Sensitivity
Search Strategy: Conservative
Sub-Pixel Accuracy ☐
☑ Search for Rotated Patterns
Angle Range +/- (degrees): 90
Mirror Angle ☑
Min -90 degrees -> Max 90 degrees
Min 90 degrees -> Max 270 degrees

Results ...	1
Center X	273.00000
Center Y	395.00000
Score	744
Angle	0.000000

Figure 3.7 Parameters setting for template matching

3.4.1.7 Red ROI shows the detection of an IC Chip

When the component gets identified in the new image, red ROI region forms around the component. This is shown in the figure below:



uall comp.png - RGB - 752x480

Template Size
Width: 220
Height: 154

Match Offset
X 0
Y 0

Ignore Black and White: Disabled

Sat. Threshold 80

1 - (273.0,395.0) - 0.0° - 744

752x480 1/1 (222,148)

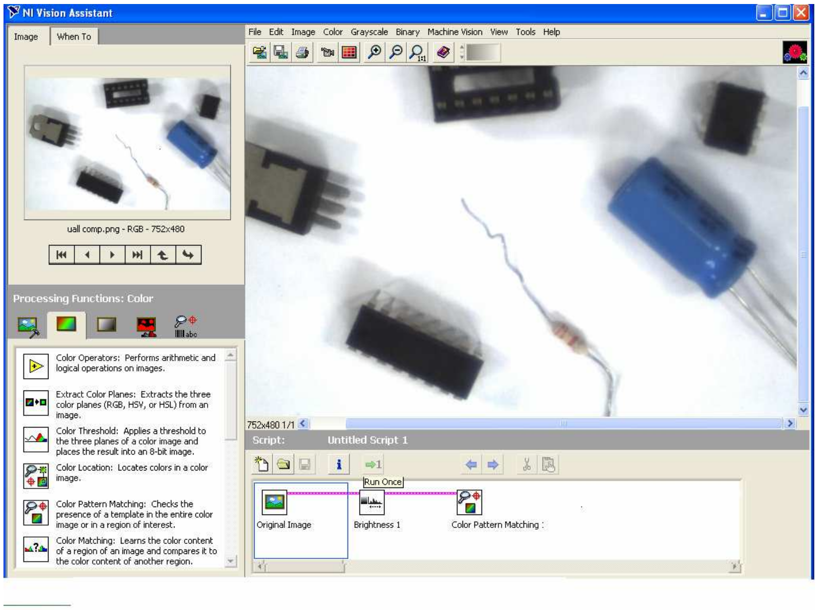
Script: Untitled Script 1 *

Results ...	1
Center X	273.00000
Center Y	395.00000
Score	744
Angle	0.000000

Figure 3.8 Identification of an IC chip in an image

3.4.1.8 Overall Script

Overall steps of the script can be visualized on the welcome screen. The steps are shown below:



uall comp.png - RGB - 752x480

Color Operators: Performs arithmetic and logical operations on images.

Extract Color Planes: Extracts the three color planes (RGB, HSV, or HSL) from an image.

Color Threshold: Applies a threshold to the three planes of a color image and places the result into an 8-bit image.

Color Location: Locates colors in a color image.

Color Pattern Matching: Checks the presence of a template in the entire color image or in a region of interest.

Color Matching: Learns the color content of a region of an image and compares it to the color content of another region.

752x480 1/1

Script: Untitled Script 1

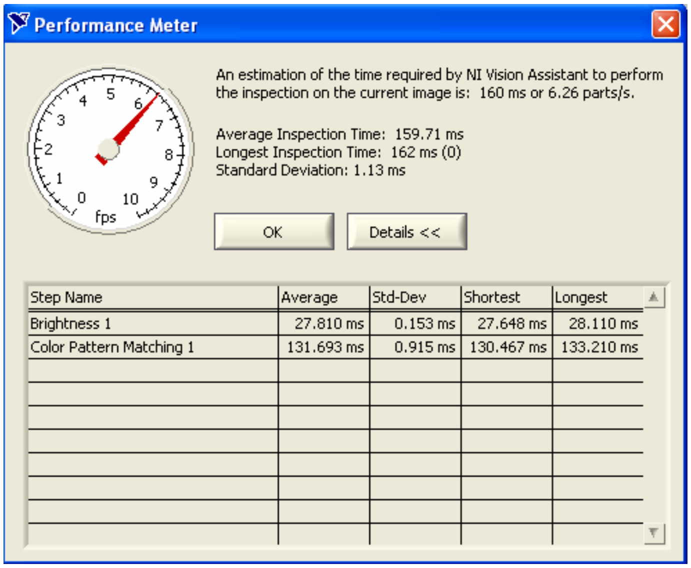
Original Image
Brightness 1
Color Pattern Matching :

Figure 3.9 Overall Script

Figure 3.10 Steps of overall script

3.4.1.9 Estimated Time for the Overall Script

It indicates the average time in which the overall script is performed.



An estimation of the time required by NI Vision Assistant to perform the inspection on the current image is: 160 ms or 6.26 parts/s.

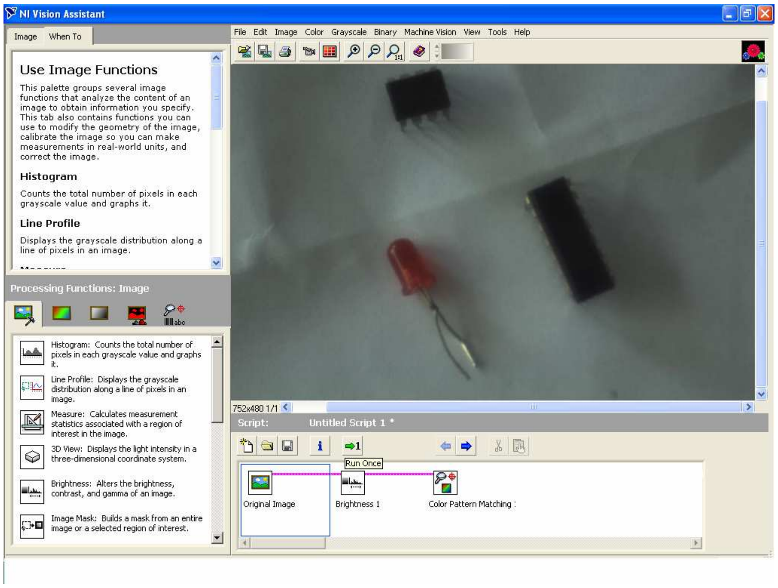
Average Inspection Time: 159.71 ms
Longest Inspection Time: 162 ms (0)
Standard Deviation: 1.13 ms

Step Name	Average	Std-Dev	Shortest	Longest
Brightness 1	27.810 ms	0.153 ms	27.648 ms	28.110 ms
Color Pattern Matching 1	131.693 ms	0.915 ms	130.467 ms	133.210 ms

Figure 3.11 Performance Meter

3.4.1.10 Identification of an IC chip in the new images

Same steps are performed on the new images except the template saving because now the pattern is to be matched with the template from the previously acquired image.



Use Image Functions

This palette groups several image functions that analyze the content of an image to obtain information you specify. This tab also contains functions you can use to modify the geometry of the image, calibrate the image so you can make measurements in real-world units, and correct the image.

Histogram

Counts the total number of pixels in each grayscale value and graphs it.

Line Profile

Displays the grayscale distribution along a line of pixels in an image.

Histogram: Counts the total number of pixels in each grayscale value and graphs it.

Line Profile: Displays the grayscale distribution along a line of pixels in an image.

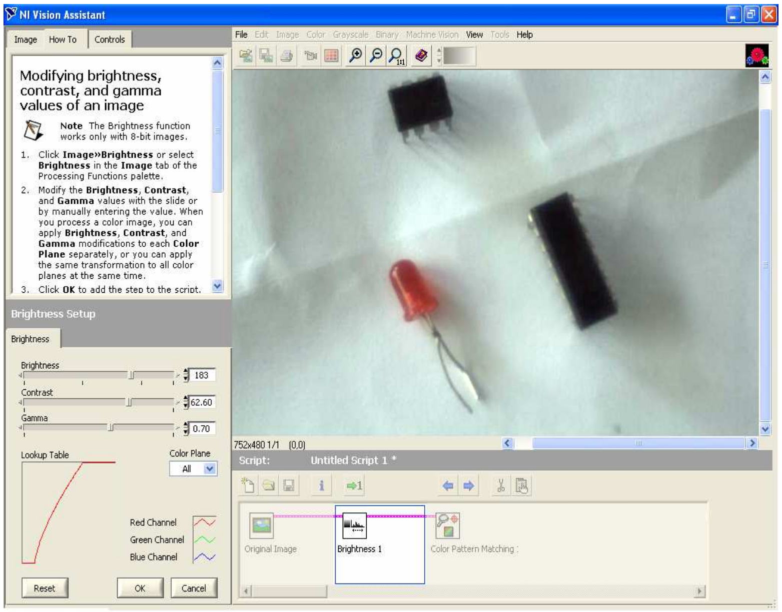
Measure: Calculates measurement statistics associated with a region of interest in the image.

3D View: Displays the light intensity in a three-dimensional coordinate system.

Brightness: Alters the brightness, contrast, and gamma of an image.

Image Mask: Builds a mask from an entire image or a selected region of interest.

Figure 3.12 Opening new image and running the same script for an IC chip



Modifying brightness, contrast, and gamma values of an image

Note The Brightness function works only with 8-bit images.

1. Click **Image»Brightness** or select **Brightness** in the **Image** tab of the Processing Functions palette.
2. Modify the **Brightness**, **Contrast**, and **Gamma** values with the slide or by manually entering the value. When you process a color image, you can apply **Brightness**, **Contrast**, and **Gamma** modifications to each **Color Plane** separately, or you can apply the same transformation to all color planes at the same time.
3. Click **OK** to add the step to the script.

Brightness 183
Contrast 62.60
Gamma 0.70
Color Plane All

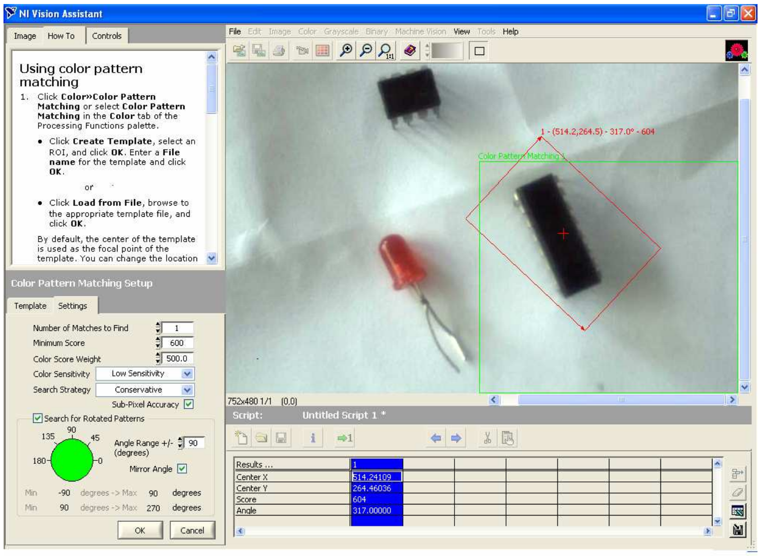
Figure 3.13 Setting the brightness parameter for template match

Brightness Parameters

1.) Brightness-183

2.) Contrast-62.60

3.) Gamma-0.7



Using color pattern matching

1. Click **Color»Color Pattern Matching** or select **Color Pattern Matching** in the **Color** tab of the Processing Functions palette.
   - Click **Create Template**, select an ROI, and click **OK**. Enter a **File name** for the template and click **OK**.

     or

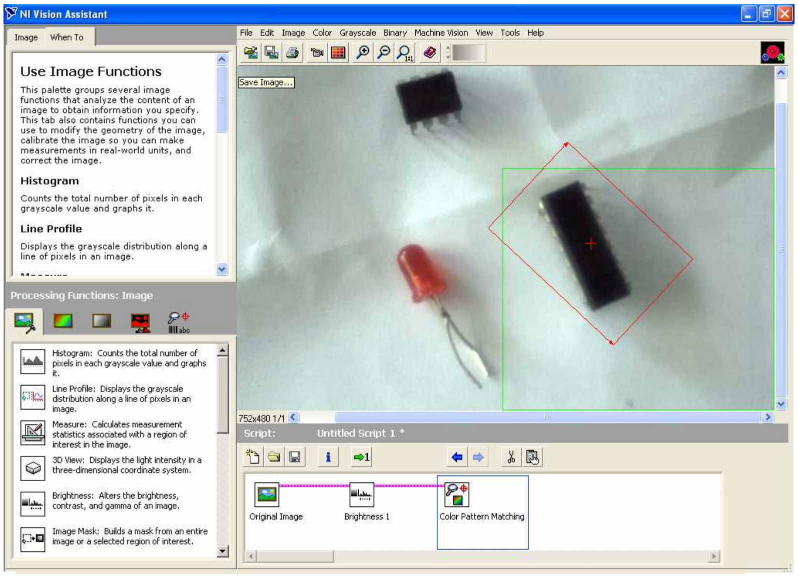
   - Click **Load from File**, browse to the appropriate template file, and click **OK**.

   By default, the center of the template is used as the focal point of the template. You can change the location

Number of Matches to Find: 1
Minimum Score: 600
Color Score Weight: 500.0
Color Sensitivity: Low Sensitivity
Search Strategy: Conservative
Sub-Pixel Accuracy ☑
☑ Search for Rotated Patterns
Angle Range +/- (degrees): 90
Mirror Angle ☑
Min -90 degrees -> Max 90 degrees
Min 90 degrees -> Max 270 degrees

Results ...	1
Center X	514.24109
Center Y	264.46036
Score	604
Angle	317.00000

Figure 3.14 Identification of an IC chip in the new image



Use Image Functions

This palette groups several image functions that analyze the content of an image to obtain information you specify. This tab also contains functions you can use to modify the geometry of the image, calibrate the image so you can make measurements in real-world units, and correct the image.

Histogram

Counts the total number of pixels in each grayscale value and graphs it.

Line Profile

Displays the grayscale distribution along a line of pixels in an image.

Histogram: Counts the total number of pixels in each grayscale value and graphs it.

Line Profile: Displays the grayscale distribution along a line of pixels in an image.

Measure: Calculates measurement statistics associated with a region of interest in the image.

3D View: Displays the light intensity in a three-dimensional coordinate system.

Brightness: Alters the brightness, contrast, and gamma of an image.

Image Mask: Builds a mask from an entire image or a selected region of interest.

Figure 3.15 Overall Script showing identification of an IC chip in new image

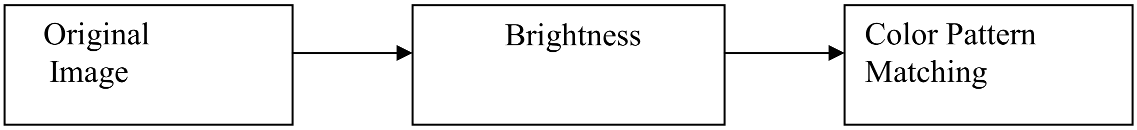
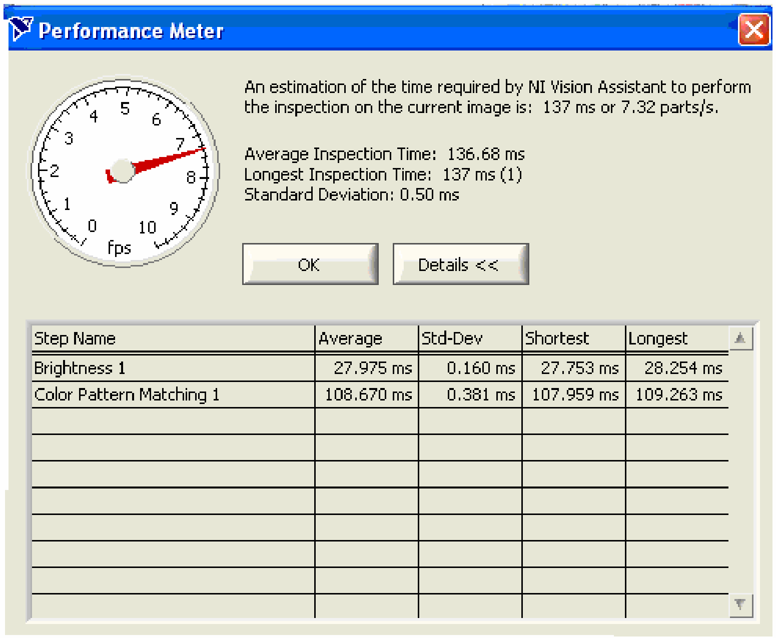


Figure 3.16 Steps of overall script

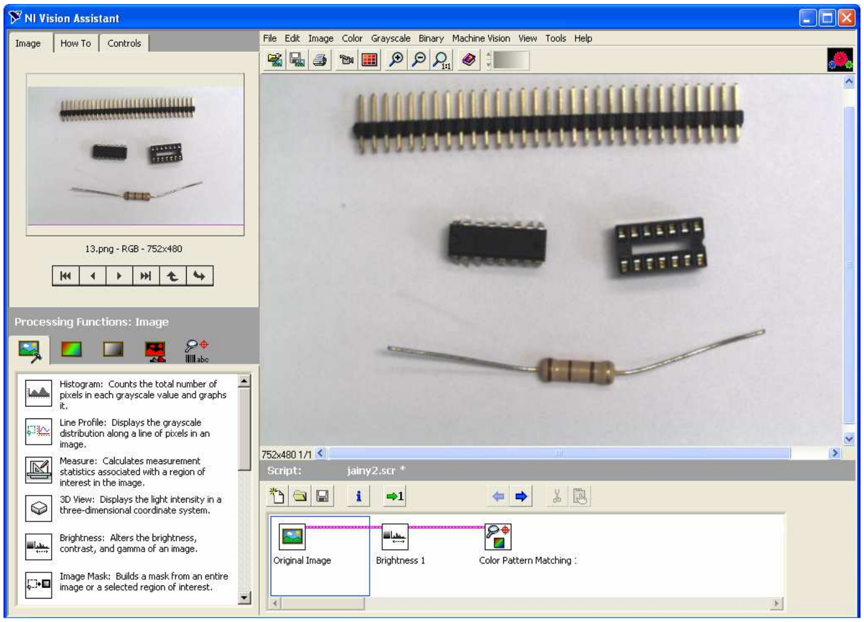


An estimation of the time required by NI Vision Assistant to perform the inspection on the current image is: 137 ms or 7.32 parts/s.

Average Inspection Time: 136.68 ms
Longest Inspection Time: 137 ms (1)
Standard Deviation: 0.50 ms

Step Name	Average	Std-Dev	Shortest	Longest
Brightness 1	27.975 ms	0.160 ms	27.753 ms	28.254 ms
Color Pattern Matching 1	108.670 ms	0.381 ms	107.959 ms	109.263 ms

Figure 3.17 Performance Meter



13.png - RGB - 752x480

752x480 1/1

Histogram: Counts the total number of pixels in each grayscale value and graphs it.

Line Profile: Displays the grayscale distribution along a line of pixels in an image.

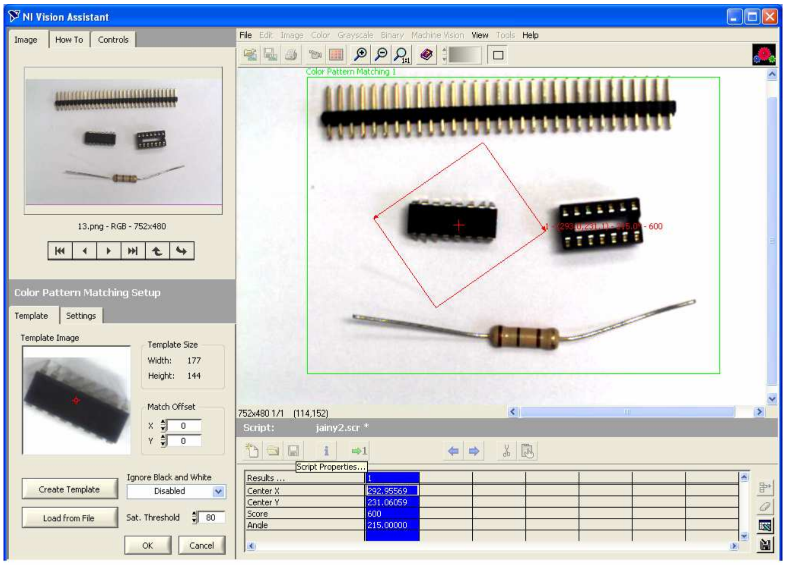
Measure: Calculates measurement statistics associated with a region of interest in the image.

3D View: Displays the light intensity in a three-dimensional coordinate system.

Brightness: Alters the brightness, contrast, and gamma of an image.

Image Mask: Builds a mask from an entire image or a selected region of interest.

Figure 3.18 Opening new image and running the same script



13.png - RGB - 752x480

Template Size
Width: 177
Height: 144

Match Offset
X 0
Y 0

Ignore Black and White: Disabled

Sat. Threshold: 80

752x480 1/1 (114,152)

Script: jainy2.scr *

Results ...	1
Center X	292.95569
Center Y	231.06059
Score	600
Angle	215.00000

Figure 3.19 Identification of an IC chip in the new image

3.4.2 Experimental Results of identification of an IC chip

The bmp images which were analyzed using Machine Vision Assistant 7.1.

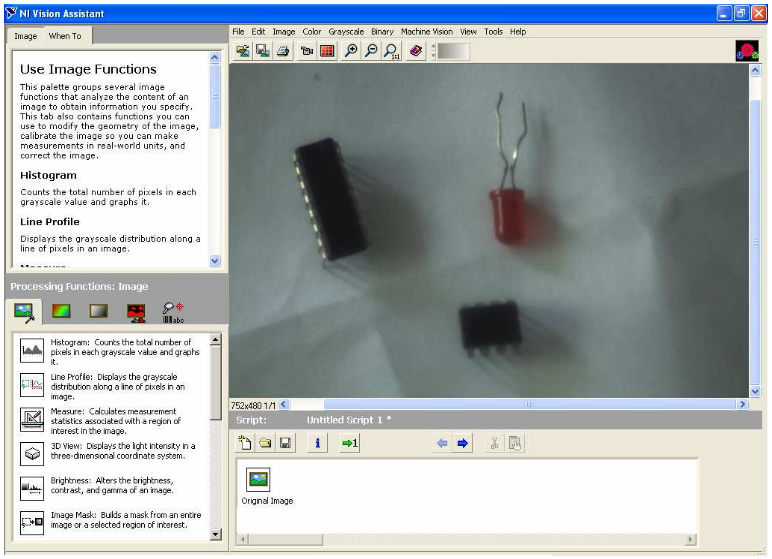
The results are tabulated below:

S. No.	Image file name	Center X (in pixels)	Center Y (in pixels)	Score (in pixels)	Angle (in degrees)
Im1	BMP	273.00000	395.00000	774	0
Im2	BMP	514.2409	264.46036	604	317
Im3	BMP	292.95569	231.06059	600	215
Im4	BMP	270.00000	390.00000	840	220
Im5	BMP	273.00000	395.00000	744	318
Im6	BMP	361.00000	346.00000	797	345
Im7	BMP	346.34897	264.64755	758	118
Im8	BMP	359.10977	349.32620	673	226
Im9	BMP	518.32617	260.89023	686	316
Im10	BMP	197.78398	218.83607	880	222

Table 3.1 Results of measurements of identification of an IC chip

3.4.3 Identification of the LED from the group of electronic components

In the following figures, from the group of electronic components LED is selected for color template matching from the rotated images. Brightness parameters are set accordingly and other parameters are kept same. The component is matched or not, can be viewed from the fact that there will be no results if the image does not contain that particular component whose template is saved for matching.



Use Image Functions

This palette groups several image functions that analyze the content of an image to obtain information you specify. This tab also contains functions you can use to modify the geometry of the image, calibrate the image so you can make measurements in real-world units, and correct the image.

Histogram

Counts the total number of pixels in each grayscale value and graphs it.

Line Profile

Displays the grayscale distribution along a line of pixels in an image.

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Line Profile: Displays the grayscale distribution along a line of pixels in an image.

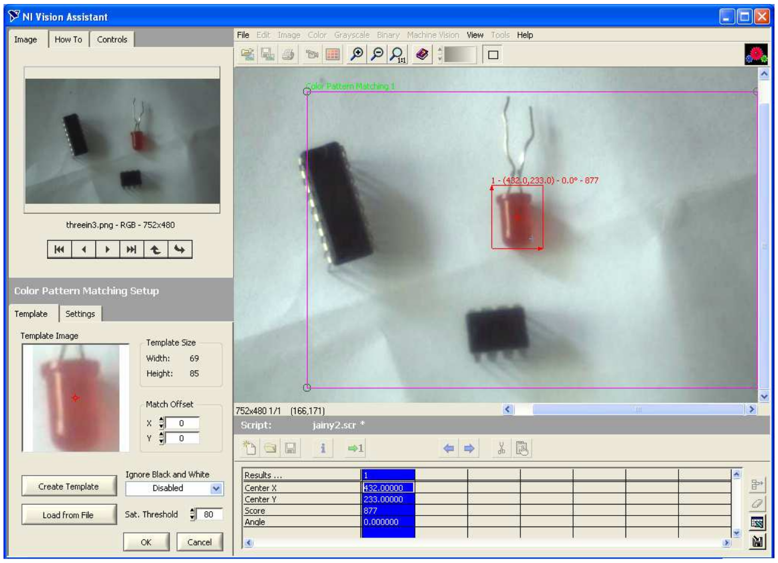
Measure: Calculates measurement statistics associated with a region of interest in the image.

3D View: Displays the light intensity in a three-dimensional coordinate system.

Brightness: Alters the brightness, contrast, and gamma of an image.

Image Mask: Builds a mask from an entire image or a selected region of interest.

Figure 3.20 Opening new image and running the same script for LED



threein3.png - RGB - 752x480

Template Size
Width: 69
Height: 85

Match Offset
X 0
Y 0

Ignore Black and White: Disabled

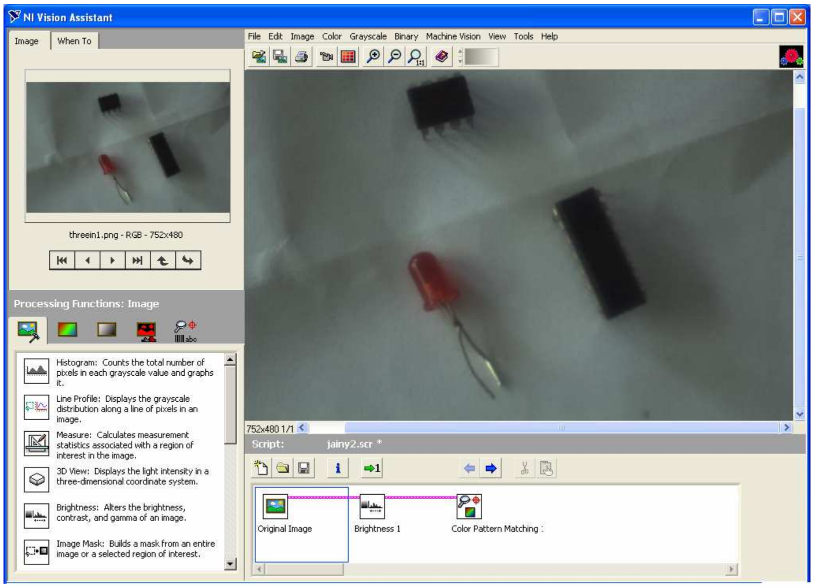
Sat. Threshold 80

752x480 1/1 (166,171)

Script: jainy2.scr *

Results ...	1
Center X	432.00000
Center Y	233.00000
Score	877
Angle	0.000000

Figure 3.21 Red ROI shows the identification of the LED



Histogram: Counts the total number of pixels in each grayscale value and graphs it.

Line Profile: Displays the grayscale distribution along a line of pixels in an image.

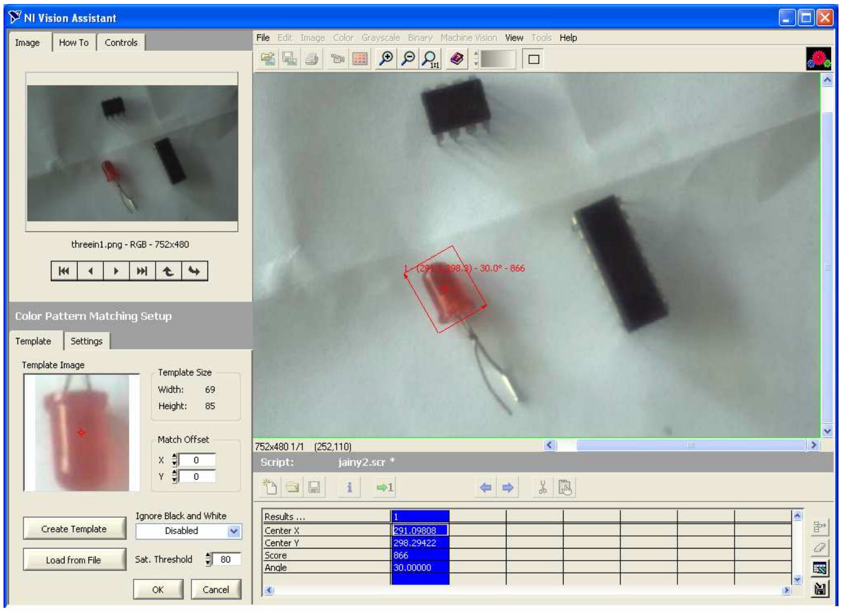
Measure: Calculates measurement statistics associated with a region of interest in the image.

3D View: Displays the light intensity in a three-dimensional coordinate system.

Brightness: Alters the brightness, contrast, and gamma of an image.

Image Mask: Builds a mask from an entire image or a selected region of interest.

Figure 3.22 Opening new image for LED detection



Template Size
Width: 69
Height: 85

Match Offset
X 0
Y 0

Ignore Black and White: Disabled
Sat. Threshold: 80

Results ...	1
Center X	291.09808
Center Y	298.29422
Score	866
Angle	30.00000

Figure 3.23 Red ROI shows the identification of the LED

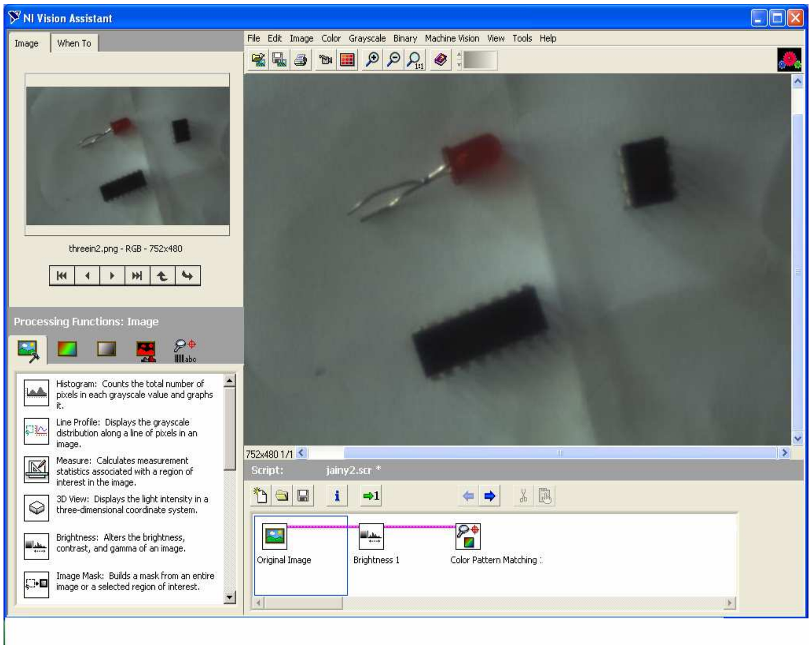
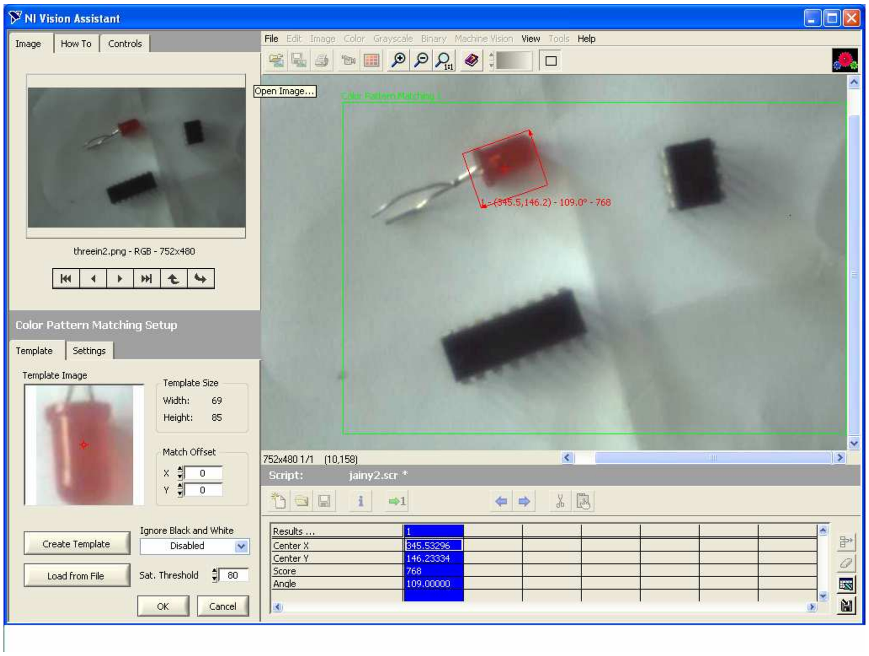


Figure 3.24 Opening new image and running the same script



Template Size
Width: 69
Height: 85

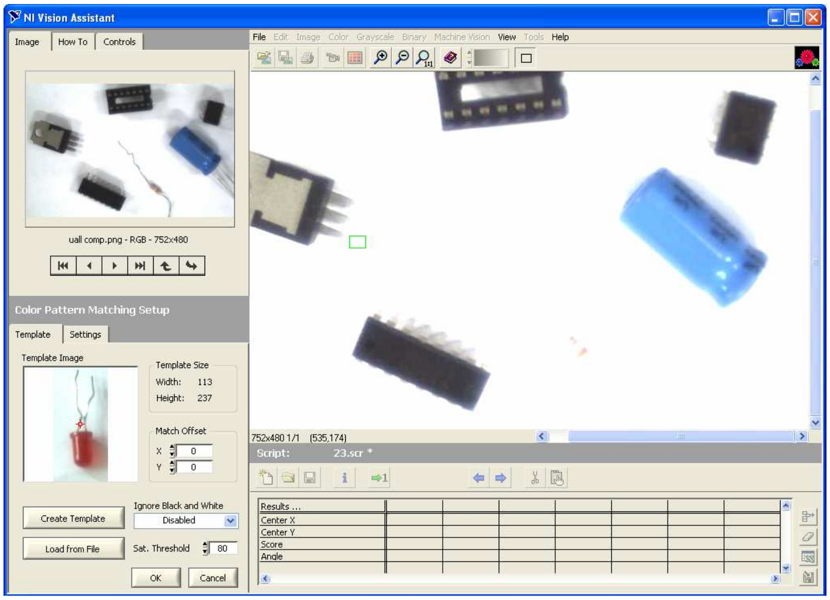
Match Offset
X 0
Y 0

Ignore Black and White: Disabled

Sat. Threshold: 80

Results ...	1
Center X	345.53296
Center Y	146.23334
Score	768
Angle	109.00000

Figure 3.25 Red ROI shows identification of the LED in the New Image



uall comp.png - RGB - 752x480

Template Size
Width: 113
Height: 237

Match Offset
X 0
Y 0

Ignore Black and White: Disabled

Sat. Threshold 80

752x480 1/1 (535,174)

Script: 23.scr *

Figure 3.26 No detection of LED if it is not present

3.4.4 Experimental Results of LED identification

The bmp images which were analyzed using Machine Vision Assistant 7.1.

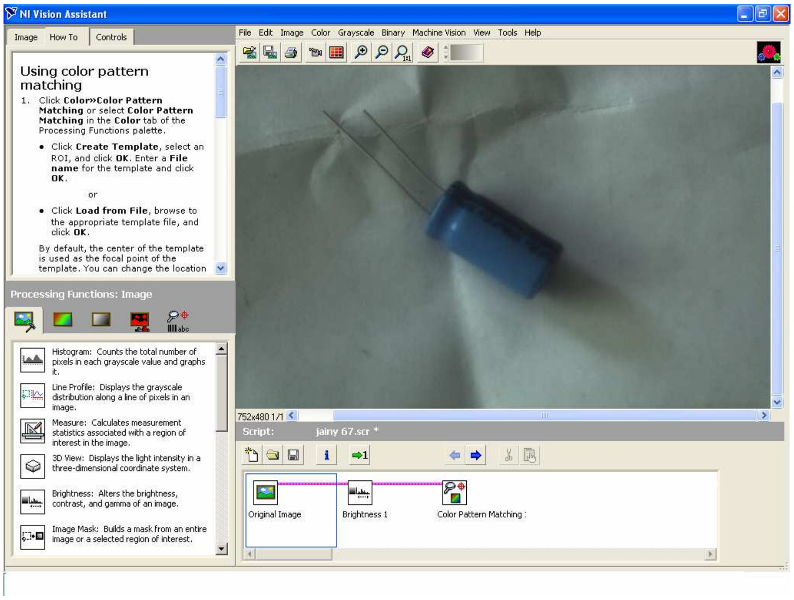
The results are tabulated below:

S. No.	Image file name	Center X (in pixels)	Center Y (in pixels)	Score (in pixels)	Angle (in degrees)
Im1	BMP	432.00000	187.00000	877	0
Im2	BMP	291.09808	298.29422	866	30
Im3	BMP	345.53296	146.23334	768	109
Im4	BMP	391.00000	308.29422	708	330
Im5	BMP	292.52249	298.88892	837	25
Im6	BMP	398.15302	298.22083	823	22
Im7	BMP	625.74036	180.93616	707	239
Im8	BMP	535.41779	342.91412	792	33
Im9	BMP	704.27808	349.11234	819	23
Im10	BMP	540.74036	287.23434	678	234

Table 3.2 Results of measurements of LED identification

3.4.5 Identification of the capacitor

In this section capacitor is identified by color pattern matching technique. Same steps are performed on the new image .Following figures shows the identification of capacitor.



Using color pattern matching

1. Click **Color»Color Pattern Matching** or select **Color Pattern Matching** in the **Color** tab of the Processing Functions palette.
   - Click **Create Template**, select an ROI, and click **OK**. Enter a **File name** for the template and click **OK**.

     or

   - Click **Load from File**, browse to the appropriate template file, and click **OK**.

   By default, the center of the template is used as the focal point of the template. You can change the location

Histogram: Counts the total number of pixels in each grayscale value and graphs it.

Line Profile: Displays the grayscale distribution along a line of pixels in an image.

Measure: Calculates measurement statistics associated with a region of interest in the image.

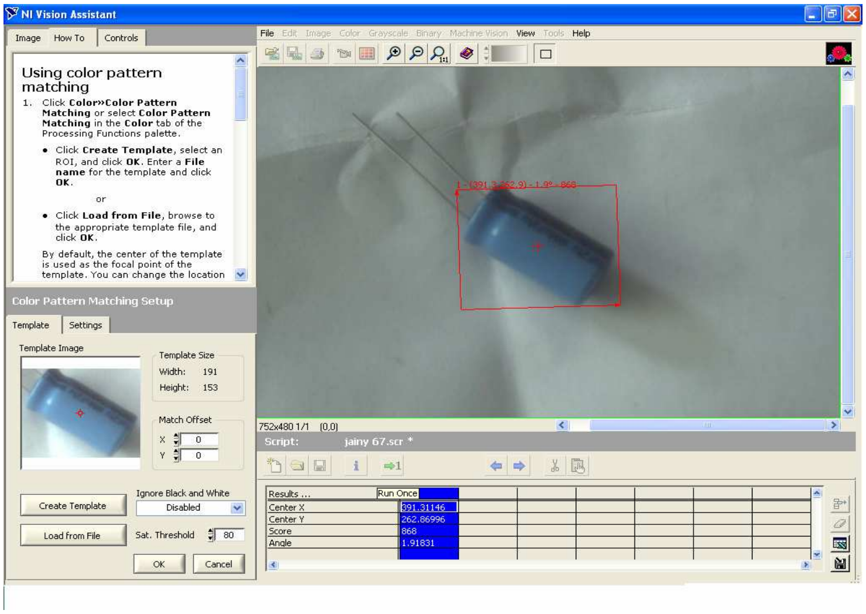
3D View: Displays the light intensity in a three-dimensional coordinate system.

Brightness: Alters the brightness, contrast, and gamma of an image.

Image Mask: Builds a mask from an entire image or a selected region of interest.

Script: jainy 67.scr *

Figure 3.27 Acquiring new image and running the same script



Using color pattern matching

1. Click **Color»Color Pattern Matching** or select **Color Pattern Matching** in the **Color** tab of the Processing Functions palette.
   - Click **Create Template**, select an ROI, and click **OK**. Enter a **File name** for the template and click **OK**.

     or

   - Click **Load from File**, browse to the appropriate template file, and click **OK**.

   By default, the center of the template is used as the focal point of the template. You can change the location

Template Size
Width: 191
Height: 153

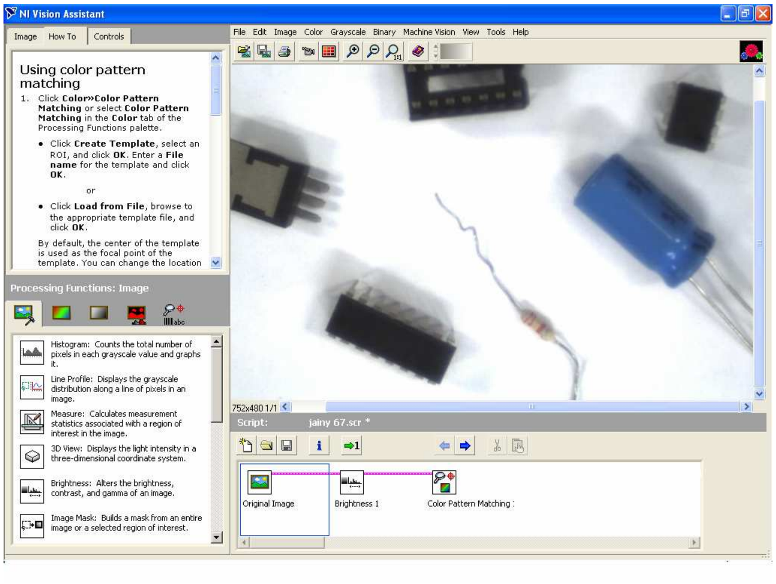
Match Offset
X 0
Y 0

Ignore Black and White: Disabled
Sat. Threshold: 80

Script: jainy 67.scr *

Results ...	Run Once
Center X	391.31146
Center Y	262.86996
Score	868
Angle	1.91831

Figure 3.28 Red ROI depicts the identification of the capacitor



Using color pattern matching

1. Click **Color»Color Pattern Matching** or select **Color Pattern Matching** in the **Color** tab of the Processing Functions palette.
    - Click **Create Template**, select an ROI, and click **OK**. Enter a **File name** for the template and click **OK**.

      or
    - Click **Load from File**, browse to the appropriate template file, and click **OK**.

   By default, the center of the template is used as the focal point of the template. You can change the location

Histogram: Counts the total number of pixels in each grayscale value and graphs it.

Line Profile: Displays the grayscale distribution along a line of pixels in an image.

Measure: Calculates measurement statistics associated with a region of interest in the image.

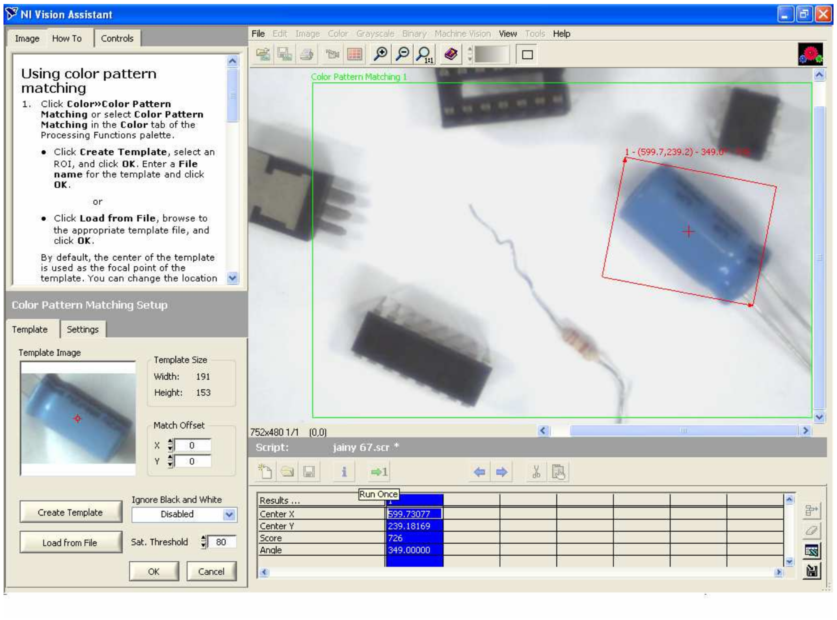
3D View: Displays the light intensity in a three-dimensional coordinate system.

Brightness: Alters the brightness, contrast, and gamma of an image.

Image Mask: Builds a mask from an entire image or a selected region of interest.

Script: jainy 67.scr *

Figure 3.29 Acquiring new image and running the same script



Using color pattern matching

1. Click **Color»Color Pattern Matching** or select **Color Pattern Matching** in the **Color** tab of the Processing Functions palette.
    - Click **Create Template**, select an ROI, and click **OK**. Enter a **File name** for the template and click **OK**.

      or
    - Click **Load from File**, browse to the appropriate template file, and click **OK**.

   By default, the center of the template is used as the focal point of the template. You can change the location

Color Pattern Matching Setup

Template | Settings

Template Image

Template Size
Width: 191
Height: 153

Match Offset
X 0
Y 0

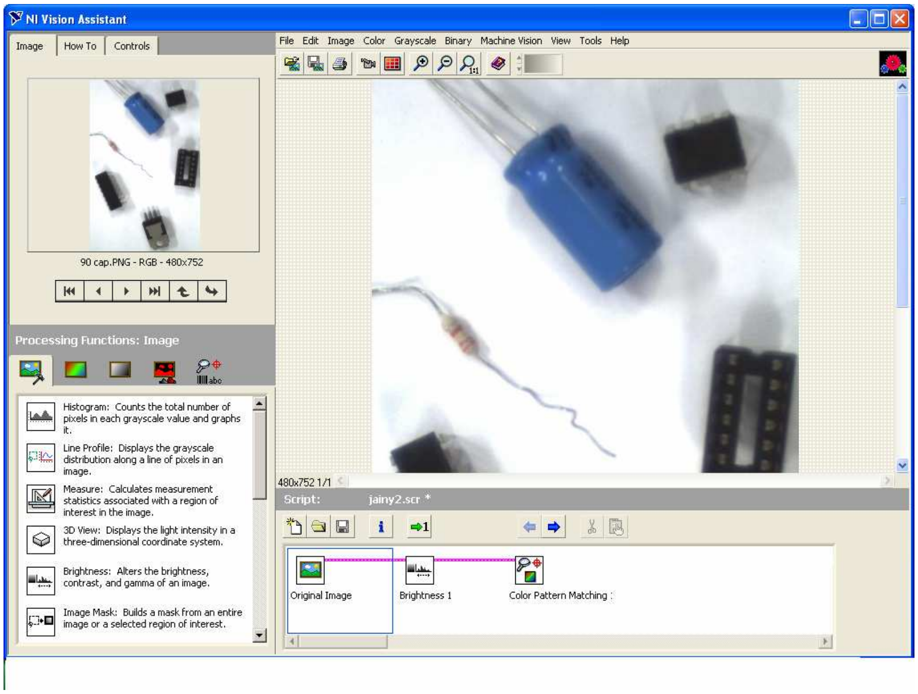
Ignore Black and White: Disabled

Sat. Threshold: 80

Script: jainy 67.scr *

Results ...	1
Center X	599.73077
Center Y	239.18169
Score	726
Angle	349.00000

Figure 3.30 Identification of the capacitor in the new image



Histogram: Counts the total number of pixels in each grayscale value and graphs it.

Line Profile: Displays the grayscale distribution along a line of pixels in an image.

Measure: Calculates measurement statistics associated with a region of interest in the image.

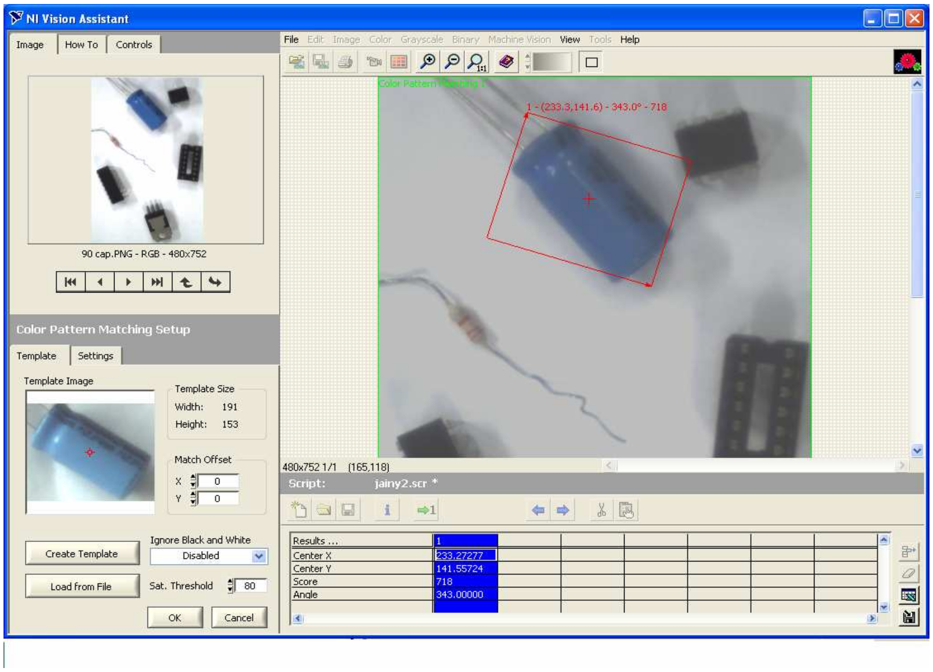
3D View: Displays the light intensity in a three-dimensional coordinate system.

Brightness: Alters the brightness, contrast, and gamma of an image.

Image Mask: Builds a mask from an entire image or a selected region of interest.

Script: jainy2.scr *

Figure 3.31 Acquiring new image and running the same script



Template Size
Width: 191
Height: 153

Match Offset
X 0
Y 0

Ignore Black and White: Disabled

Sat. Threshold 80

Script: jainy2.scr *

Results ...	1
Center X	233.27277
Center Y	141.55724
Score	718
Angle	343.00000

Figure 3.32 Red ROI depicts the identification of capacitor

3.4.6 Experimental Results of identification of capacitor

The bmp images which were analyzed using Machine Vision Assistant 7.1.

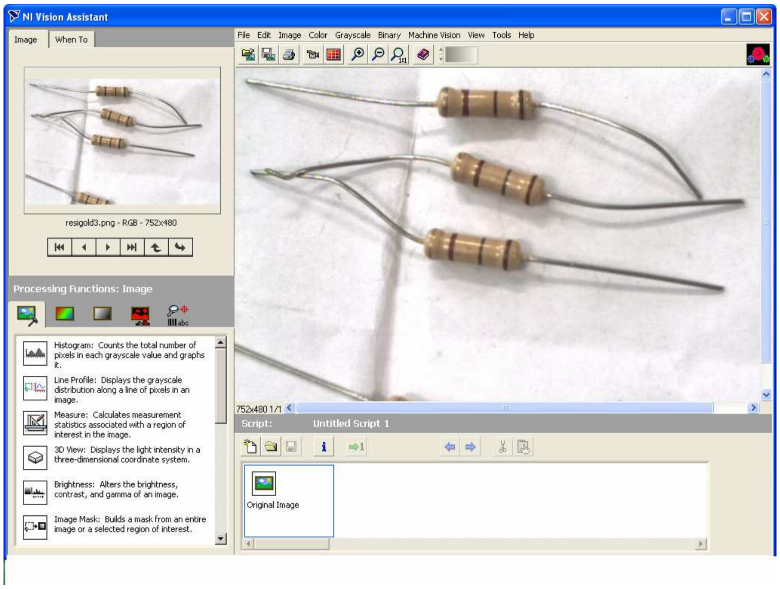
The results are tabulated below:

S. No.	Image file name	Center X (in pixels)	Center Y (in pixels)	Score (in pixels)	Angle (in degrees)
Im1	BMP	391.31146	262.86996	868	0
Im2	BMP	599.73077	239.18169	726	349
Im3	BMP	264.75446	359.13780	782	89
Im4	BMP	391.86252	264.75446	809	359
Im5	BMP	215.24556	391.86252	791	269
Im6	BMP	138.83118	247.66277	704	74
Im7	BMP	150.17650	238.55261	636	170
Im8	BMP	142.55724	248.72723	760	73
Im9	BMP	233.27277	141.55724	718	343
Im10	BMP	359.85825	216.75688	678	181

Table 3.3 Results of measurements of identification of capacitor

3.4.7 Identification of resistor (s) from the group

In this example, numbers of templates to be matched are taken more than one. But from the parameters setting, the option of Number of Matches found is made equal to three. In the group of resistors if the template saved, matches with more than one resistor, the red ROI will be seen around the number of template found. This shown in figure 3.34.



Histogram: Counts the total number of pixels in each grayscale value and graphs it.

Line Profile: Displays the grayscale distribution along a line of pixels in an image.

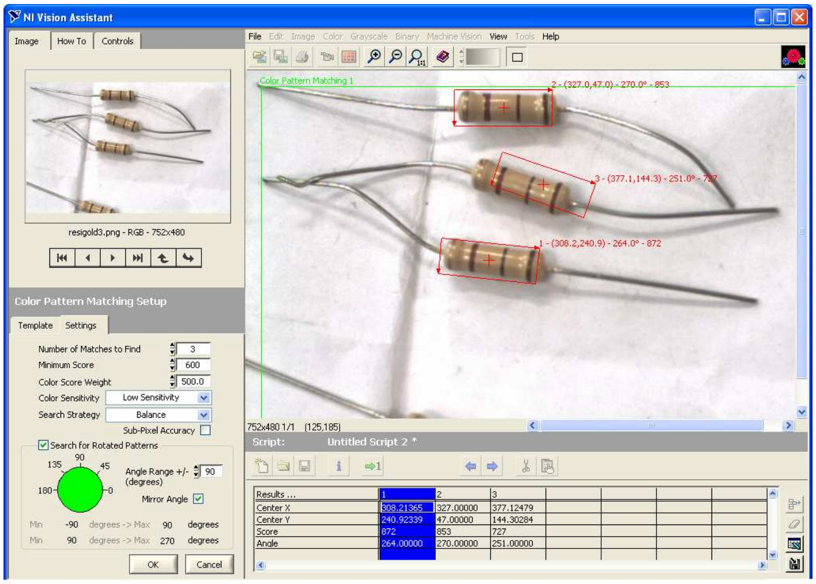
Measure: Calculates measurement statistics associated with a region of interest in the image.

3D View: Displays the light intensity in a three-dimensional coordinate system.

Brightness: Alters the brightness, contrast, and gamma of an image.

Image Mask: Builds a mask from an entire image or a selected region of interest.

Figure 3.33 Acquiring new image and running the same script

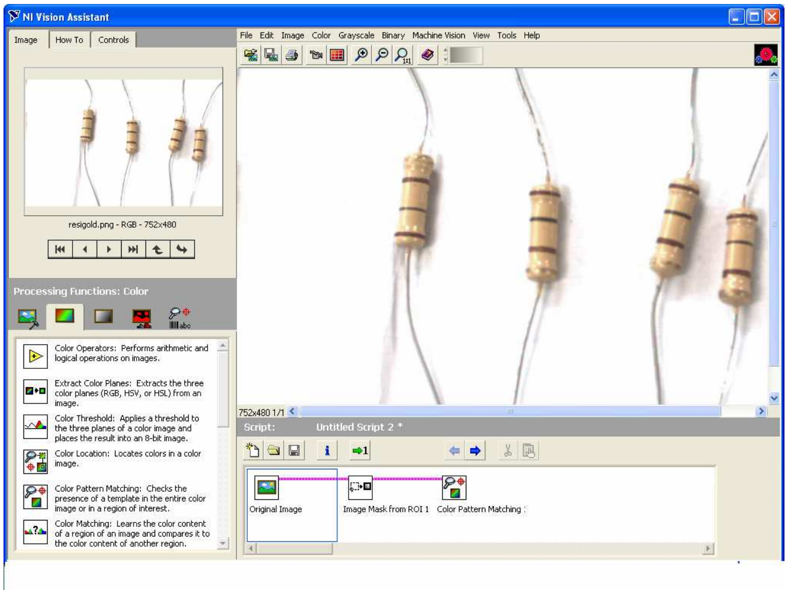


Number of Matches to Find: 3
Minimum Score: 600
Color Score Weight: 500.0
Color Sensitivity: Low Sensitivity
Search Strategy: Balance
Sub-Pixel Accuracy ☐
☑ Search for Rotated Patterns
Angle Range +/- (degrees): 90
Mirror Angle ☑
Min -90 degrees -> Max 90 degrees
Min 90 degrees -> Max 270 degrees

Results ...	1	2	3
Center X	308.21365	327.00000	377.12479
Center Y	240.92339	47.00000	144.30284
Score	872	853	727
Angle	264.00000	270.00000	251.00000

Figure 3.34 Identification of resistors in the new image

Number of matches=3



Color Operators: Performs arithmetic and logical operations on images.

Extract Color Planes: Extracts the three color planes (RGB, HSV, or HSL) from an image.

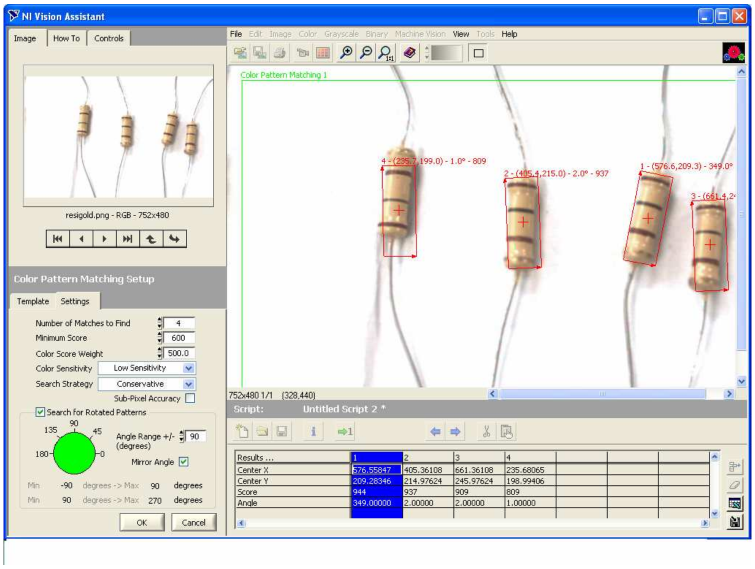
Color Threshold: Applies a threshold to the three planes of a color image and places the result into an 8-bit image.

Color Location: Locates colors in a color image.

Color Pattern Matching: Checks the presence of a template in the entire color image or in a region of interest.

Color Matching: Learns the color content of a region of an image and compares it to the color content of another region.

Figure 3.35 Acquiring new image and running the same script



Number of Matches to Find 4
Minimum Score 600
Color Score Weight 500.0
Color Sensitivity Low Sensitivity
Search Strategy Conservative
Sub-Pixel Accuracy ☐
☑ Search for Rotated Patterns
Angle Range +/- (degrees) 90
Mirror Angle ☑
Min -90 degrees -> Max 90 degrees
Min 90 degrees -> Max 270 degrees

Results ...	1	2	3	4
Center X	576.55847	405.36108	661.36108	235.68065
Center Y	209.28346	214.97624	245.97624	198.99406
Score	944	937	909	809
Angle	349.00000	2.00000	2.00000	1.00000

Figure 3.36 Red ROI depicts the identification of resistors

Number of matches =4

3.4.8 Experimental Results of identification of resistors

The bmp images which were analyzed using Machine Vision Assistant 7.1.

S. No.	Image file name	Center X (in pixels)	Center Y (in pixels)	Score (in pixels)	Angle (in degrees)
Im1	BMP Match 1	308.21365	240.92339	872	264
	Match 2	327.00000	47.00000	853	270
	Match 3	377.12479	144.30248	727	251
Im2	BMP Match 1	576.55847	209.28346	944	349
	Match 2	405.36108	214.97624	937	2
	Match 3	661.36108	245.97624	909	2
	Match 4	235.68065	198.99406	809	1
Im3	BMP	347.10535	155.73122	758	250
Im4	BMP	315.13904	245.23326	737	261
Im5	BMP	354.99057	134.37788	647	244
Im6	BMP	456.95047	59.16302	784	92
Im7	BMP	63.24220	216.56543	837	37
Im8	BMP	180.25470	172.91478	831	3
Im9	BMP	262.37320	169.15993	863	13
Im10	BMP	339.23328	213.86096	812	351

Table 3.4 Results of Measurements of identification of resistors

3.5 Linking with Lab VIEW

Vision Assistant 7.1 creates a Lab VIEW VI corresponding to the algorithm we prototype in Vision Assistant. Based on the options we select, the Lab VIEW VI Creation Wizard creates a new VI that implements the image processing steps of the current script or of a saved script file. Only Lab VIEW version 7.1 or above is compatible with VA 7.1. It does not support Lab VIEW version below 7.1.

Lab VIEW programs are called virtual instruments, or VIs, because their appearance and operation imitate physical instruments, such as oscilloscopes and multi-meters. Lab VIEW contains a comprehensive set of tools for acquiring, analyzing, displaying, and storing data, as well as tools to help we troubleshoot our code. In Lab VIEW, we build a user interface, or front panel, with controls and indicators. Controls are knobs, push buttons, dials, and other input devices. Indicators are graphs, LEDs, and other displays. After we build the user interface, we add code using VIs and structures to control the front panel objects. The block diagram contains this code. Use Lab VIEW to communicate with hardware such as data acquisition, vision, and motion control devices and GPIB, PXI, VXI, RS-232, and RS-485 instruments.

3.5.1 Front Panel

The front panel is the user interface of a VI. We build the front panel by using controls and indicators, which are the interactive input and output terminals of the VI, respectively. Controls and indicators are located on the Controls palette. Controls are knobs, push buttons, dials, and other input devices. Controls simulate the input devices on a physical instrument and supply data to the block diagram of the VI. Indicators are graphs, LEDs, and other displays. Indicators simulate the output devices on a physical instrument and display data the block diagram acquires or generates.

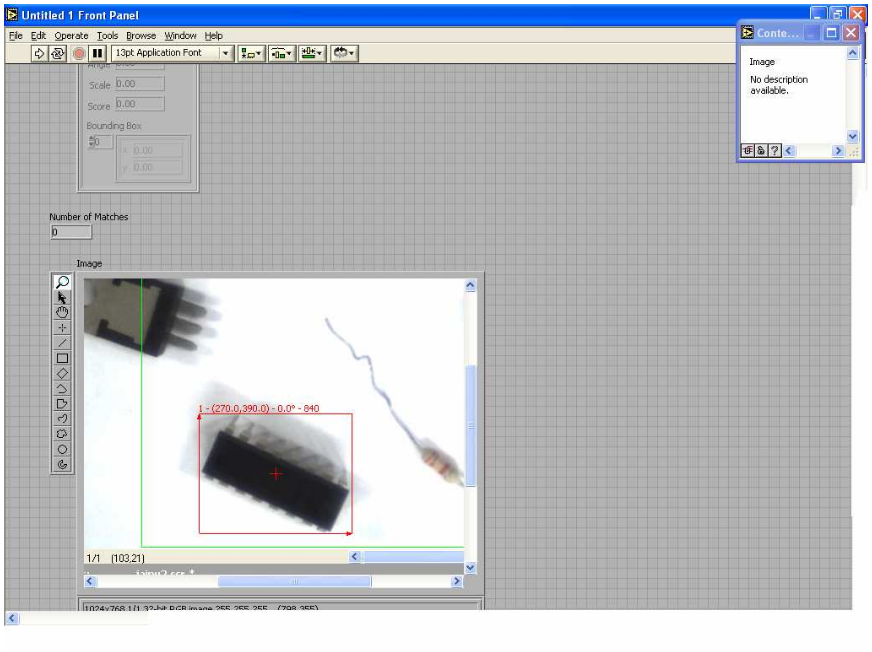


Figure 3.37 Front Panel View

3.5.2 Block Diagram

The block diagram contains the graphical source code for how the VI runs. Front panel objects appear as icon terminals on the block diagram. Wires connect control and indicator terminals to Express VIs. Data flows from controls to Express VIs, from Express VIs to Express VIs, and from Express VIs to indicators through the wires.

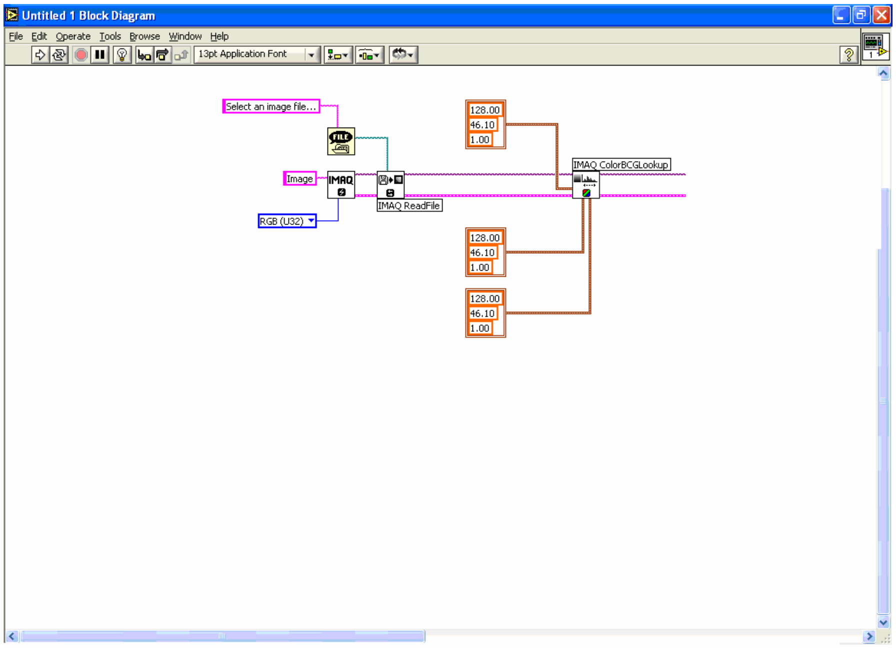


Figure 3.38 Block Diagram Part 1

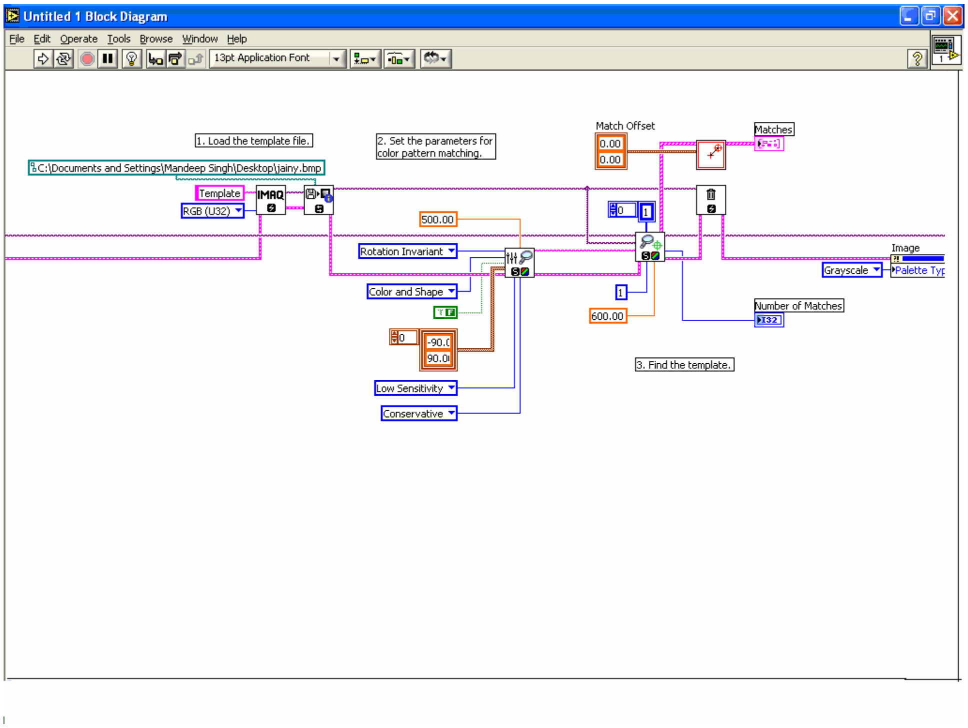


Figure3.39 Block Diagram Part 2

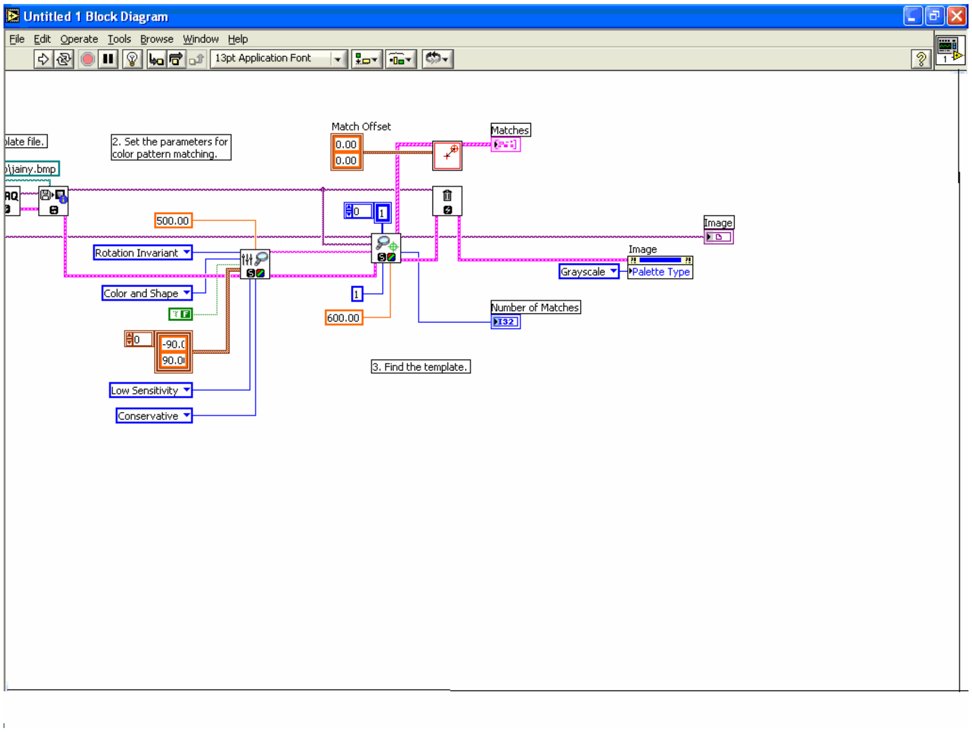


Figure 3.40 Block Diagram Part 3

3.6 Results and Discussion

In this system identification of electronic components such as IC chips, resistors capacitors, LEDs etc, components can be easily identified by color pattern matching. Labeling of electronic components can be done very fast as compared to manual labeling. This algorithm is also adaptable when size and rotation of electronic components is changed. Processing time of script is 159.71ms, which is very less.

Chapter 4: Using Gauging for Dimensional Measurement

4.1 Introduction to Gauging

Gauging refers to the task of measuring distances in images, such as to determine the size of objects or separation between objects in an image.

The two basic steps are:

1.) To first identify object locations and/or boundaries.
2.) To calculate distances or angles based on those boundaries.

The techniques used for Gauging are:

1.) Color Pattern Matching
2.) Template Matching
3.) Edge Detection
4.) Caliper

Gauging applications are used for making critical dimensional measurements such as length, distance, diameter, angle, and quantity—to determine if the product under inspection is manufactured correctly. Depending on whether the gauged parameters fall inside or outside of the user-defined tolerance limits, the component or part is either accepted or rejected [6].

Gauging is used both as:

1.) Inline Production
2.) Offline Production

1.) Inline Production

During inline processes, each component is inspected as it is manufactured. Visual inline gauging inspection is a widely used inspection technique in applications such as mechanical assembly verification, electronic packaging inspection, and electronic connector inspection.

2.) Offline Production.

Gauging applications often measure the quality of products offline. First, a sample of products is extracted from the production line. Next, measured distances between features on the object are studied to determine if the sample falls within a tolerance range. The distances separating the different edges located in an image can be measured, as well as positions can be measured using particle analysis or by color pattern matching techniques. Edges can also be combined in order to derive best fit lines, and angles. Part present/not present applications are typical in electronic connector assembly and mechanical assembly applications. The objective of the application is to determine if a part is present or not present using line profiles and edge detection.

Gauging techniques also allows us to measure the distance between particles and edges in binary images and easily quantify image measurements.

Concepts

The gauging process consists of the following four steps:

1.) Locates the component or part in the image.

2.) Locates features in different areas of the part.

3.) Make measurements using these features.

4.) Compare the measurements to specifications to determine if the part passes inspection.

4.2 Gauging Tools

4.2.1 Introduction

Dimensional measurements or gauging tools in IMAQ Vision are used to obtain quantifiable, critical distance measurements—such as distances, angles, mid points, and quantities. These measurements help us to determine if a product was manufactured correctly or not. Components such as connectors, switches, and relays are small and manufactured in high quantity. Human inspection of these components is tedious, time consuming, and inconsistent. IMAQ Vision can quickly and consistently measure certain features on these components and generate a report of the results. If the gauged distance or count does not fall within user-specified tolerance limits, the component or part fails to meet production specifications and is rejected.

4.2.2 Locating the Part in the Image

A typical gauging application extracts measurements from ROIs rather than from an entire image. To use this technique, the necessary parts of the object must always appear inside the ROIs defined by us. Usually, the object under inspection appears shifted or rotated within the images to be processed. When this occurs, the ROIs need to shift and rotate in the same way as the object. In order for the ROIs to move in relation to the object, object must be located in every image. Locating the object in the image involves determining the x, y position and orientation of the object in the image using the reference coordinate system functions. A coordinate reference system can be built using edge detection or pattern matching.

4.2.3 Locating Features

To gauge an object, object features are to be find on which measurements can be based. In most applications, measurements can be based on points detected in the image

Object features that are useful for measurements fall into two categories:

1.) Edge points along the boundary of an object located by the edge detection method.
2.) Shapes or patterns within the object located by color pattern matching

(a) Making Measurements

Different types of measurements can be made from the features found in the image. Typical measurements include the distance between points; the angle between two lines represented by two, three or four points.

(b) Qualifying Measurements

The last step of a gauging application involves determining the quality of the part based on the measurements obtained from the image. It determines the quality of the part using either relative comparisons or absolute comparisons.

In many applications, the measurements obtained from the inspection image can be compared to the same measurements obtained from a standard specification or a reference image. Because all the measurements are made on images of the part, so these can be compared directly. In other applications, the dimensional measurements obtained from the image must be compared with values that are specified in real units.

(c) Coordinate System

In a typical machine vision application, measurements are extracted from an ROI rather than from the entire image. The object under inspection must always appear in the defined ROI in order to extract measurements from that ROI. When the location and orientation of the object under inspection is same in the inspection images, measurements can be made directly without locating the object in every inspection image. In most cases, the object under inspection is not positioned in the camera field of view consistently enough to use fixed search areas. If the object is shifted or rotated within an image, the search areas should shift and rotate with the object. The search areas are defined relative to a coordinate system. A coordinate system is defined by a reference point (origin) and a reference angle in the image or by the lines that make up its two axes.

In gauging application coordinate systems are used when the object does not appear in the same position in every inspection image. A coordinate system is also used to define search areas on the object relative to the location of the object in the image.

Concepts

All measurements are defined with respect to a coordinate system. A coordinate system is based on a characteristic feature of the object under inspection, which is used as a reference for the measurements. When an object is inspected, firstly the reference feature is located in the inspection image, a feature on the object is chosen that the software can reliably detect in every image. A feature that may be affected by manufacturing errors and that would make the feature impossible to locate in images of defective parts should not be chosen. The region of the image is restricted in which the software searches for the feature by specifying an ROI that encloses the feature. Defining an ROI in which the feature is expected to be found prevents mismatches, if the feature appears in multiple regions of the image. A small ROI may also improve the locating speed.

Steps to define a coordinate system and make measurements based on the new coordinate system.

1.) Define a reference coordinate system.

2.) Define a search area that encompasses the reference feature or features on which we have based our coordinate system. The search area should encompass the features in all of our inspection images.

3.) An easy-to-find reference feature is to be located of the object under inspection. That feature serves as the base for a reference coordinate system in a reference image. Two primary techniques are to be used to locate the feature:

(i) Edge detection

(ii) Color Pattern matching.

4.) The software builds a coordinate system to keep track of the location and orientation of the object in the image.

5.) Measurement areas are to be set up within the reference image in which measurements are to be made.

6.) An image of the object is acquired for inspection or measurement.

7.) Update the coordinate system. During this step, IMAQ Vision locates the features in the search area and builds a new coordinate system based on the new location of the features.

8.) Within the updated measurement area, measurements are made. IMAQ Vision computes the difference between the reference coordinate system and the new coordinate system. Based on this difference, the software moves the new measurement areas with respect to the new coordinate system. .

Edge-Based Coordinate System Functions

These functions determine the axis of the coordinate system by locating edges of the part under inspection. An edge-based method is used if identification of two straight, distinct, non-parallel edges on the object on which we want to:

1 Search Area for the Coordinate System

2 Object Edges

3 Origin of the Coordinate System

4 Measurement Areas

(d) Finding Features or Measurement Points

Before making measurements, features must be located on which measurements are to be made. There are many ways to find these features on an image. The most common features used to make measurements are points along the boundary of the part to be gauged.

(e) Edge-Based Features

To find edge points along a single search contour or along multiple search contours defined inside a 2D search area. Edge detection Techniques are used

1.) Located Feature
2.) Coordinate System
3.) Origin of the Coordinate System
4.) Measurement Areas

(f) Distance Measurements

Using one of the following methods we can make distance measurements:

Measure the distance between points found by one of the feature detection methods.

Measure the distance between two edges of an object using the clamp functions available in IMAQ Vision. They then compute the distance between the detected points and return the largest or smallest distance.

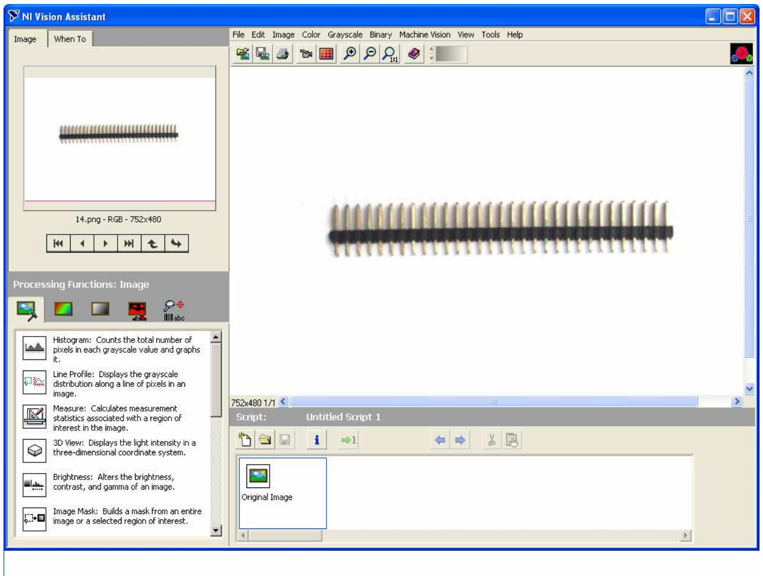
4.3 Problem Solution

4.3.1 Dimensional Measurement of a 62 pin connector

In this section dimensional measurement is done on a 62 pin connector and this technique is further applied on the other electronic components in the following sections.

4.3.1.1 Loading an original image of 62 pin connector in the welcome screen

The dimensional measurements are done on 62 pin connector. The original image is being loaded. Initial steps such as color pattern matching, template learning and saving are performed on the image, step by step procedure is illustrated in the figures below.



Histogram: Counts the total number of pixels in each grayscale value and graphs it.

Line Profile: Displays the grayscale distribution along a line of pixels in an image.

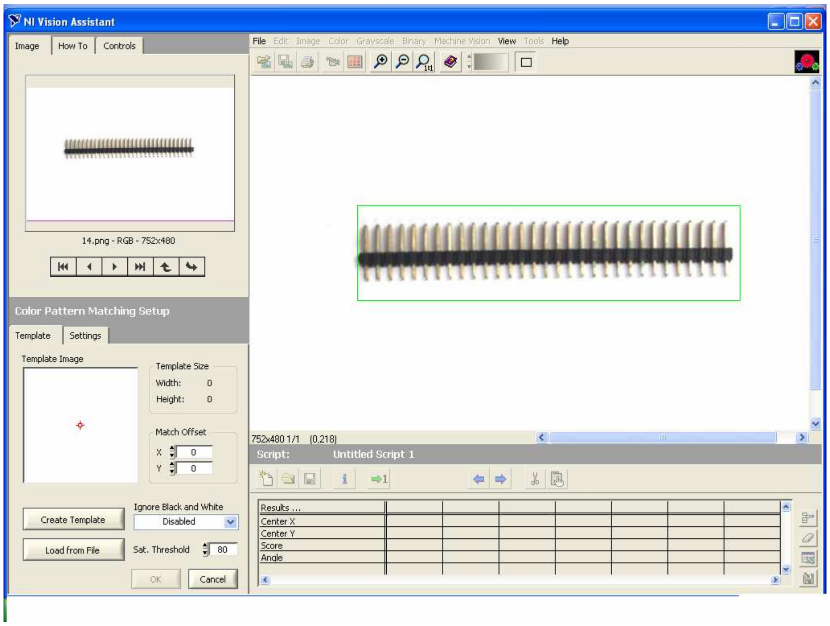
Measure: Calculates measurement statistics associated with a region of interest in the image.

3D View: Displays the light intensity in a three-dimensional coordinate system.

Brightness: Alters the brightness, contrast, and gamma of an image.

Image Mask: Builds a mask from an entire image or a selected region of interest.

Figure 4.1 Opening image of 62 pin connector



Template Size
Width: 0
Height: 0

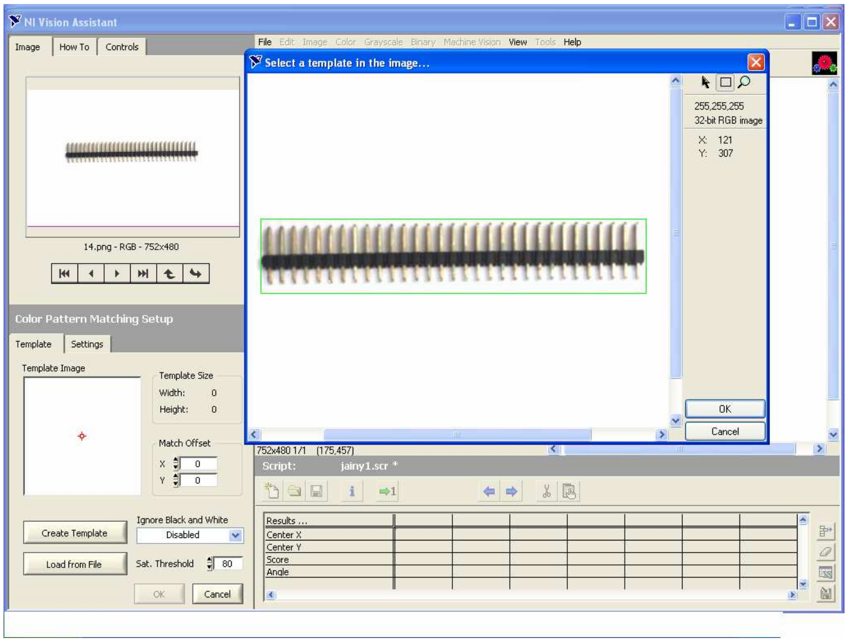
Match Offset
X 0
Y 0

Ignore Black and White: Disabled

Sat. Threshold: 80

ROI drawn around the image

Figure 4.2 Color pattern matching



14.png - RGB - 752x480

255,255,255
32-bit RGB image
X: 121
Y: 307

752x480 1/1 (175,457)

Script: jainy1.scr *

Color Pattern Matching Setup

Template Image

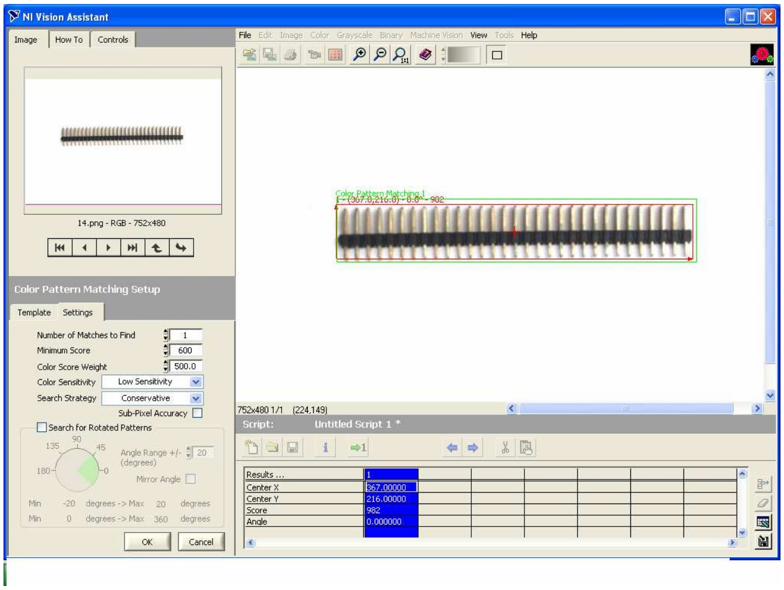
Template Size
Width: 0
Height: 0

Match Offset
X 0
Y 0

Ignore Black and White: Disabled
Sat. Threshold: 80

Results ...	
Center X	
Center Y	
Score	
Angle	

Figure 4.3 Learning of template match in the image



14.png - RGB - 752x480

Color Pattern Matching Setup

Template Settings

Number of Matches to Find: 1
Minimum Score: 600
Color Score Weight: 500.0
Color Sensitivity: Low Sensitivity
Search Strategy: Conservative
Sub-Pixel Accuracy ☐
☐ Search for Rotated Patterns
Angle Range +/- (degrees): 20
Mirror Angle ☐
Min -20 degrees -> Max 20 degrees
Min 0 degrees -> Max 360 degrees

752x480 1/1 (224,149)

Script: Untitled Script 1 *

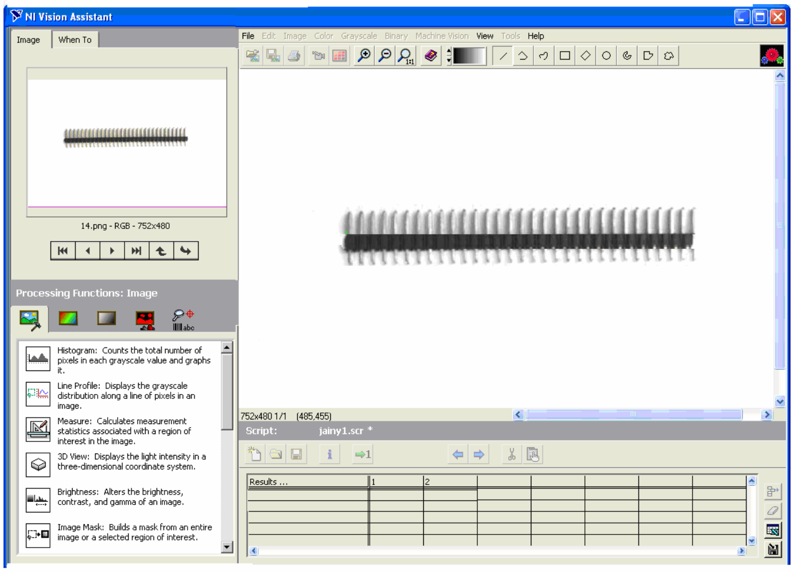
Results ...	1
Center X	367.00000
Center Y	216.00000
Score	982
Angle	0.000000

Figure 4.4 Matched values of the template and the image

4.3.1.2 Extracting RGB plane

RGB (Red, Green, and Blue) plane is extracted because dimensional measurement functions such as edge detector and caliper functions do not support RGB image type. These functions support only 8 bit, 16 bit, and binary image type(s).

Because each color plane is made up of 8 bits, the color plane extracted i.e. red color is extracted from the image so that measurement functions can be performed on the image.



Histogram: Counts the total number of pixels in each grayscale value and graphs it.

Line Profile: Displays the grayscale distribution along a line of pixels in an image.

Measure: Calculates measurement statistics associated with a region of interest in the image.

3D View: Displays the light intensity in a three-dimensional coordinate system.

Brightness: Alters the brightness, contrast, and gamma of an image.

Image Mask: Builds a mask from an entire image or a selected region of interest.

Figure 4.5 Extraction of RGB plane

4.3.1.3 Edge Detection

This section describes edge detection techniques and tools that locate edges and caliper in the given image.

Edge Definition

An edge along the line profile is defined by the level of contrast between background and foreground pixels. It refers to the process of identifying and locating sharp discontinuities in an image. The discontinuities are abrupt changes in pixel intensity that characterize boundaries of objects in a scene. The location of the edge is used to make measurements, such as the width of the part. Using this technique, the number of edges along the line profile can be counted and the result is compared to an expected number of edges. An edge is a significant change in the grayscale values between adjacent pixels in an image. In IMAQ Vision, edge detection works on a 1D profile of pixel values along a search region. The 1D search region can take the form of a line, the perimeter of a circle or ellipse, the boundary of a rectangle or polygon, or a freehand region. The software analyzes the pixel values along the profile to detect significant intensity changes. Characteristics of the intensity changes can be specified to determine which changes constitute an edge.

Detection of Edges

Edge detection finds edges along a line of pixels in the image. Edge detection tools are used to identify and locate discontinuities in the pixel intensities of an image. The discontinuities are typically associated with abrupt changes in pixel intensity values that characterize the boundaries of objects in a scene. To detect edges in an image, a search region is specified in which image is to be located .Search region can be specified interactively or programmatically. When specified interactively, one of the line ROI tools is used to select the search path to be analyzed. The search regions can programmatically fixed based either on constant values or the result of a previous processing step. For example, we may want to locate edges along a specific portion of a part that has been previously located using particle analysis or pattern matching algorithms. The edge detection software analyzes the pixels along this region to detect edges. The edge detection tool can be configured to find all edges, to find the first edge, or to find the first and last edges in the region.

Why Edge Detection is used?

This method offers a less numerically intensive alternative to other image processing methods such as image correlation and pattern matching.

Figure 4.6 shows a simple detection application in which the number of edges detected along the search line profile determines if a connector has been assembled properly. Detection of eight edges indicates that there are four wires. Any other edge count means that the part has been assembled incorrectly.

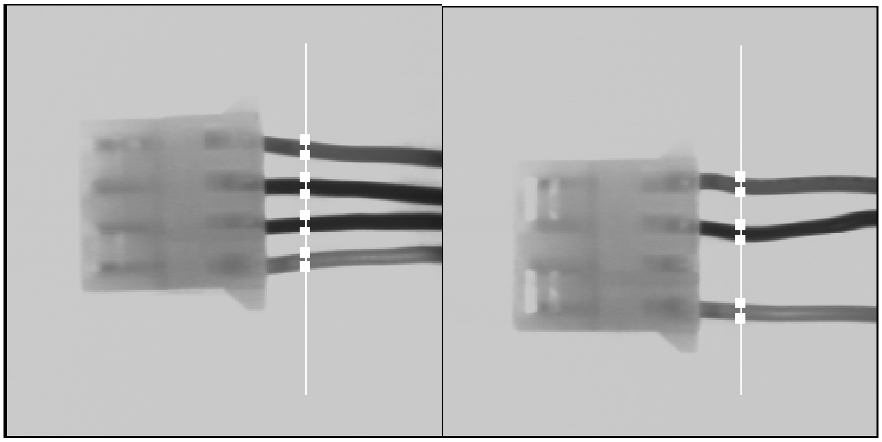


Figure 4.6 Edge Detection

Edge detection is also used to detect structural defects, such as cracks, or cosmetic defects, such as scratches, on a part. If the part is of uniform intensity, these defects show up as sharp changes in the intensity profile. Edge detection identifies these changes.

Alignment determines the position and orientation of a part. In many machine vision applications, the object that is inspected may be at different locations in the image. Edge detection finds the location of the object in the image before performing the inspection, so only the regions of interest can be inspected.

When to Use

Edge detection is an effective tool for many machine vision applications. It provides our application with information about the location of object boundaries and the presence of discontinuities.

Edge detection can be used in the following three application areas:

1.) Gauging

2.) Detection

3.) Alignment.

Characteristics of an Edge

Following are the characteristics of an edge

1.) Edge strength— It defines the minimum difference in the grayscale values between the background and the edge. The edge strength is also called the edge contrast. Figure 4.7 shows an image that has different edge strengths. The strength of an edge can vary for the following reasons:

Lighting conditions—If the overall light in the scene is low, the edges in image will have low strengths. Figure 4.7 illustrates a change in the edge strength along the boundary of an object relative to different lighting conditions.

Objects with different grayscale characteristics—The presence of a very bright object causes other objects in the image with lower overall intensities to have edges with smaller strengths.

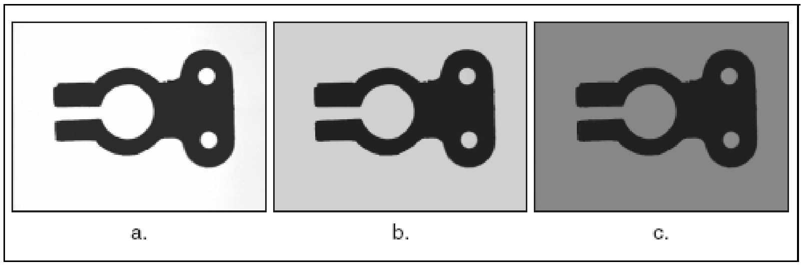


Figure 4.7 Examples of Images with different Edge Strengths

2.) Edge length—It defines the maximum distance in which the desired grayscale difference between the edge and the background must occur. The length characterizes the slope of the edge. A longer length is used to detect edges with a gradual transition between the background and the edge.

3.) Edge polarity—It defines whether an edge is rising or falling. A rising edge is characterized by an increase in grayscale values as the edge is crossed. A falling edge is characterized by a decrease in grayscale values as the edge is crossed. The polarity of an edge is linked to the search direction. Figure 4.8 shows examples of edge polarities.

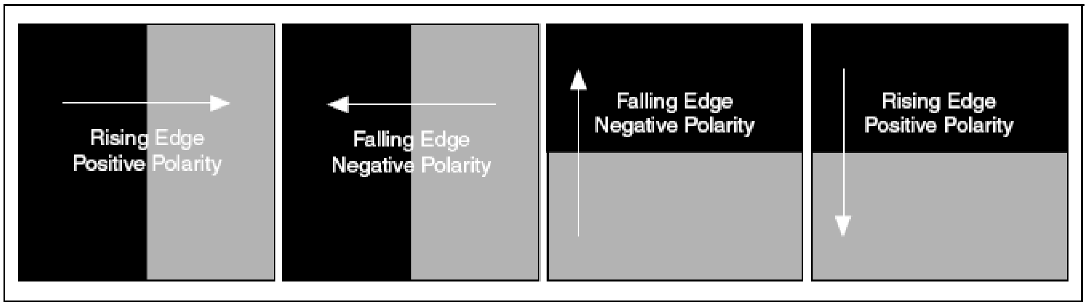


Figure 4.8 Edge polarities

4.) Edge position—The x, y location of an edge in the image. Figure 4.9 shows the edge position for the edge model.

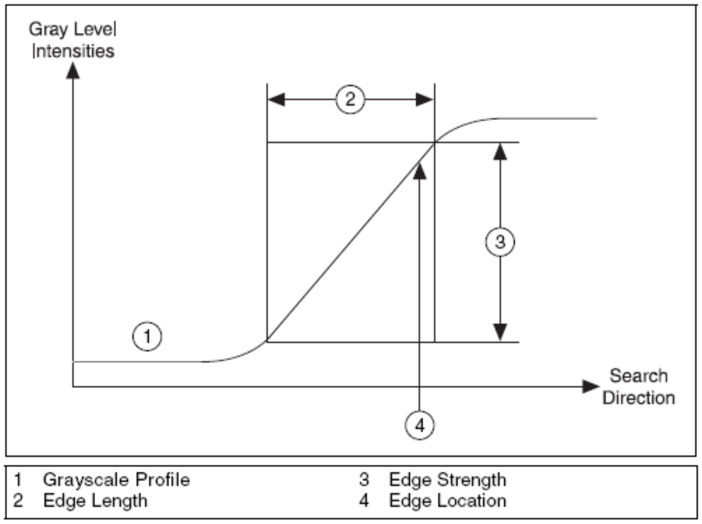


Figure: 4.9 Edge Model

Edge Detection Methods

IMAQ Vision offers two ways to perform edge detection. Both methods compute the edge strength at each pixel along the 1D profile. An edge occurs when the edge strength is greater than a minimum strength. Additional checks find the correct location of the edge. The minimum strength is specified by using the contrast parameter in the software. IMAQ Vision offers two ways to perform edge detection. Both methods compute the edge strength at each pixel along the 1D profile. An edge occurs when the edge strength is greater than a minimum strength. Additional checks find the correct location of the edge.

Edge Detection Methods are:

(a) Simple Edge Detection

(b) Advanced Edge Detection

(a) Simple Edge Detection

The software uses the pixel value at any point along the pixel profile to define the edge strength at that point. To locate an edge point, the software scans the pixel profile pixel by pixel from the beginning to the end. A rising edge is detected at the first point at which the pixel value is greater than a threshold value plus a hysteretic value. This threshold value is set to define the minimum edge strength required for qualifying edges. When a rising edge is detected, the software looks for a falling edge. A falling edge is detected when the pixel value falls below the specified threshold value. This process is repeated until the end of the pixel profile. The first edge along the profile can be either a rising or falling edge. The simple edge detection method works well when there is little noise in the image and when there is a distinct demarcation between the object and the background.

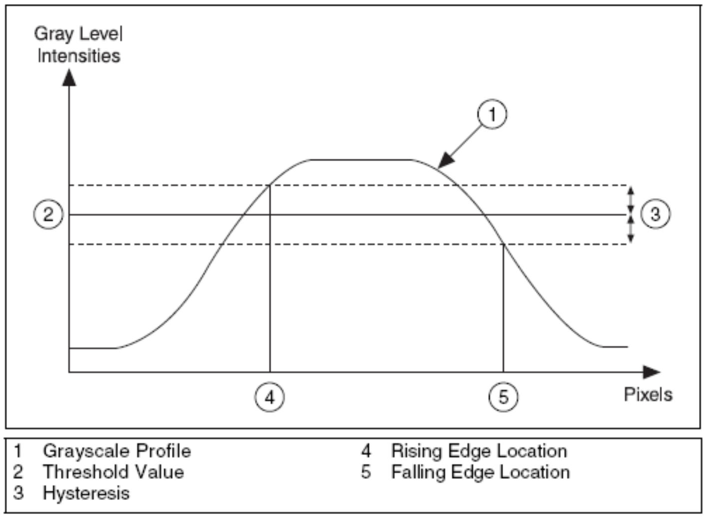


Figure: 4.10 Simple Edge Detection

(b)Advanced Edge Detection

To compute the edge strength at a given point along the pixel profile, the software averages pixels before and after the analyzed point. The pixels that are averaged after the point can be a specific pixel distance from the point, which is defined by setting the steepness parameter. This number corresponds to the expected transition region in the edge profile. Edge steepness is the number of pixels that corresponds to the slope or transition area of an edge

After computing the average, the software computes the difference between these averages to determine the contrast. Figure 4.11 illustrates the relationship between the parameters and the edge profile**.** To find the edge, the software scans across the 1D grayscale profile pixel by pixel. At each point, the edge strength, or contrast, is computed. If the contrast at the current point is greater than the user-set value for the minimum contrast for an edge, the point is stored for further analysis. Starting from this point, successive points are analyzed until the contrast reaches a maximum value and then falls below that value. The point where the contrast reaches the maximum value is tagged as the start edge location. The value of the steepness parameter is added to the start edge location to obtain the end edge location. The first point between the start edge location and end edge location—where the difference between the point intensity value and the start edge value is greater than or equal to 90% of the difference between the start edge value and end edge value—is returned as the edge location.

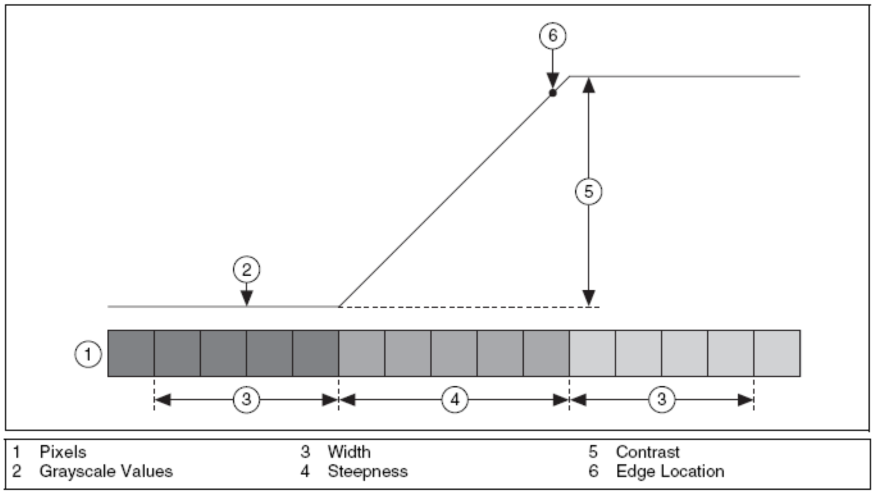
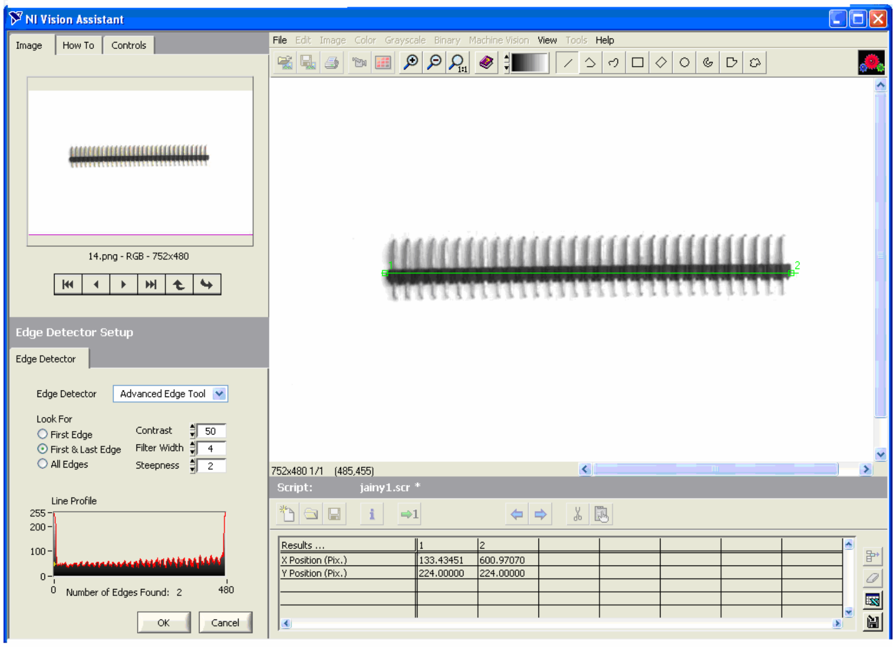


Figure 4.11 Advanced Edge Detection

The Edge Detector is selected from the tools menu. The first and the last edges are selected so that vision assistant finds and labels only the first and the last edge and these are labeled as 1 and 2.The horizontal line is drawn across the edges of the 62 pin connector in the image for length measurement as shown in figure 4.12



Edge Detector: Advanced Edge Tool

Look For
○ First Edge
● First & Last Edge
○ All Edges

Contrast 50
Filter Width 4
Steepness 2

Number of Edges Found: 2

Results ...	1	2
X Position (Pix.)	133.43451	600.97070
Y Position (Pix.)	224.00000	224.00000

Creation of edges in an image

Figure 4.12 Edge Detection in an image

4.3.1.4 Caliper Function

Caliper is a measurement function that finds edge pairs along a specified path in the image. This function performs an edge extraction and then finds edge pairs based on specified criteria such as the distance between the leading and trailing edges, edge contrasts, and so forth. It is basically a tool that uses points on the image to calculate measurements such as distances, angles, the center of a segment, or the area depending on the number of points that are selected on the image. These points are results of earlier processing steps, such as edge detection and pattern matching [7].

Length Measurement

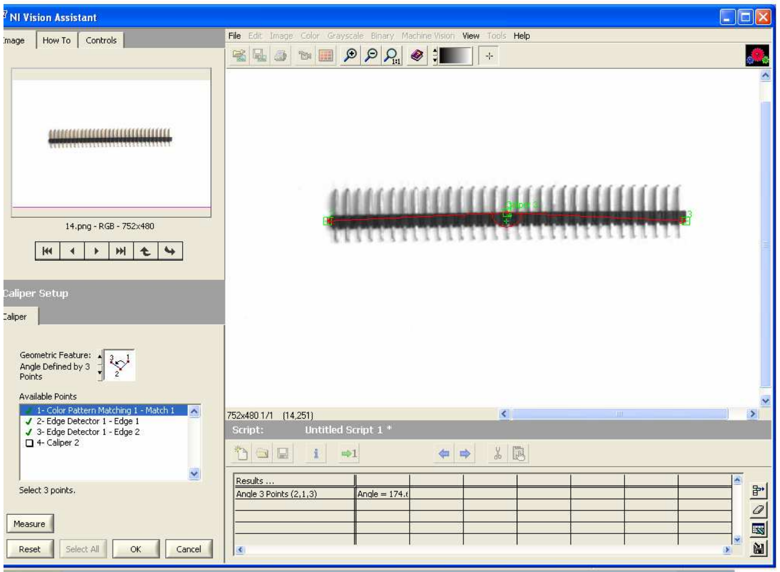
Caliper is selected from the tools menu and after that the distance is selected in the geometric feature list box. In the image 1and 2 points are clicked to find the first measurement, which measures the distance between the two points as shown in figure 4.13.

Mid Point Measurement

Again Caliper is selected from the tools menu and mid point measurement is selected from the geometric feature list box. The points 1 and 2 are selected to obtain the second measurement. Measure is clicked to compute the mid point. It is marked as Caliper 2 in the image as shown in figure 4.14.

Angle Measurement

Lastly the angle is to be measured between the three points that is done by again selecting the Caliper from tools menu. Angle defined by three points is selected in the geometric feature list box. 1, 2, 3 points are clicked in the image. After that Measure is clicked to compute the angle measurement as shown in figure 4.15.



Geometric Feature: Angle Defined by 3 Points

Available Points

- ✓ 1- Color Pattern Matching 1 - Match 1
- ✓ 2- Edge Detector 1 - Edge 1
- ✓ 3- Edge Detector 1 - Edge 2
- ☐ 4- Caliper 2

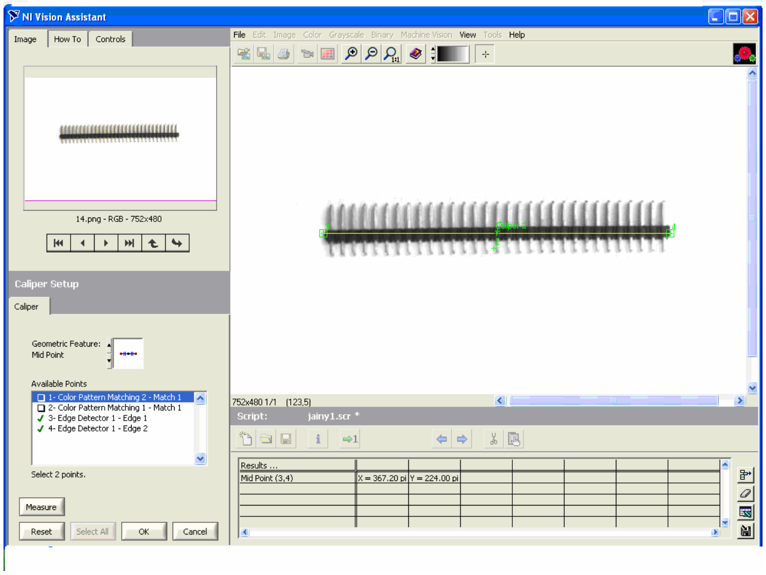
Select 3 points.

752x480 1/1 (14,251)

Results ...	
Angle 3 Points (2,1,3)	Angle = 174.

Marking of points for length measurement

Figure 4.13 Caliper 1 for length measurement



Geometric Feature: Mid Point

Available Points
- ☐ 1- Color Pattern Matching 2 - Match 1
- ☐ 2- Color Pattern Matching 1 - Match 1
- ✓ 3- Edge Detector 1 - Edge 1
- ✓ 4- Edge Detector 1 - Edge 2

Select 2 points.

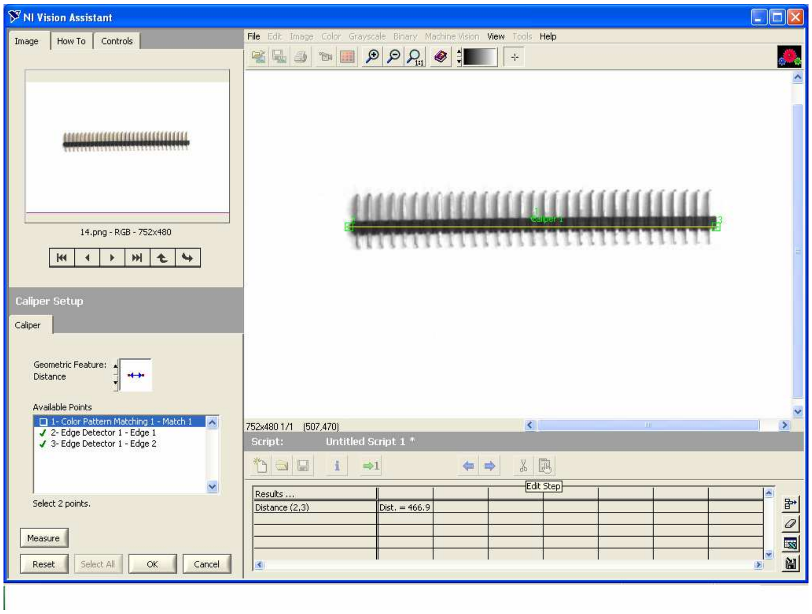
752x480 1/1 (123,5)

Script: jainy1.scr *

Results ...		
Mid Point (3,4)	X = 367.20 pi	Y = 224.00 pi

Marking of points for mid point measurement

Figure 4.14 Caliper 2 for mid point measurement



Geometric Feature: Distance

Available Points
- ☐ 1- Color Pattern Matching 1 - Match 1
- ✓ 2- Edge Detector 1 - Edge 1
- ✓ 3- Edge Detector 1 - Edge 2

Select 2 points.

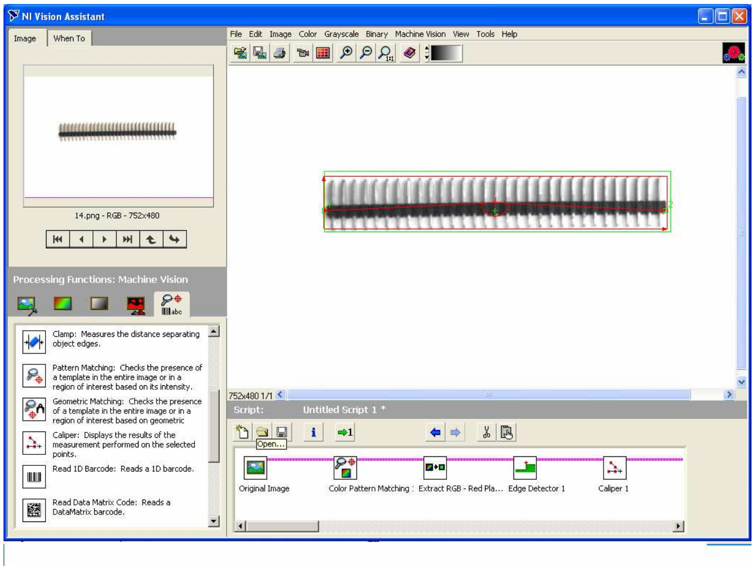
752x480 1/1 (507,470)

Script: Untitled Script 1 *

Results ...	
Distance (2,3)	Dist. = 466.9

Marking of points for angle measurement

Figure 4.15 Caliper 3 for angle measurement



Clamp: Measures the distance separating object edges.

Pattern Matching: Checks the presence of a template in the entire image or in a region of interest based on its intensity.

Geometric Matching: Checks the presence of a template in the entire image or in a region of interest based on geometric

Caliper: Displays the results of the measurement performed on the selected points.

Read 1D Barcode: Reads a 1D barcode.

Read Data Matrix Code: Reads a DataMatrix barcode.

Figure 4.16 Final image of 62 pin connector

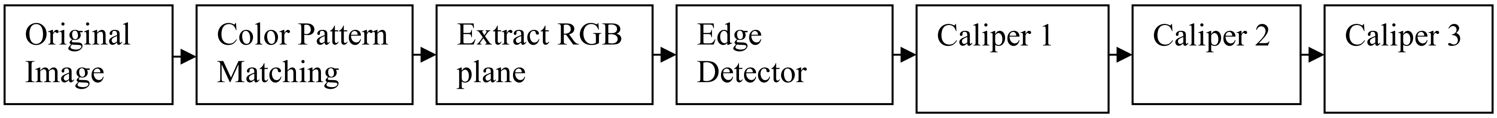
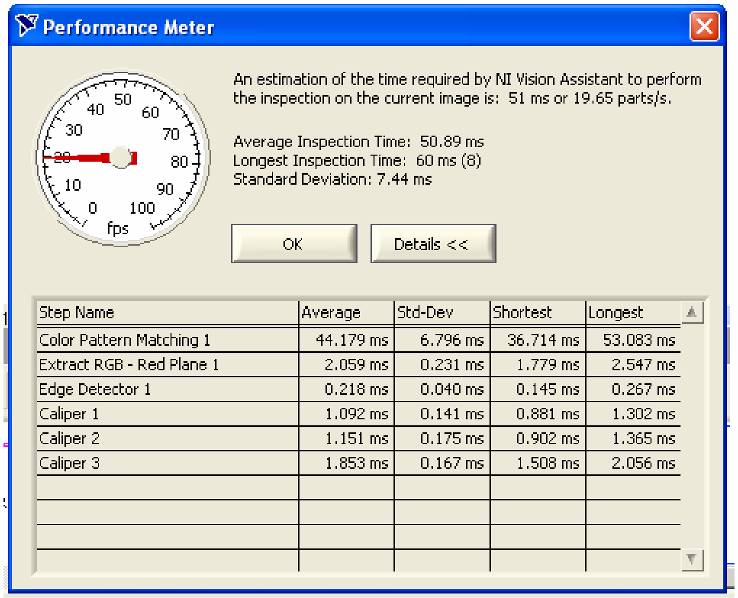


Figure 4.17 Overall Script

4.3.1.4.5 Estimated Time

The amount of time, overall script takes is shown by the performance meter.



An estimation of the time required by NI Vision Assistant to perform the inspection on the current image is: 51 ms or 19.65 parts/s.

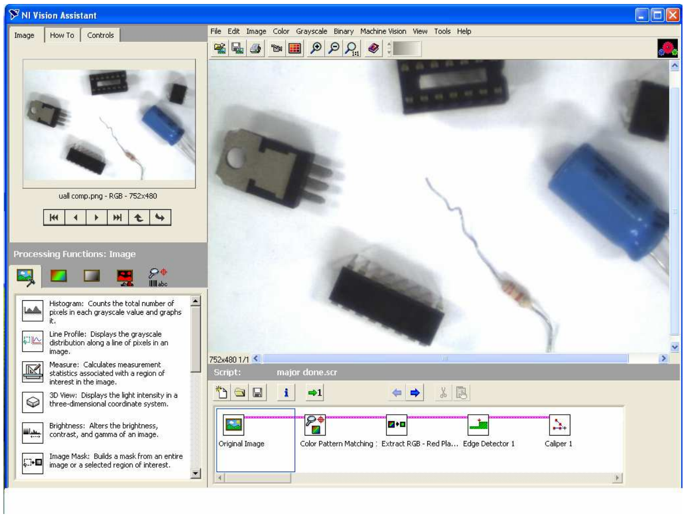
Average Inspection Time: 50.89 ms
Longest Inspection Time: 60 ms (8)
Standard Deviation: 7.44 ms

Step Name	Average	Std-Dev	Shortest	Longest
Color Pattern Matching 1	44.179 ms	6.796 ms	36.714 ms	53.083 ms
Extract RGB - Red Plane 1	2.059 ms	0.231 ms	1.779 ms	2.547 ms
Edge Detector 1	0.218 ms	0.040 ms	0.145 ms	0.267 ms
Caliper 1	1.092 ms	0.141 ms	0.881 ms	1.302 ms
Caliper 2	1.151 ms	0.175 ms	0.902 ms	1.365 ms
Caliper 3	1.853 ms	0.167 ms	1.508 ms	2.056 ms

Figure 4.18 Performance Meter

4.3.2 Dimensional Measurement of a 16 pin IC chip and of a resistor

The dimensional measurement can also be further performed on any of the components which is placed in a group of electronic components or on any surface. For example this technique can be applied on the 16 pin IC chip and of a resistor. Following figures illustrated the measurement of 16 pin IC chip and of a resistor.



Histogram: Counts the total number of pixels in each grayscale value and graphs it.

Line Profile: Displays the grayscale distribution along a line of pixels in an image.

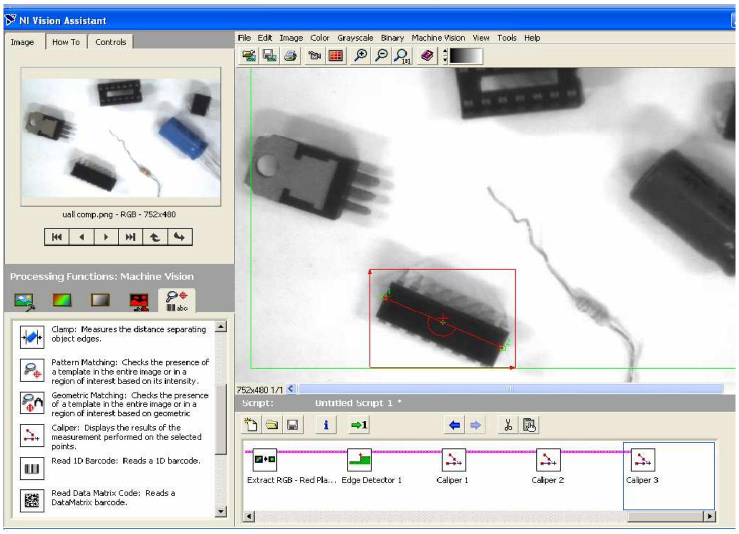
Measure: Calculates measurement statistics associated with a region of interest in the image.

3D View: Displays the light intensity in a three-dimensional coordinate system.

Brightness: Alters the brightness, contrast, and gamma of an image.

Image Mask: Builds a mask from an entire image or a selected region of interest.

Figure 4.19 Opening image for dimensional measurement of 16 pin IC chip



Clamp: Measures the distance separating object edges.

Pattern Matching: Checks the presence of a template in the entire image or in a region of interest based on its intensity.

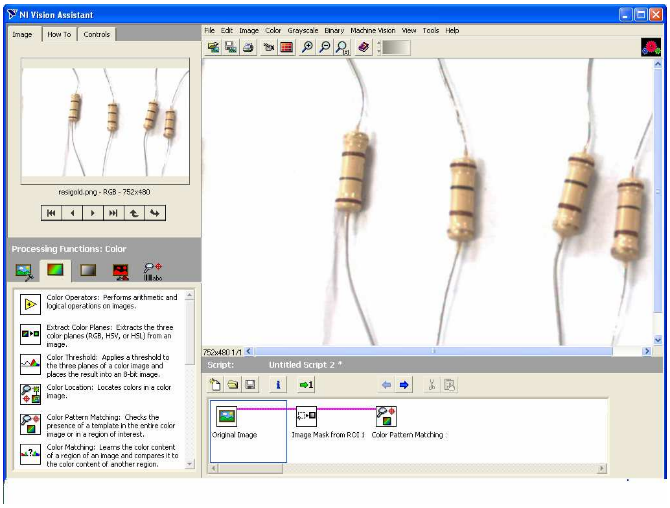
Geometric Matching: Checks the presence of a template in the entire image or in a region of interest based on geometric

Caliper: Displays the results of the measurement performed on the selected points.

Read 1D Barcode: Reads a 1D barcode.

Read Data Matrix Code: Reads a DataMatrix barcode.

Figure: 4.20 Final image of 16 pin IC chip



Color Operators: Performs arithmetic and logical operations on images.

Extract Color Planes: Extracts the three color planes (RGB, HSV, or HSL) from an image.

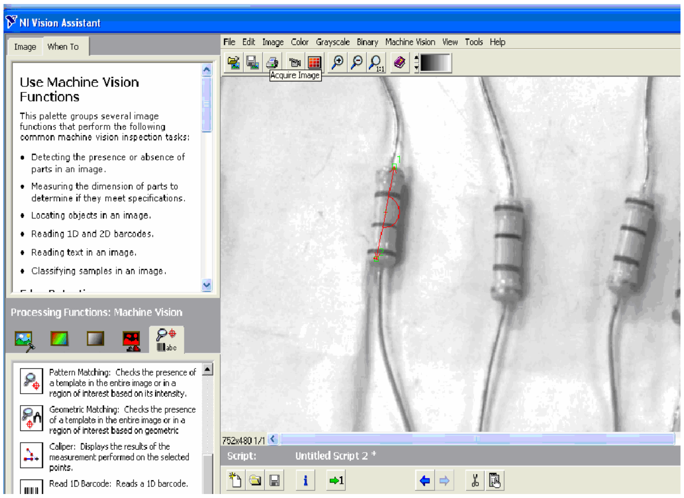
Color Threshold: Applies a threshold to the three planes of a color image and places the result into an 8-bit image.

Color Location: Locates colors in a color image.

Color Pattern Matching: Checks the presence of a template in the entire color image or in a region of interest.

Color Matching: Learns the color content of a region of an image and compares it to the color content of another region.

Figure 4.21 Opening image for dimensional measurement of resistor



Use Machine Vision Functions

This palette groups several image functions that perform the following common machine vision inspection tasks:

- Detecting the presence or absence of parts in an image.
- Measuring the dimension of parts to determine if they meet specifications.
- Locating objects in an image.
- Reading 1D and 2D barcodes.
- Reading text in an image.
- Classifying samples in an image.

Pattern Matching: Checks the presence of a template in the entire image or in a region of interest based on its intensity.

Geometric Matching: Checks the presence of a template in the entire image or in a region of interest based on geometric

Caliper: Displays the results of the measurement performed on the selected points.

Read 1D Barcode: Reads a 1D barcode.

Figure: 4.22 Final image of resistor

4.3.3 Experimental Results of dimensional measurement of electrnic components is given below:

The bmp images which were analyzed using Machine Vision Assistant 7.1.

The results are tabulated below

Image file name	Length Measurement (in pixels)	Mid Point Measurement (in pixels)	Angle Measurement (in degrees)
Im1 BMP (62 pin connector)	467.09	X=367.14 Y=224.00	180
Im2 BMP (16 pin IC Chip)	162.89	X=269.89 Y=395.97	180
Im3 BMP (Resistor)	117.69	X=229.50 Y=168.47	180
Im4 BMP (Horizontal 40 pin IC chip)	96.65	X=279.00 Y=241.01	180
Im5 BMP (IC Base)	157.20	X=237.94 Y=59.97	180
Im6 BMP (Regulator)	96.38	X=75.68 Y=191.63	180
Im7 BMP (Capacitor)	185.05	X=592.14 Y=269.81	180
Im8 BMP (6 pin IC chip)	65.19	X=392.00 Y=298.13	180
Im9 BMP (Vertical 40 pin IC chip)	312.79	X=312.78 Y=337.00	180

Table 4.1 Results of Dimensional Measurements of Electronic Components

4.4 Linking with Lab VIEW

4.4.1 Front Panel

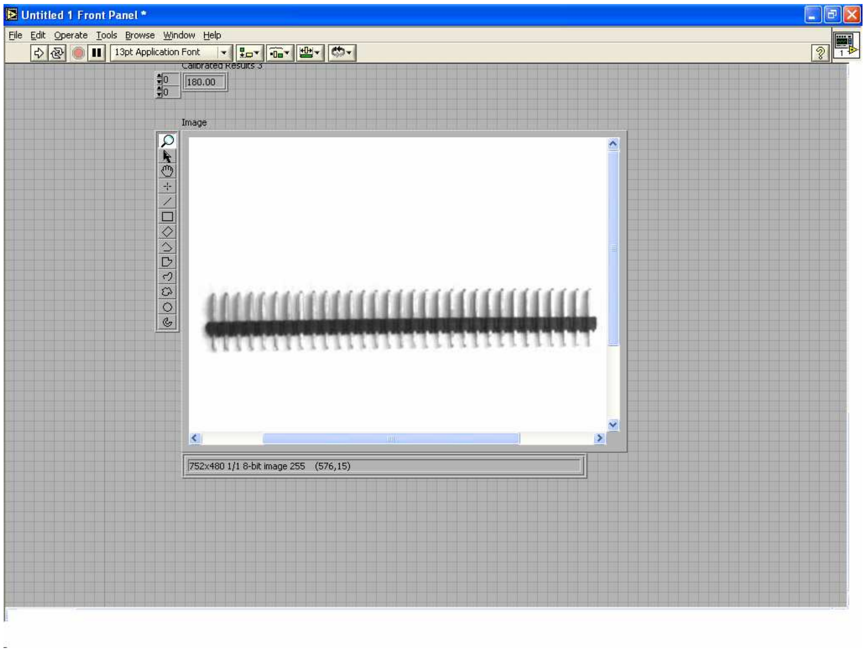
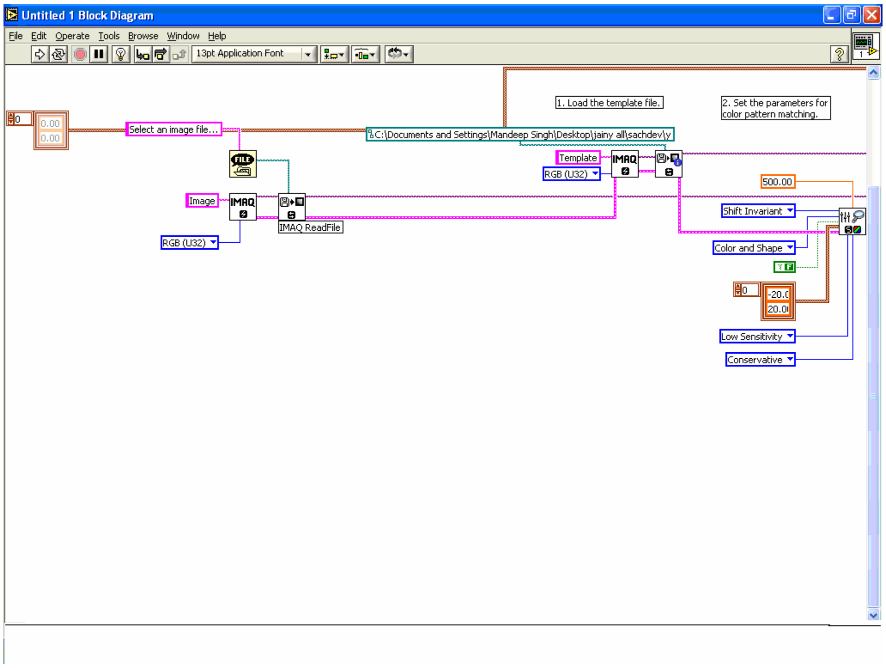


Figure 4.23 Front Panel View

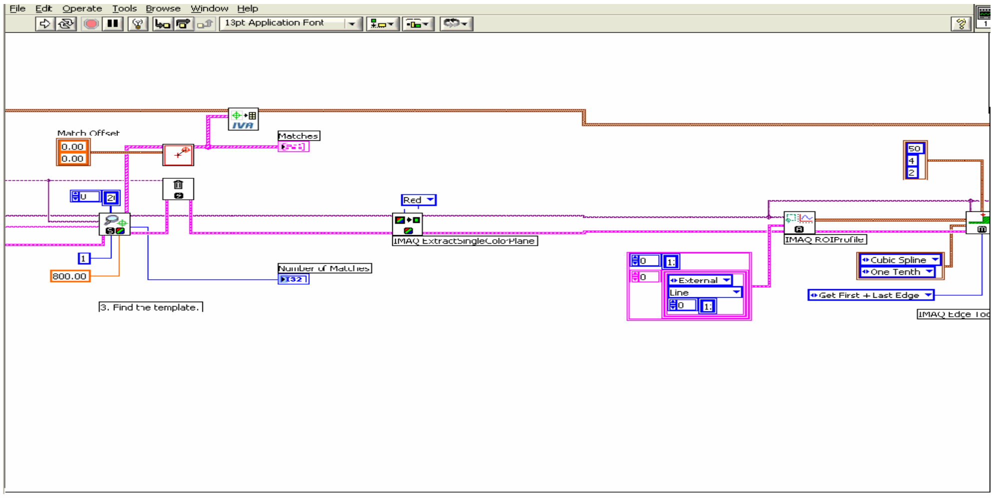
4.4.2BlockDiagram



1. Load the template file.

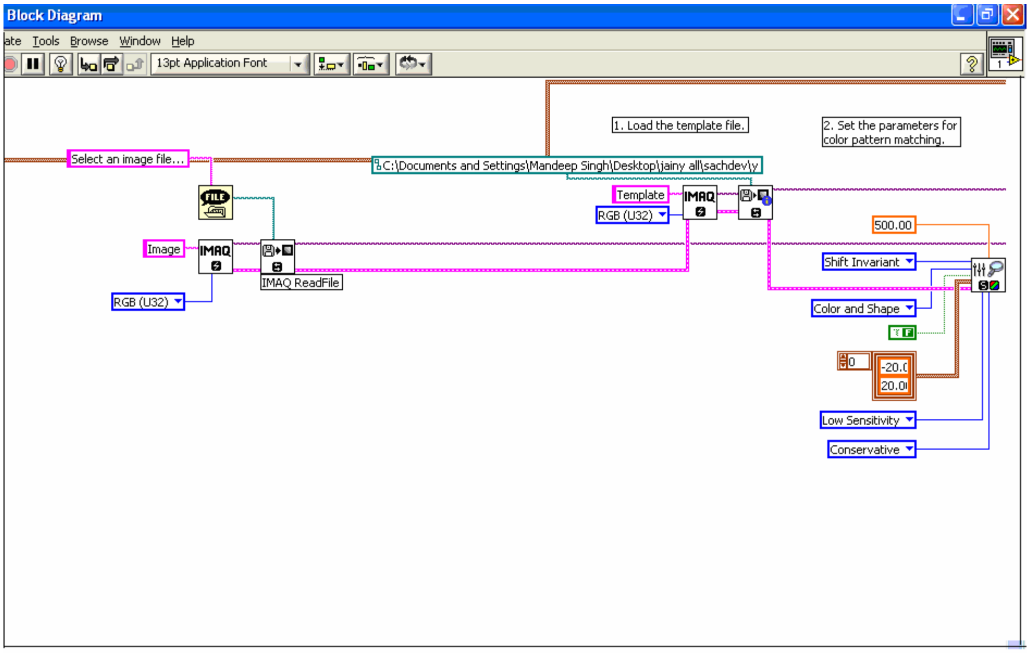
2. Set the parameters for color pattern matching.

Figure 4.24 Block Diagram Part 1



3. Find the template.

Figure 4.25 Block Diagram Part 2



C:\Documents and Settings\Mandeep Singh\Desktop\jainy all\sachdev\y

1. Load the template file.

2. Set the parameters for color pattern matching.

Figure 4.26 Block Diagram Part 3

4.5 Conversion Factor

Pixel values of length and mid point can be calibrated in terms of real length units of meters and centimeters by getting number of pixels in known length of block. Suppose a block of 5 meters is taken and numbers of pixels are counted by the above defined method, now this is taken as normalized length and components can be measured with reference to the normalized length. It indicates that numbers of pixels are directly proportional to length.

4.6 Results and Discussion

In this system dimensional measurement of electronic components in an image is done .By measuring length, mid point, angle of an electronic components such as that of 62 pin connector and 16 pin IC chip , it is seen that these parameters can be calculated accurately and fastly and surface defects can be easily identified .Processing time is in the order of milliseconds, which is very less as compared to manual inspection .The time of processing for this script is 50.89 milliseconds which is very less.

Chapter 5: Conclusion and Future Scope

5.1 Conclusion

Machine vision is an emerging area of technology in automation and control, wherein the images captured by camera or the images previously taken are processed and analyzed in real time. There are different software tools available for image processing and analysis. Vision Assistant 7.1 is one of these tools and is useful for doing real time operations. Electronic component identification and dimensional measurement is required in number of fields where the measurements of manufactured goods such as that of semiconductor chips, automobiles parts etc. are to be noted. Manual measurement of large number of manufactured goods in any of these applications can be a tedious and time consuming process, prone to human errors.

The thesis presents the introduction to machine vision; emphasizes the concept of automatic identification and dimensional measurement of electronic components, discusses the simple approach to solve this problem and discusses in detail the color pattern matching which makes the process easy, fast and accurate. In practice, I have found color pattern match making with machine vision tool to be very powerful. The matchmaking framework's ability to allow component matching and its further utilization for dimensional measurement is unique and necessary for preserving important details of electronic components. The identification of electronic components by matchmaking and measuring allows the matchmaker to have much quicker response in a short time of milliseconds and the overall process does not change even when the new type of component is to be matched .The template learning and saving gives designer a relaxed mechanism to work on.

I have identified the electronic components that comprise a matchmaking system and their dimensional measurement by gauging and have validated many key issues through practical design and implementation.

5.2 Future Scope

Rapid expansion in the digitization of image and image collections has vastly increased the numbers of images available to researchers through electronic means. Machine vision assistant systems are very efficient at managing for high-performance computing, and can also handle the complexity and dynamism of electronic components in high-throughput computing environments and can be used for many other applications. In this thesis images explored are acquired prior to analysis. Identification of electronic components through color pattern matchmaking is a relatively new area, and is therefore rich with many interesting sub problems that require further study. Many applications can be developed around it, for example, reading a six band color of a metal film resistance to know its nominal value, tolerance, temperature coefficient etc.

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