Verification of Parts Using Digital Image Processing in Machine Vision

M. Gopala Krishnan and S. Saravana

Bharath University, Chennai, India

Abstract: In every company, inspecting the products manufactured at various stages is of great importance. This paper proposes a technique to detect the presence or absence of the parts in various devices. This inspection is done by using template matching and cross correlation in digital image processing. The image of the device which has to be inspected is captured using camera. In the template matching technique, the image of the object to be inspected is compared with a reference image. The reference image is the image which contains all the necessary parts that must be present. Pattern matching can be used to recognize and/or locate specific objects in an image. Correlation provides a direct measure of the similarity between two images. Though sensitive to the scaling or rotation of objects, normalized correlation is robust to changes in lighting. Cross correlation is the basic statistical approach to image registration. It is used for template matching or pattern recognition. Template can be considered a sub-image from the reference image, and the image can be considered as a sensed image. The objective is to establish the correspondence between the reference image and sensed image. The measure of the degree of similarity between an image and template can be accepted or rejected. Thus using the Template matching and cross correlation we can detect the presence or absence of the components in the mobile.

Key words: Machine Vision · Inspection · Template Matching · Pattern · Cross Correlation

INTRODUCTION

Machine vision has been defined by the machine vision association of the society of manufacturing engineers and the automated imaging association as the use of devices for optical, noncontact sensing to automatically receive and interpret images of a real scene in order to automatically receive and/or control machines or process. Machine vision is a data acquisition system. Manufacturing or Quality assurance data management involves the collection (when and where) and analysis (how) of data which convey results of the manufacturing process to upper management as part of a factory-wide information system. Machine vision represents a piece of the manufacturing or quality control universe [6-8]. That universe is driven by data related to the manufacturing process. That data is of importance to upper management as it relates directly to bottom-line results. Sophisticated manufacturing systems require automated inspection and test methods to guarantee quality. Machine vision can be applied in all manufacturing processes: incoming receiving, forming, assembly, and warehousing and shipping. It is the manufacturing data that impact quality, not data that impact manufacturing. The quality of the manufacturing data is important. For it to have an impact on manufacturing, it must be timely as well as accurate. By recording this data automatically from vision system, input errors are significantly reduced and human interaction minimized [1, 9].

The machine vision industry is a segment of the larger industry characterized as Electronic Imaging. With in Electronic Imaging there are basically two major components. One deals with the application of computers to generate images such as in CAD and The second deals with the application of computers to acquired images. Within this second segment, there are a number of
distinct classifications [2, 3]. These include images acquired as a result of remote sensing techniques. There are those systems that acquire engineering drawings as input to a computer. Finally, in the last class of segment of electronic imaging is the use of computers operating on the acquired image.

According to Researchers at University of Iowa, people asked to perform the visual sorting task of picking out a minority of black ping pong balls from a production line of white ones. Even two operators together were only about 95% effective. People are only 70-85% effective, especially when dealing with repetitive tasks. People have limited attention span. Susceptible to distractions. People are inconsistent. In consistencies from person to person. Justification need not be based on solely on labor displacements. Machine vision should be considered wherever the prevention of failure or the reduction of the cost of failure is a priority. The inspection is done by comparing the images of the mobile device and the parts of the mobile which is a separate image [4]. First the image of the mobile device which has all the specified parts should be taken. Using cameras we can capture the image clearly. Proper choice of cameras is so important such that it does not lead to any false results.

The sensors used are CMOS type (complementary metal oxide semi conductors). They convert light into electrons. This is less expensive than the CCD sensors.

The sensors used are CMOS type (complementary metal oxide semi conductors). They convert light into electrons. This is less expensive than the CCD sensors.

Fig 3: CMOS image sensor

The other important of the camera is lens. We are using a 12mm lens. A good lens allows enough light to pass through it to produce properly-illuminated and sharply defined images on film with short exposure times. Each of these elements directs the path of light rays to recreate the image as accurately as possible on the digital sensor. As we said earlier, lighting helps in getting a good image. We use ring lighting here. Lighting is by light emitting diodes.

Fig 4: Ring Lighting

The saved image is processed by the image processing tool box present in MATLAB. The name MATLAB stands for MATrixLA Boratory. MATLAB is a high-performance language for technical computing. MATLAB is an interactive system whose basic data element is an array that does not require dimensioning. Here we read the image pixel by pixel and denote the image in terms of rows and columns [5, 9]. This is the reason why we use mat lab in case of image processing. Specific applications are collected in packages referred to as toolbox. The major tools within or accessible from the desktop are:

- The Command Window
- The Command History
- The Workspace
- The Current Directory
Many pre-processing techniques can be done using appropriate commands in Mat lab. Image pre-processing is the name for operations on images at the lowest level of abstraction whose aim is an improvement of the image data that suppress undesired distortions or enhances some image features important for further processing. Its methods use the considerable redundancy in images. Neighbouring pixels corresponding to one object in real images have the same or similar brightness value and if a distorted pixel can be picked out from the image, it can be restored as an average value of neighboring pixels. Image pre-processing tool, created in Mat lab, realizes many brightness transformations and local pre-processing methods. This is by selecting the image enhancement toolbox. We can perform some enhancements like histogram equalization, filtering.

**Inspection of the Mobile Device:** Template matching is a technique in digital image processing for finding small parts of an image which match a template image. It can be used in manufacturing as a part of quality control. Template matching can be subdivided between two approaches: feature-based and template-based matching [7, 9]. The feature-based approach uses the features of the search and template image, such as edges or corners as the primary match-measuring metrics to find the best matching location of the template in the source image. The template-based, or global, approach, uses the entire template, with generally a sum-comparing metric that determines the best location by testing all or a sample of the viable test locations within the search image that the template image may match up. A basic method of template matching uses a convolution mask (template), tailored to a specific feature of the search image, which we want to detect. This technique can be easily performed on grey images or edge images. The convolution output will be highest at places where the image structure matches the mask structure, where large image values get multiplied by large mask values.

This method is normally implemented by first picking out a part of the search image to use as a template: We will call the search image \( S(x, y) \), where \( (x, y) \) represent the coordinates of each pixel in the search image. We will call the template \( T(x, y) \), where \( (x, y) \) represent the coordinates of each pixel in the template. We then simply move the center (or the origin) of the template \( T(x, y) \) over each \( (x, y) \) point in the search image and calculate the sum of products between the coefficients in \( S(x, y) \) and \( T(x, y) \) over the whole area spanned by the template. As all possible positions of the template with respect to the search image are considered, the position with the highest score is the best position. This method is sometimes referred to as 'Linear Spatial Filtering' and the template is called a filter mask.

For example, one way to handle translation problems on images, using template matching is to compare the intensities of the pixels, using the SAD (Sum of absolute differences) measure.

A pixel in the search image with coordinates \((x_1, y_1)\) has intensity \(I(x_1, y_1)\) and a pixel in the template with coordinates \((x_2, y_2)\) has intensity \(I(x_2, y_2)\). Thus the absolute difference in the pixel intensities is defined as:

\[
\text{Diff}(x_1, y_1, x_2, y_2) = |I(x_1, y_1) - I(x_2, y_2)|
\]

The mathematical representation of the idea about looping through the pixels in the search image as we translate the origin of the template at every pixel and take the SAD measure is the following:

\[
\sum_{i=0}^{S_{row}} \sum_{j=0}^{S_{col}} \text{SAD}(x, y)
\]

\(S_{row}\) and \(S_{col}\) denote the rows and the columns of the search image and \(T_{row}\) and \(T_{col}\) denote the rows and the columns of the template image, respectively. In this method the lowest SAD score gives the estimate for the best position of template within the search image. The method is simple to implement and understand, but it is one of the slowest methods. The above is an example which clearly shows the template image and the current image. The template image consists of the face of the cat. The result image shows the deducted face of the cat in the current image by finding the match between the input and the template. The matching process moves the template image to all possible positions in a larger source image and computes a numerical index that indicates how well the template matches the image in that position. Match is done on a pixel-by-pixel basis [6]. The image of the mobile device to be tested is captured by the camera. The image is read using the mat lab software to process the image. The component to be found is cropped from the default image consisting of all the components using the in crop option in the mat lab. This cropped image is also read for the comparison to be done. A function is used to call the subprogram. In the subprogram both the image is checked whether it is a gray image or not. If it is a RGB image then it should be converted to gray image.
The size of the two images is being compared. The one with the larger size is assigned to be the input image and the other is considered to be the template image. Now the search process is to find the presence of template image in the input image by using the method of correlation. The number of rows and columns in the input image are represented by $r_1$ and $c_1$. That of template images is $r_2$ and $c_2$ respectively. The correlation between the images is found by manipulating the rows and columns of both the images. The component identified in the input image can be represented by a plot box which is white in colour. The starting and ending of rows and columns of the template image in the input image is found. Along these points white lines are formed by assigning those pixels to be 255 i.e. white. Hence in the output the presence of template can be seen using the plot box.

**Experimental Result:** The figure 8(a) is a portion enclosing the template in the original image captured and the figure 8(b) indicates the template image. The figure 8(c) shows the result indicating the presence of the template in the original image for mobile device. The figure 7 shows the results for CRO probe. The white square box indicates the location of the template. Correlation between the original image and the template image is found. Using this technique, the template image is correctly located in the original image. The applications of this technique are to ensure the quality of the device, control the manufacturing process, more accurate and faster than the human inspection. Particularly useful in places where human involvement is not possible. For example: nuclear powerplant.

**Template Matching:** Template matching is a technique in digital image processing for finding small parts of an image which match a template image. It can be used in manufacturing as a part of quality control. The template matching method gives high recognition accuracy and reduces the processing time compared to other Methods such as cross-correlation. The pattern matching technique is a suitable technique for the recognition of single-font, not-rotated, and fixed-size characters. Although this method is preferably used in binary images, properly built templates also obtained very good results for gray-level images. In computer science, pattern matching is the act of checking some sequence of tokens for the presence of the constituents of some pattern. In contrast to pattern recognition, the match usually has to be exact. The patterns generally have the form of either sequences or tree structures [8, 2]. Uses of pattern matching include outputting the locations (if any) of a pattern within a token sequence, to output some component of the matched pattern, and to substitute the matching pattern with some other token sequence. Correlation is an important tool in image processing, pattern recognition, and other fields. The correlation between two signals (cross correlation) is a standard approach to feature detection as well as a building block for more sophisticated recognition techniques.

Fig 6: block diagram of template matching employed in machine vision system

Fig 7: Output of template matching for CRO probe

Fig 8: Output of template matching for mobile device
CONCLUSION

This paper proposes a technique that detects the presence or absence of the parts in various devices. The inspection is done by using template matching and cross correlation in digital image processing. When the devices are moving in the conveyor belt, the images of it will be taken by the camera which is connected to the computer through an interface. In this template matching technique, the image of the object is compared with the template image. Using cross correlation we found the direct measure of the similarity between two images. The main objective of establishing the Correspondence between the original image and template image is done, as it gives the measure of the degree of similarity between the two images. Even the location of the template is found using plot box. Using MATLAB version 7.8.0.347(R2009a) software we have obtained the result by executing necessary commands. Thus using the Template matching and cross correlation we have detected the presence or absence of the components in the device and template have been located correctly.

REFERENCES