Vol. XI & Issue No. 2 February - 2018
INDUSTRIAL ENGINEERING JOURNAL

AUTOMATION OF VISUAL INSPECTION USING IMAGE PROCESSING

Abhash Jain
Dr. Girish Thakar

Abstract:

With current era of the Automobile industry, the product is manually or visually checked by using check list there is difficulty in inspection due to dependence on human skills and lack of ergonomic applications which cause fatigue. Inspection is one of the primary segments of the industrial parts production process. Machine vision is a present day strategy to inspect produced parts and it is a subcategory of engineering machinery, dealing with issues of information technology, optics, mechanics and industrial automation. Machine vision systems are used increasingly to solve problems of industrial inspection. This paper introduces an automatic vision based defect inspection or detection and dimensional measurement. The system identifies defects (Part Miss, Part Location, Welding Defects and grinding defects etc.) which usually occur in an assembly Structure component. The image processing technique used for Defect detection and algorithms developed for defect detection and linear dimension measurement. Various types of sensors were interfaced with the vision hardware and the part handling mechanism, to complete the total automated vision based inspection system. This system is an accurate, repeatable, fast and cheap solution for industries. This image processing technique is finished utilizing MATLAB programming. This work presents a strategy which decreases the manual work.

Keywords— Image Processing, Machine Vision, Defect detection, MATLAB etc.

I. INTRODUCTION

Machine vision (MV) is the technology to replace manual inspections and measurements with digital cameras and image processing. The technology is used in a variety of different industries to automate the production, increase production speed and yield, and to improve product quality [7].

It developed as an essentially new system for industrial inspection and quality control in the mid-1980s. At the point when legitimately applied, machine vision can give accurate and cheap inspection of work pieces, hence significantly increasing product quality. It is additionally utilized as an in-process gaging tool for controlling the process and amending patterns that could prompt the production of defective parts. The automotive and electronics industries make substantial utilization of machine vision for automated high volume, labour intensive and repetitive inspection operations

Machine vision in operation can be defined by a four-stage flow:

1. Imaging: Take a picture.
2. Processing and analysis: Analysed the picture to acquire an outcome.
3. Communication: Send the outcome to the system in control of the process.
4. Action: Take action depending on the vision systems outcome.

Fig 1.1: Working principle of the system

1.1 Digital Image Processing

Digital computers are utilized to handle the image. The image will be converted to digital form utilizing a scanner digitizer and after that procedure it. It is characterized as the subjecting numerical representations of objects to a series of operations in order to acquire the coveted outcome. It begins with one image and produces an altered adaptation of the same. It is, therefore, a process that takes an image into another. It generally refers to the processing of a 2-D picture by a digital computer. In a broader context, it implies digital processing of any 2-D data. A digital image is an array of real numbers and it's represented by a limited number of bits. The principle benefit of Digital Image Processing methods is its versatility, repeatability and the preservation of original data precision. There are various Image Processing Techniques: Image representation, Image pre-processing, Image enhancement, Image restoration, Image analysis, Image reconstruction, Image data compression.

II. LITERATURE REVIEW

Defect detection using digital image processing has received considerable attention during the past two - three decades and a number of approaches have been proposed in the literature.

J.Wang [1] has introduced 2 approaches to detect defects: gray-level statistical and morphological methods. In view of the high degree of periodicity for fabrics image. The greater part of algorithms utilized today for defect localization or detection is computationally intensive and less precise. T.D.Venkateswaran & G.Arumugam [2] have introduced two-dimensional discrete wavelet transformation methods have been successfully utilized for the improvement of the automated defect detection scheme for fabric images. Trials on real texture and slate surface pictures with defects show that the proposed method is technique is vigorous in discovering fabric defects and slate defects. Hazem (Moh'd Said) Hatamleh[3] has introduced the differences between two similar images can be noticed by eye, but sometimes those differences take a lot of time to be discovered, and also using MATLAB image processing system with suitable code the system can easily discover the main difference points between the two images. Patel Jagrti, Jain Meghna and Dutta Papiya [4] have introduced the automatic detection of fabric defects using digital image processing. They have also proposed a method to recognize fabric defects in the textile industry for minimizing production cost and time. As well as acquires digital fabric images by image acquisition device and converts that image into the binary image by restoration and threshold techniques.Using MATLAB image processing. R Deepa, Usha and P V Shashi Kumarb [5] have introduced the automated vision inspection of a defect and sorting system for a plastic injection mold component called a Retractor Retaining Bush. The system developed which is able to capture defects like partial part, burn marks, flash etc., which generally occur in an injection mold component. And they also introduce about different types of sensors and actuators were interfaced with the vision hardware and the part handling mechanism, to complete the total automated vision based inspection system. Peng Gaoliang, Zhang Zhujun, Li Weiquan [9] have presented an approach to utilize the detection algorithms based on computer vision technology to control the quality of O-rings, which includes the accurate measurement algorithm for the internal/sectional diameter and the classification algorithm for the surface defects. They also introduce about the setup for vision system for measurement and inspection. M. Jalili, H. Dehgan and E. Nourani [6] have done the dimensional inspection is one of the main sections of the industrial parts production process. They have been introducing problems of visual dimensional inspection and some solutions have been proposed to improve these systems performance. To improve system performance, some methods have been used that they are described such as Use Fixture, Use Pattern Recognition, Raising the Number of Edge Detections, Increase Uniformity of Parts. They have also described hardware and software used for dimension inspection. In this paper, the algorithm used is basic and more productive for implementation. There is a noteworthy change in computational time.

III. EXPERIMENTALARRANGEMENT

The object is placed at fixed position in front of the camera to capture a sharp image and for subsequent processing. As shown in Figure.2.1 bus roof sub-assembly structure placed on the table and the camera cover entire length of the object and its capture various images from a various location (pre decided) for the analysis. The dimension of the object is length =1992mm, width =990 mm, Number of mounting plates is 7. And the Camera contacted to Machine control system.

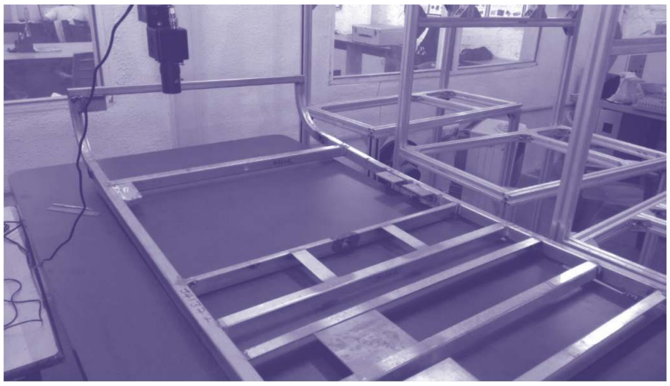

Fig.3.1 Experiment setup for defect detection

IV. PARAMETER CONSIDER FOR INSPECTION

The parameters which considers for inspection and analysis in above setup are follows. These parameters has been checked for the quality and strength of final product.

Table 4.1: Parameter consider for inspection

Sr.No.	Parameter Name	Value
1	Welding – welding miss, non-uniform welding,	Ok/Not ok
2	Grinding – grinding miss	Ok/Not Ok
3	Part	Present/Absent
4	Dimension (Width of the Horizontal Beam)	X mm

V. METHODOLOGY

The digital analysis of two-dimensional images of the object is based on processing the image acquirement, with the utilization of a computer. The image is depicted by a two-dimensional matrix of real or imaginary numbers introduced by a distinct number of bytes. The arrangement of digital image processing might be displayed schematically as appeared in Figure below.

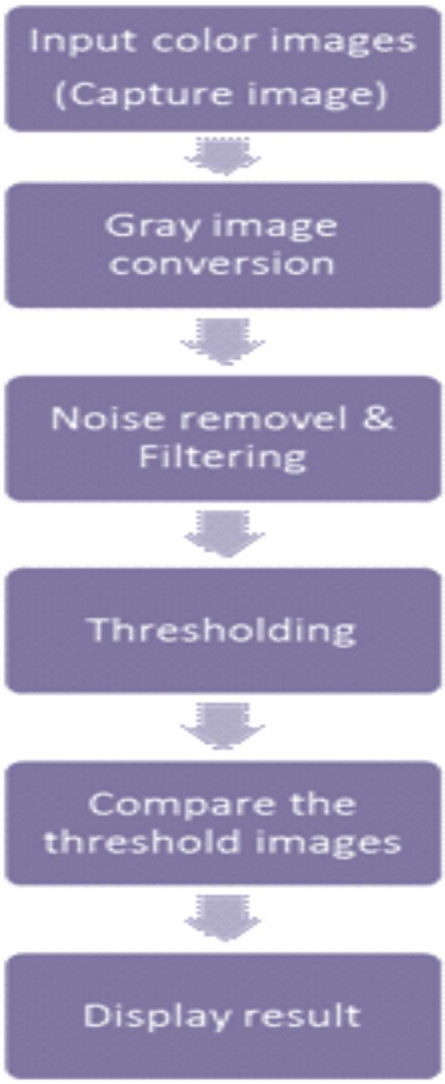

Fig 5.1 Flowchart for digital image processing

The strategy utilized as a part of this paper is processed using MATLAB software with image processing toolbox. It underpins an extensive variety of image processing operations, including open image document, add noise to intensity image, 2-D median filtering and adaptive filtering, Image analysis and enhancement, Color Image disintegration into RGB Channels, Image segmentation and etc. The Algorithm demonstrates the general stream of the Few Modules of MATLAB Programming utilized as a part of this work:

Capture Image: The image is captured by using a CMOS camera from the top of the object from a distance adjusted so as to get an ideal perspective of the interested area. That obtains Input color image to the MATLAB in image processing framework. The image formats are .bmp,.tif, .Jpeg, and .png. In this paper, we utilized color images (RGB images) and isolated into their segments (Red, Green, and Blue).

Gray Image Conversion: The RGB color image is converted into a gray image. A grayscale image generally requires that every pixel is stored as a value between 0 - 255(Byte), where the value speaks to the shade of gray of the pixel. The number of gray levels is an integer power of 2(L=2k).

Noise Removal & Filtering: At whatever point an image is converted from one form to other many types of noise can be available in the image. Here we utilize the 'Median' filtering to reduce noise. It is a nonlinear operation often used in image processing to reduce "salt and pepper" noise. Median filtering is more effective than convolution when the goal is to simultaneously reduce noise and preserve edges.

Thresholding: It is a procedure of converting a grayscale input image to a bi-level image by using an ideal threshold. The reason for thresholding is to extricate those pixels from some image which represent an object (such as graphs, maps). Though the information is binary the pixels represent a range of intensities.

Compare the threshold images: After the thresholding, the image capture/test image compare with defect free image or master image. If the distinction is more prominent than detection sensitivity level, announce that catch/test image is defective; otherwise, capture/test image is defect free. In this thesis, we use "imabsdiff" and "imshowpair" function for compare the image.

VI. ALGORITHM

Discrete Cosine Transform (DCT) is a well-known procedure in imaging compression, which transforms signals in spatial domain into a frequency domain.

The forward 2D-DCT of a M x N block image is characterized as:

$$C(u,v)= \alpha(u)\alpha(v) \sum_{X=0}^{M-1} \sum_{y=0}^{N-1} f(x,y) \text{ x cos } \left[\frac{\pi(2x+1)u}{2M}\right] \left[\frac{\pi(2y+1)v}{2N}\right] \quad \dots (1)$$

The inverse transformed is defined as:

$$f(x,y) \sum_{X=0}^{M-1} \sum_{y=0}^{N-1} \alpha(u)\ \alpha(v) C(u,v) \text{xcos} \left[\frac{\pi(2x+1)u}{2M}\right] \left[\frac{\pi(2y+1)v}{2N}\right] \dots (2)$$

Where,

$$\alpha(u,v) = \begin{cases} \frac{1}{\sqrt{M}}, & u = 0 \\ \sqrt{\frac{2}{M}}, & u = 1,2,3\dots\dots M-1 \end{cases}$$

x and y are spatial coordinates in the image block, and u and v are coordinated in the DCT coefficients block. Below demonstrates the properties of the DCT coefficients in M x N blocks with the zigzag pattern used to process the DCT coefficients. Despite the fact that the aggregate energy continues as before in the M x N blocks, the energy distribution changes with most of the energy being compacted to the low frequency coefficients. C (0,0) is the DC coefficient in the forward 2D-DCT condition. As the cosine of zero is one, the condition (1) is rearranged to:

$$C(0, 0) = \sqrt{\frac{1}{MN}} \sum_{X=0}^{M-1} \sum_{y=0}^{N-1} f(x,y) \quad \dots\dots (3)$$

The DC coefficient, which is situated at the upper left corner, holds the greater part of the image energy and represents the proportional average of the M x N blocks. The remaining ((M x N) – 1) coefficients mean the changes among the block and referred as AC coefficients.

VII. FLOWCHART FOR MEASUREMENT

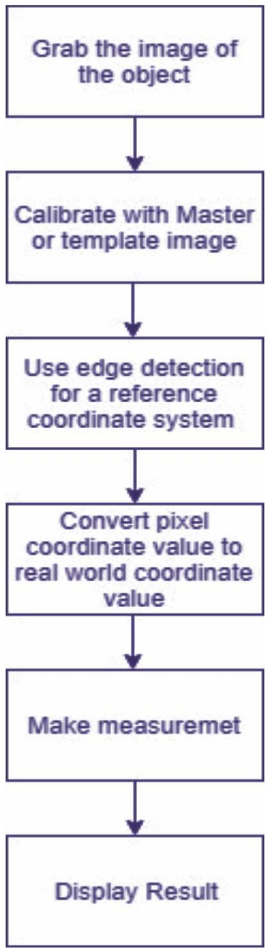

Fig. 7.1 flowchart for linear dimension measurement

VIII. MATLAB ANALYSIS

1. Convert original color image into gray scale image: Converting original images into grayscale in MATLAB is given below:

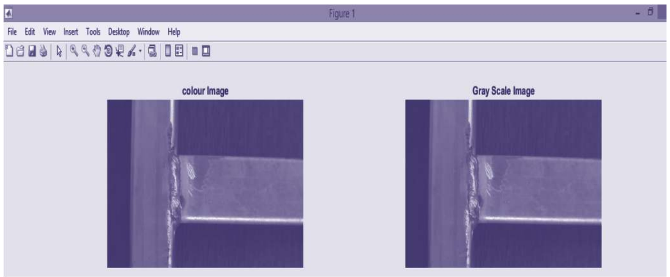

Figure 8.1 Convert original color image into gray scale image

2. Noise removal & filtering of the gray image:
Noise removal & filtering of images in MATLAB is given below:

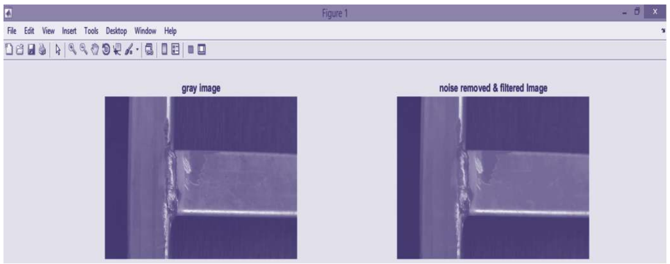

Figure 8.2 Noise removal & filtering of the gray image

3. Apply Fourier transform to compress the image:
Compressed the image using discrete cosine transformation in MATLAB is given below:

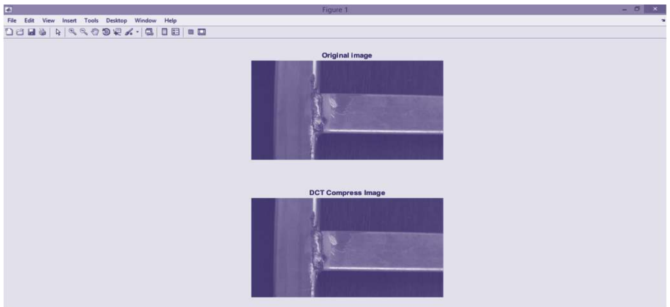

Figure 8.3 Apply Fourier transform to compress the image

4. Thresholding of the image:
Thresholding the image in MATLAB is shows below:

Figure 8.4 Thresholding of the image

5. Compression of the captured image with Template /Master Image:
Compression of the captured image with Template/Master image in MATLAB is given below:

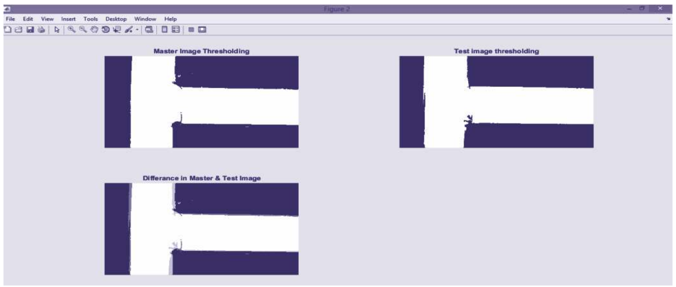

Figure 8.5 Compression of the captured image with Template /Master Image

IX. EXPERIMENTAL RESULTS

Below screenshots images show the result of the experiment carried out on small roof subassembly structure of bus.

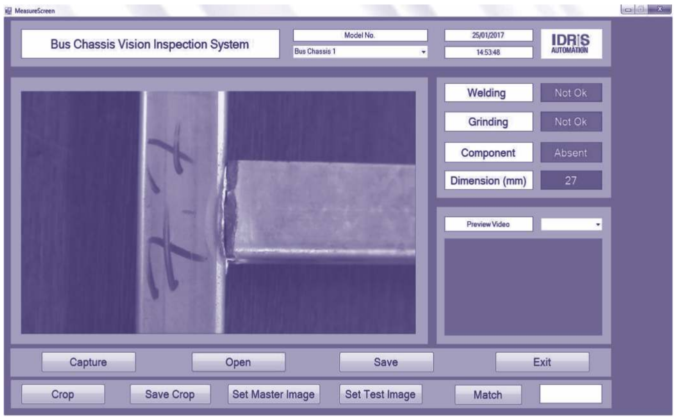

Figure 9.1 Measurement Screen 1

In the above picture one parameter like as dimension value are shown green on display screen means that value is as per master image (or defect free image) in another word there is no error or acceptable but other three parameter like as grinding, welding and component values are shown red on the display screen means that values are not as per master image (or defect free image) in another word there is error or not acceptable and need to do rework.

Figure 9.2 Measurement Screen 2

In the above picture three parameter like as welding, grinding and dimension values are shown green on display screen means that values are as per master image (or defect free image) in another word there is no error or acceptable but one parameter like as component value is shown red on the display screen means that value is not as per master image (or defect free image) in another word there is error or not acceptable and need to do rework.

Figure 9.3 Measurement Screen 3

In the above picture all parameter like as welding, grinding, component and dimension values are shown green on display screen means that values are as per master image (or defect free image) in another word there is no error or acceptable. There no need for rework and directly forward to next process.

X. CONCLUSION

The presented machine vision system has a purpose of replacing a human vision quality controller in Bus Assembly Industry. This paper introduce an automatic vision based defect inspection and Dimension measurement system for the small roof sub-assembly of the bus structure. The Bus body structure is a tubular structure and it consists various mounting plates which develop various types of defects during its production.

1. This system is able to detect defects like Part Miss, welding miss and its defects such as spatter, non uniform welding, grinding miss & its defects and linear dimensional error etc., which generally occur in Bus body structure . Thus the quality level have improved. by using image processing technique .

2. Algorithms for defect detection and measurement of the linear dimensions are developed and Graphical User Interface has developed for operating the system which helps to eliminate human skill dependency and human error.

3. This work will reduce quality inspection time or cycle time from 22 min to approx. 5 min and improve productivity by reducing cycle time as well as save rework time and cost.

LIMITATION

The limitation of this system is inspection station covered from all sides will be required as lux level and position of structure to be fixed.

XI. FUTURE WORK

This paper showed an effective automated inspection strategy which was applied on small roof assembly of bus structure through different procedures. Meanwhile, there are some fundamental aspects where the technique's execution can be improved. We, therefore, propose the following points as possible outlines for additionally work.

1. While this work gave a new path to inspect and detect defects either online or offline, the application of such inspection presently can't seem to be extended to other assembly process inspection like as colour, dent, crack, profile measurement etc.
2. With more understanding of the relationship between of Discrete Cosine Transform and properties, we can try to implement the algorithm to study some other characteristics rather than defects.

ACKNOWLEDGMENT

This work was academically supported by Faculty of Industrial & Production Engineering Department, Shri Govindram Seksaria Institute of Technology and Science Indore and VE Commercial Vehicles Ltd. Baggad, Dhar (MP).

REFERENCES

[1]. J.Wang, R.A. Campbell and R.J. Harwood, Automated inspection of carpets, in Proc. SP IE, Vol. 2345, 1995, pp. 180-191.

[2]. T.D.Venkateswaran & G.Arumugam, Defect detection in fabric images using two-dimensional discrete wavelet transformation technique, International Journal of Computer Science & Communication Networks, Vol 4(1), 2014, pp.33-40.

[3]. Hazem (Moh'd Said) Hatamleh, Image Processing of Two Identical and Similar Photos, Journal of Information Engineering and Applications, Vol.3, No.1, 2013.

[4]. Patel Jagrti, Jain Meghna and Dutta Papiya, Detection of Faults Using Digital Image Processing Technique, Asian Journal of Engineering and Applied Technology, ISSN 2249-068X Vol. 2 No. 1, 2013.

[5]. R Deepa,S Usha, P V Shashi Kumar ,Automated Vision Inspection System for a Plastic Injection Mould, 5th International & 26th All India Manufacturing Technology, Design and Research Conference (AIMTDR 2014) December 12th– 14th, 2014, IIT Guwahati, Assam, India.

[6]. Jalili M., Dehgan H. and Nourani E.,A Cheap Visual Inspection System for Measuring Dimensions of Brass Gear, International Journal of Computer and Electrical Engineering, Vol. 5, No. 2, April 2013.

[7]. Short Martin, Mike Madden, Stefanova Hristina, Machine Vision: The key considerations for successful visual inspection, Michael Hill,13 May 2013.

[8]. Yang Yuxiang, Zha Zheng-Jun, Gao Mingyu and He Zhiwei, A robust vision inspection system for detecting surface defects of film capacitors, Elsevier, Signal Processing 124(2016), October 2015, pp. 54–62.

[9]. Peng Gaoliang, Zhang Zhujun, Li Weiquan , Computer vision algorithm for measurement and inspection of O rings, Elsevier, Measurement 94 (2016), September 2016, pp. 828–836.

AUTHORS

Abhash Jain, Post graduate student, Industrial & Production, Engineering Department, Shri G.S. Institute of Technology & Science, 23 Park Road, Indore – 452 003 (MP)
Email: abhashjain9@gmail.com

Dr. Girish Thakar, HOD & Professor, Industrial & Production, Engineering Department, Shri G.S. Institute of Technology & Science, 23 Park Road, Indore – 452 003 (MP)
Email: thakargirish@yahoo.co.in