Real Time Metal Inspection for Surface and Dimensional Defect Detection Using Image Processing Techniques

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Abstract

Quality control is a very important process in any manufacturing industry. Quality control is tedious and time-consuming if it is done by human experts. An automated vision system can significantly improve the quality control process both in terms of speed and accuracy. This paper proposes methods for quality control in the metal industry by finding and classifying defects in the metals so that defected metals should not be included with the non-defected metal object. The defect finding in this paper includes major surface defects and dimensional defects associated with the metal object as these defects play a major role to ensure the quality of the metal object. In the proposed method, surface defects such as cracks, pinholes, corrosion along with dimensional defects in metals are obtained by different image processing techniques by taking images of the metal object in real-time using a pi camera and further processing it on the raspberry pi.

1 Introduction

Machine vision using image processing techniques is one of the fastest growing and widely used technologies in the area of manufacturing and quality control due to the increasing quality demands of manufacturers and customers. Machine vision utilizes industrial image processing by the use of cameras mounted on production lines and cells in order to visually inspect products in the real-time without operator intervention.

Quality control in the metal objects is an important aspect of today’s highly competitive metal Industries. The quality of the end product can be improved by inspecting the product at each manufacturing stage in the production line. However, a manual inspection of the object slows down the entire process as well as it becomes costly, difficult and time-consuming. It can also be affected by the effectiveness of human experts due to the hazardous atmosphere of the industry. There are many more issues associated with manual quality control which can lead to less effectiveness of the complete production line. Therefore, the process of inspection is needed to be automated and inspection results should be fed back to the upstream manufacturing process for improvement of final product quality. However, the metal inspection system is needed to be designed with the intelligence of human experts and atomization techniques. Image processing techniques can be used very effectively to find out the defects in the metal object in a real-time industrial manufacturing process.

1.1 Types of the defects in metal

1.1.1 Surface defects

Surface defects are any abnormality present on the metal surface. Fig.1 shows different possible surface defects in case of metals. There are many types of possible surface defects as shown below.

Fig.1. Different types of the surface defects in metals

<table>
<thead>
<tr>
<th>Defects</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>Cracks</td>
<td>Unwanted discontinuity at the metal surface</td>
</tr>
<tr>
<td>Pinhole</td>
<td>Holes on the metal surface</td>
</tr>
<tr>
<td>Corrosion</td>
<td>Corroded metal surface</td>
</tr>
</tbody>
</table>

Table 1. Types of surface defects
1.1.2 Dimensional Variability
Sometimes it is possible that metal object is not in its proper dimensions due to cutting or heating types of errors. There is a need to calculate the dimensions of the metal object to check whether it is matching with the standards or not.

1.2 Issues with the defect inspection
At present, there are many commercially available products which can detect the presence or absence of the surface defects at reasonable costs. However, this problem still remains an open research issue due to the difficulties faced during the real-time defect Detection, Identification and Localization of the faults. The major obstacles in this area are mainly due to the computational cost, lack of expert knowledge in the defect feature selection or modeling and availability of the proper defect samples.

2 Related Work
In previous years many methods were proposed to find out the defects in the metals.

Anders Landström and Matthew J. Thurley proposed crack detection in the steel slabs [1]. This work is based on morphological operations. Crack probability measure for each detected potential crack is provided and experiments are performed on different samples. The limitation of this method is that it cannot deal accurately with short length cracks, therefore other methods like Hough transform and watershed segmentation are suggested by author for future work.

Aswini E. and Divya S. have proposed the method which deals with the structural defects (i.e. Crack) on metal disc surfaces in relays [2]. The acquired metal disc images were enhanced by the preprocessing techniques. To extract the cracks in the metal disc surfaces two methods were proposed. The first approach used mathematical morphology and watershed segmentation. The second method makes use of mathematical morphology and bottom-hat filtering. The result shows that the latter approach is superior for crack detection.

Defect detection in the plain ceramic tiles by using image processing is presented in [3] which deals with finding the defects like cracks, pinholes, color-defects, etc. The approach used for defect detection includes calculation of connected pixel components, some image filtering and transformation algorithms like median filtering, Laplacian of Gaussian transform etc.

Research has been carried out for automatic fault detection and classification for metals by using enhanced Gabor filters [4], this technique is inspired by fault finding in textile materials by Gabor filters. This automated classification method helps to acquire knowledge about the pattern of the defect within a very short period of time and so that the defected metal may not be mixed with the fresh metal.

The defect region such as cracking and shrinkage of the metal surface image is detected by binarization using an iterative thresholding technique [5]. The real-time defected color metal surface images are used in this approach and experimental results are shown. In order to identify the defects, the input color image is transferred to gray scale. Then the binarization technique is applied using iterative thresholding, in which the defect region is differentiated from the non-defected region. Experimental results prove that the presented defect detection approach using iterative thresholding techniques provides promising performance for the real-time color metal surface images.

T. Aarthi and M. Karthi [6] proposed a new method for explicit analysis of surface the defects. In this proposal, the images are acquired using a Panasonic BBHCM381 camera. These images are subjected to 2-D discrete wavelet transform which uses subband coding algorithm for feature extraction. The analysis of surface features is rendered by obtaining numerical data from the image. This data aids in performing statistical analysis that involves the calculation of mean, variance, standard deviation, skewness and kurtosis from the acquired image. These parameters are calculated for different wavelets like HAAR, Daubechies, and a comparative study is made. LabVIEW is the system design platform used for developing this application.

Suchart Yammen has proposed the method for automatic detection of corrosion on hard disk drives [10]. To detect and characterize the corrosion on the HDD tips, calculation of feature area and contour based methods are used.

3 Proposed Method
The proposed method involves findings of the dimensional defects and major surface defects like cracks, pinholes and corrosion. Algorithms are developed to detect and classify these defects on dedicated raspberry pi hardware to make it completely independent system. The complete system block diagram is shown as in following fig. 2.

Image acquisition by Pi camera

Raspberry Pi

Feature Extraction

Template Matching & defect detection

Edge detection

Image Preprocessing

Fig.2. Block Diagram

1.3 Image Acquisition
Images of the metal objects are captured in the real time by using Pi camera which is a dedicated camera for raspberry Pi.

1.4 Raspberry Pi
We have used raspberry Pi 2 as a processor to minimize the hardware cost and make the overall system robust and compact. Raspberry Pi is the credit card size computer having all features like four USB ports, external memory card slot, camera and LCD interface.

1.5 Image Preprocessing
Image preprocessing involves the conversion of a color image to grayscale image and some image enhancement operations
to improve the image quality and reduce noise. Image enhancement in the proposed method involves contrast stretching and image smoothening operation on the images which are captured in the real time by Pi camera.

1.6 Edge detection
Edges are the boundary between two dissimilar regions and are found by a change in the pixel intensity in the image. For the proposed method we have used canny edge detection.

1.7 Feature extraction
Feature extraction for the particular defect is a very important step in the overall algorithm. Selecting a particular feature so as to get accurate result is the crucial task. In our proposed method, we have selected the features based on the area and pixel values of the image. Contour method is used for calculating feature area, a region of interest and locating the defects in the image. Contours are also used for shape analysis, object detection and recognition.

4 Algorithms for proposed defect detection

4.1 Dimensional measurement and defect detection
1. Image Acquisition by Pi Camera.
2. Image Preprocessing: RGB to gray scale Conversion & Image Blurring.
3. Edge Detection: Canny edge detection.
5. Finding Contours of the image.
6. Sorting of the contours and Computation of bounding Box.
7. Calculation of midpoints of the edges.
8. Computation of Euclidian distance between the midpoints.
9. Computing the dimensions of the reference image and test image by applying steps 1 to 8.
10. Comparing the dimensions of both the images and generating the results of whether object dimensions are matching or not.

4.2 Crack Detection
1. Image acquisition by Pi camera.
2. RGB to grayscale conversion.
3. Contrast enhancement of the image.
4. Check every pixel from left to right up to the last pixel.
5. If a pixel has value 1, then consider its eight neighbors and find which are 1.
6. Increment current pixel coordinates by 1.
7. Apply backtracking process to find out the connected pixels.
8. Counting no of connected pixels, finding out region of interest and obtaining its contour.
9. If an area of the contour is greater than particular threshold value, then crack is present. Else crack is not present.

4.3 Pinhole defect detection
1. Image Acquisition by Pi Camera.
2. RGB to grayscale conversion.
3. Noise reduction by median filtering.
4. Check every pixel from left to right to the last pixel.
5. Check whether a pixel has value 0 or 1.
6. If the value is zero, then check its eight neighbours.
7. Finding out region of interest.
8. Draw the contour of the region containing 0 pixel values.
9. If an area of the contour is in between the threshold values, then pinhole is detected. Else pinhole is not detected.

4.4 Detection of corrosion on metal surface
1. Image acquisition by Pi camera.
2. RGB to HSV conversion.
3. Finding out region of interest based on color of corrosion.
4. Convert the image into grayscale.
5. Finding out the connected pixel components to calculate the overall region of corrosion.
6. If an area is greater than particular threshold value, then corrosion defect is present, else not.

5 Experimental Results
In order to evaluate the performance of the system experiments are performed on multiple real time images taken from the metal objects by Pi camera. 20 samples are selected for defect detection of each type.

Results for different defect detection are shown below.
Table 2 shows the accuracy of the different defect detection algorithm tested over multiple samples of the metal object in real time, as below-

<table>
<thead>
<tr>
<th>Defects</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimensional variability</td>
<td>98%</td>
</tr>
<tr>
<td>Cracks</td>
<td>99%</td>
</tr>
<tr>
<td>Pinholes</td>
<td>98%</td>
</tr>
<tr>
<td>Corrosion</td>
<td>92%</td>
</tr>
</tbody>
</table>

Table 2. Results in terms of accuracy for different defects

Conclusion and Future work

In this paper, efficient surface and dimensional defect detection method is presented based on different image processing techniques. The real-time metal images are used for defect detection and classification. The proposed defect detection rate is better than many of the existing methods. Experimental results prove that the presented defect detection approach using proposed algorithms provides promising performance for the real-time metal images. Automotive defect detection will help the industry to maintain the quality of product with less false detection and increased speed. This will completely eliminate the need for a human expert from quality control process. Use of the raspberry pi over CPU will minimize the overall system cost.

Proposed methods deal with finding the major defects but there is a possibility to have many minor defects in case of metal object like shrinkage, micro cracks etc. The future work is to detect other metal defects rather than proposed to improve overall system performance.

References

Image Processing”, International Research Journal of Computer Science Engineering and Applications Vol 2 Issue 4 April 2013 ISSN 2319-8672


